Conservation Agriculture

A manual for farmers and extension workers in Africa

A.C.T.

IIRR

CONSERVATION AGRICULTURE

A MANUAL FOR FARMERS AND EXTENSION WORKERS IN AFRICA

A.C.T.

IIRR

International Institute of Rural Reconstruction

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The International Institute of Rural Reconstruction is a non-profit, non-governmental organization that aims to improve the quality of lives of the rural poor in developing countries through rural reconstruction: a sustainable, integrated, people-centred development strategy generated through practical field experiences. Based in the Philippines, IIRR has regional offices in Africa (located in Nairobi), Latin America (Quito) and Asia (Silang, the Philippines). IIRR's Africa office is committed to strengthening the institutional capacity of partner organizations through knowledge generation, acquisition and sharing.

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The African Conservation Tillage Network promotes the sharing of information and experiences and facilitates the adaptation and adoption of conservation agriculture principles and practices in Africa. ACT is a Pan-African, international association, involving private, public and non-government sectors, and including farmers, input and machinery manufacturers and suppliers, researchers and extensionists, with an active conviction to promote, support and apply conservation agriculture to ensure viable and sustainable agriculture productivity while minimizing or reversing the environmental degradation that is devastating the continent. Membership is open to any individuals or groups committed to the development and promotion of conservation farming/tillage technologies for smallholder farmers in Africa.

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Contents

Foreword

Over the last couple of decades, conservation agriculture has gained increasing interest worldwide as well as in Africa. This approach to farming is very attractive for African farmers: it boosts yields, saves labour and money, and conserves the soil and the environment. It appeals to all categories of farmers – from small-scale subsistence farmers to high-tech commercial producers. It can be used in all climates and on all soils where it is possible to grow crops. And it appeals to the general public and to national leaders as a policy to promote and approve.

Conservation agriculture contributes significantly to meet three of the Millennium Development Goals.

- **MDG 1: Eradicate extreme poverty and hunger** Conservation agriculture helps farmers produce more food – for themselves and for the market. It helps stabilize yields, especially during drought. It uses less labour and fewer expensive inputs than conventional agriculture.
- **MDG 7: Ensure environmental sustainability** Conservation agriculture produces a healthy, productive soil, halts erosion, reduces river pollution, increases the amount of organic matter in the soil, and takes CO_2 out of the atmosphere.
- **MDG 8: Develop a global partnership for development** Conservation agriculture is a global movement. It brings development agencies, the private sector, civil society, research institutions, local organizations and farmers together to contribute to the other MDGs.

Conservation agriculture also fits in well with two of the major NEPAD (New Partnership for Africa's Development) sectoral priorities: agriculture and the environment.

This book explains why conservation agriculture has such promise. It shows how farmers and extension workers can do it.

This book is the result of an initiative by a group of people from various institutions across Africa and throughout the world. This group includes farmers and researchers, extension workers and policy makers, governments, non-government organizations and the private sector. A unique alliance for a uniquely promising approach.

They have drawn on their own knowledge, on the work of their organizations, and on the successes of hundreds of thousands of farmers through Africa. They have put all these experiences together into this guide: the first manual on conservation agriculture covering the whole of Africa.

The method used to create this book – a "writeshop" involving more than 90 contributors – is highly appreciated. It shows an impressive will by a large group from many different countries, from different walks of life, and with highly different specializations and interests, to come together and produce a product that all agree upon. The feeling of joint ownership will help the message of conservation agriculture spread much more quickly than if a single person had attempted to write this book alone.

It is a special joy to see that the two areas of agriculture and communication have joined hands in a common understanding that a written manual is of little use if its messages are not communicated wide and far.

It is our hope that this book will be distributed widely, and will be read by many. More important, we urge readers to put to use the information it contains. While the book is intended especially for extension workers and other agricultural service providers, we would also recommend that students in schools and universities read it. So should many farmers, and those who represent our peoples in various forums on agriculture and food security.

Finally, we want to recognize the international aspect of conservation agriculture. This book is "African". But it reaches even further out. It will be a major input into the World Congress on Conservation Agriculture, to be held in Nairobi in October 2005 under a NEPAD arrangement and with the African Conservation Tillage Network. This congress marks a new beginning for a continent with an increasing will to get together to influence global policies and decision making.

We thank all involved in producing and distributing this book, and those charged with transforming its messages into practical use. Most of all, though, we hope that our farmers will be able to use conservation agriculture to bring prosperity to their families and for their societies.

Hon. Kipruto arap Kirwa
Minister of Agriculture and
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Republic of Kenya

Nairobi, August 2005

Preface

Over 60% of Africans depend on some form of farming for their sustenance and livelihoods. Agriculture remains vital for the continent's development and economic growth. So the recent stagnation or decline in farm productivity in in many parts of Africa is a major concern. For many communities and countries, this has translated into chronic food insecurity and growing poverty. Households and communities are increasingly vulnerable, as their only resource – their land – can no longer sustain them.

Africa is witnessing severe degradation to its farmlands. Much of this degradation can be attributed to common, but exploitative, farming practices – ploughing that destroys the soil structure and degrades organic matter, burning or removing crop residues, monocropping, and so on.

Soil and water management practices that sustain and enhance the productivity of arable soils are a **must** for Africa. They are a vital part of the long-term solution to food insecurity and poverty.

Conservation agriculture aims to overcome these problems. It consists of three simple principles – *disturb the soil as little as possible*, *keep the soil covered*, and *mix and rotate crops*. These principles can be put into practice in many different ways. Farmers throughout Africa, and throughout the world, are beginning to adopt them; they have seen their yields rise, their soil gain in fertility, and their labour needs fall.

But conservation agriculture must be promoted actively if it is to be spread rapidly. Grassroot players (farmers, extension workers, input suppliers, etc…) often lack information on what to do and where to do it. This manual aims to fill this gap.

This manual

This manual tries to do the following:

- It explains what conservation agriculture is, and why it is important.
- It describes how to use conservation agriculture principles in the field.
- It highlights the issues and challenges that farmers and extension personnel may encounter when they adopt and adapt conservation agriculture.
- It suggests ways to adapt and disseminate this approach.
- It gives examples of experiences with conservation agriculture in real life.

This manual is part of a larger effort to develop and promote conservation agriculture in Africa and worldwide. It is designed to reflect the experiences and views of many conservation agriculture practitioners (farmers, researchers and support organizations) to respond to the looming hunger and environmental degradation in sub-Saharan Africa. It aims to enhance knowledge and awareness on conservation agriculture and promote the adoption and adaptation of this approach throughout Africa. It is the first truly Africa-wide manual on conservation agriculture.

African farmers face a bewildering variety of conditions: highland and lowland, tropical and temperate, high and low rainfall, rich and poor soils, large and small farms. They grow a huge range of crops. Some farmers are commercially oriented; others eat everything they grow. It is impossible for one book to cover all the different variations.

Fortunately, this is not necessary. Conservation agriculture is not a single set of techniques – there is no one "best practice". Rather, its three principles can be applied in different ways in different situations. This book outlines these principles (on page 3), then shows how to adapt them to suit the particular set of circumstances that you – the farmer or extension worker – face. It is up to you to decide on what is best for you. Innovate, test and adapt the techniques in this book, and encourage your friends and neighbours to do the same.

The manual also reflects the character of conservation agriculture – holistic and multi-disciplinary. It also describes how conservation agriculture relates to other key areas that farmers are concerned with: socio-economic issues, culture and traditions, marketing, and livestock.

This manual is intended primarily for Africa's farmers and extension workers: the people who stand to benefit directly from conservation agriculture. It is written in simple language so it is easy to understand, and easy to translate into local languages. Many of the illustrations can be enlarged or adapted for use on posters or training materials.

The book should also prove useful for others interested in conservation agriculture: agricultural researchers and policymakers, NGO staff, trainers, teachers and students. It should serve as a comprehensive resource on conservation agriculture in Africa and worldwide.

How this manual was prepared

The initial idea for this manual came from a meeting in Zambia, when over 40 researchers and field practitioners from Africa met to prepare for the Second World Congress on Conservation Agriculture (held in Brazil in 2003). The large number of papers and posters gathered for this meeting formed a rich potential basis for a comprehensive manual on conservation agriculture in Africa.

The International Institute of Rural Reconstruction (IIRR) developed the concept of a manual further, and discussed the idea with RELMA, ICRAF's Regional Land Management Unit. RELMA provided a start-up fund. FAO, CTA and IFAD also provided valuable financial support. The resulting manual was to be ready for the third World Congress, held in Nairobi in October 2005.

A small consultative group of key stakeholders was formed into a steering committee, which decided that IIRR and the African Conservation Tillage

Network (ACT) be the lead agencies. IIRR was designated as manager and overall project coordinator.

A group of key stakeholders met in November 2004 in Nairobi to generate a set of themes and topics for the manual. The same group identified various promising practices and suggested organizations that practised conservation agriculture, as well as resource persons and individuals who might generate case materials and manuscripts on various topics. IIRR then invited them to prepare manuscripts on the selected topics and to present them at a "writeshop".

The Karen writeshop

The writeshop (an intensive, 2-week workshop) was held in Karen, near Nairobi, on 18–29 April 2005. The contributors brought their manuscripts with them, along with other printed materials, photographs and conservation agriculture equipment. In all, some 60 farmers, extension staff, scientists and practitioners from 14 African countries, as well as from Brazil and Europe, participated. Another 30 contributors were unable to attend the writeshop but submitted manuscripts for discussion by the participants.

The writeshop began with a series of presentations by participants on various aspects of conservation agriculture. The participants were then divided into a number of groups, each focusing on a specific theme, such as "land preparation" or "economics". These groups were asked to write a draft chapter on their theme, based on the manuscripts that had been prepared for the writeshop and their own knowledge and experience. Each group prepared a draft chapter, which they presented to the plenary.

The other participants commented on the drafts, asked questions, and suggested additions or changes. The individual groups then revised their drafts. A team of editors assisted with drafting and revising the text, and artists drew illustrations to accompany it.

The groups presented their revised drafts to the plenary a second time, along with the illustrations, and the other participants were able to make further suggestions. The editors and artists again helped revise the text and illustrations. By the end of the writeshop, the groups had completed drafts for each of the chapters in the book you are holding.

The groups were fairly fluid: individual participants were able to move from group to group, so contributing to the detailed drafting of more than one chapter.

Throughout the writeshop, participants wrote about their specific experiences with conservation agriculture. These cases appear in boxes in the text. They provide valuable examples of how conservation agriculture works in practice.

After the writeshop, considerable restructuring and rewriting were necessary to eliminate overlap among the various chapters and to ensure the style was clear and consistent. This was done by the chief editor, who also commissioned new artwork to fill in gaps.

Through this process, the initial manuscripts were revised substantially or were completely rewritten. The information they contained was selected, sifted, and combined with ideas from other sources, and was distributed throughout the manual. A single section in the book may contain information provided by many different participants. This means it is not possible to label a particular chapter or section as the work of a particular participant. The "authors" of the manual are thus the contributors listed on page xviii: both those who attended the writeshop and those who provided manuscripts.

Writeshop advantages

The sequence described above is an adaptation of the writeshop approach pioneered by IIRR at its headquarters in the Philippines. IIRR-Africa has used this approach to produce extension and information materials on a wide range of subjects.

Writeshops have several advantages over conventional methods of producing a publication. They speed up the production process, taking full advantage of the participants' expertise. The process of writing, getting comments, revising and illustrating takes place at the same time, considerably shortening the often-difficult process of writing, editing and publishing. A large number of participants contribute to each topic: in effect, the writeshop provides an opportunity for technical peer review by a large number of reviewers, as well as pretesting for understandability and field relevance by a group of the intended readers.

In addition, writeshops bring together a large number of people from various institutions and walks of life, each with different perspectives and expertise. They are an excellent training and networking opportunity, with individuals learning about each other's work and exchanging ideas and experiences that will be of value for them when they return home. It is hoped that the relationships and networks forged during the writeshop will continue long into the future.

Structure of this book

This book is divided into 14 chapters.

Chapter 1, *What is conservation agriculture?*, explains the principles of conservation agriculture, and describes the benefits it can bring to farmers who adopt it. It compares conservation agriculture with conventional farming practices, and tells readers what to expect in the first few years after they adopt it. It also briefly describes the history of the approach in Africa and worldwide, and outlines some challenges facing its rapid spread.

Chapter 2, *Converting to conservation agriculture*, guides readers through the challenges of starting out with this new approach to farming. It lists some questions farmers should ask, and describes how to find the answers.

Chapter 3, *Field preparation and planting*, describes how to prepare a field for conservation agriculture, various ways of planting crops, and how to work out how much seed and fertilizer to use.

Chapter 4, *Keeping the soil healthy*, introduces the concept of soil health – which depends on the amount of organic matter in the soil. It shows how to tell whether your soil is sick, and what to do to nurse it back to health.

Chapter 5, *Soil cover*, discusses the importance of keeping the soil covered, and the two main ways of doing so: using cover crops and mulch. It especially addresses a major problem that many farmers face when they first adopt conservation agriculture: the choice of a cover crop and how to obtain seeds.

Chapter 6, *Crops and cropping systems*, discusses various types of cropping systems (intercropping, sequential cropping, and so on), the benefits of crop rotation, and factors to consider when choosing which crops to grow.

Chapter 7, *Controlling weeds*, discusses the vital topic of how to control the weeds that will take over the fields unless the farmer manages them properly. It describes various ways to control them: by maintaining soil cover, by mechanical weeding, or using herbicides. It gives special attention to using the right amount of herbicides, in a correct and safe way.

Chapter 8, *Conserving soil and water*, describes various soil and water conservation technologies that can be combined with conservation agriculture.

Chapter 9, *Livestock*, covers three issues relating to livestock and conservation agriculture: feeding animals, protecting fields from livestock, and training animals to pull conservation agriculture equipment.

Chapter 10, *Harvesting, marketing and input supplies*, addresses issues that farmers are likely to encounter in harvesting, storing, processing and marketing their produce, and in obtaining inputs and credit for their conservation agriculture operation.

Chapter 11 is entitled *Should you adopt conservation agriculture?* It poses (and answers) some questions that farmers may have about conservation agriculture before they adopt it: How does it benefit me? How much does it cost? Is it profitable?, and so on. For each question, it shows how farmers can work out the answers themselves so they can make an informed decision on what to do.

Chapter 12, *Conservation agriculture and people*, explores the social and cultural dimensions of this approach. It looks at five areas: the roles of women and men, cultural beliefs, HIV/AIDS, farmers with disabilities, and young people.

Chapter 13, *Encouraging adaptation and adoption*, is aimed primarily at extension workers, researchers and policymakers. It suggests various ways to test and adapt particular conservation agriculture practices in a participatory way with groups of farmers. It also provides ideas on how to promote conservation agriculture through various extension approaches.

Chapter 14, *Resources*, includes the profiles and contact details of the contributors, a list of resource organizations and websites, manufacturers of conservation agriculture equipment, and publications with further information on this approach.

Throughout the manual, boxes describe how farmers, projects and research institutions have applied conservation agriculture. These cases are drawn from the experiences of the manual's contributors, who represent a wide range of countries and farming conditions from throughout Africa. For further details on the individual experiences, please contact the individuals and organizations listed on page xviii (see addresses in Chapter 14).

Acknowledgements

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Cordaid
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Sincere thanks also to:

- The writeshop participants and staff: see the *List of participants* (page xiv) and *Participants' profiles* (page 238).
- The staff of IIRR's Africa Regional Centre and Acacia Consultants, Cordaid regional and headquarters staff, and I/C Consult.
- The many other, unnamed local people, extension workers, researchers, government and NGO staff, whose knowledge and experiences are reflected in this book.
- The management and staff of the Agricultural Finance Corporation Training Centre, where the writeshop to produce this book was held.

The following FAO programmes and projects contributed funds:

- Piloting Conservation Agriculture to Improve Livelihoods and Food Security for Smallholder Farmers in Kenya.
- Promotion of Conservation Agriculture in Eritrea.
- Conservation Agriculture for Sustainable Agriculture and Rural Development in Southern and Eastern Africa (CA-SARD). This project operates in Kenya and Tanzania and is funded by the German government.

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August studied theology at Stellenbosch University and has been pastoring with the Lesotho Evangelical Church for at least 12 years. He has been training farmers on conservation agriculture since 2002.

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Martin holds an MSc in agricultural engineering and mechanization management. He has for many years been involved in on-farm agricultural development programmes, such as the development of animal-powered implements, training of farmers and staff, and the development of agricultural information materials related to sustainable/conservation agriculture. He now focuses on development, synthesis, and dissemination of information on conservation agriculture, facilitation of on-farm experiments, and group learning and training in conservation agriculture.

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Brian Sims

Independent Consultant on Small Farm Mechanization, Engineering for Development

3 Bourneside, Bedford, MK41 7EG, UK. Tel. +44 1234 271699, 7966 155738, email briangsims@aol.com

Brian has 30 years of experience of smallholder farm mechanization development, especially in Latin America. He has focused on needs assessment, participatory technology development, on-farm testing and evaluation, and communal manufacture and distribution. He is now using his experience to enhance conservation agriculture technology in sub-Saharan Africa.

Kurt Steiner

Independent Consultant in Land Management

Goethestr. 7, 69250 Schonau, Germany. Tel. +49 6228 8457, email kurtsteiner@t-online.de

Kurt has worked on agricultural research in Africa since 1970, first in plant pathology and then plant breeding. Since 1980, he has worked on smallholder farming systems, promoting intercropping in West and East Africa. He has introduced on-farm experimentation in research and development projects in various countries. He has promoted sustainable soil management and conservation tillage throughout the continent. He is co-founder of the African Conservation Tillage Network.

Gelson Tembo

Lecturer/Research Consultant, Department of Agricultural Economics and Extension Education, University of Zambia

PO Box 32379, Lusaka 10101, Zambia. Tel. +260 1 295419, 97 445494, email tembogel@zamnet.zm

Gelson holds a PhD in agricultural economics and statistics from Oklahoma State University and a bachelor of agricultural sciences from the University of Zambia. He has worked for the Dutch-funded Farming Systems Research Team-Western Province project, and as an agricultural economist for the Zambian government. He has conducted research on economics in Zambia and the USA, and has been involved in various regional and international missions, including for the United Nations, NEPAD, FAO and the African Conservation Tillage Network. He is currently part of a team of designing a collaborative masters programme in agricultural and applied economics, involving 16 African universities.

Melesse Temesgen

Researcher, Agricultural Engineer, Ethiopian Agricultural Research Organization

PO Box 954, Nazareth, Ethiopia. Tel. +251 9 253409, +251 2 110566, fax +251 2 110566, email melesse@ethionet.et

Melesse holds a BSc from Alemaya University and an MSc in agricultural engineering from Newcastle University in the UK. He has been researcher in Ethiopia for 16 years and is currently studying for his PhD on conservation tillage in the Netherlands.

Bernard Triomphe

Researcher, Conservation Agriculture and Participatory Approaches, CIRAD

TA 60115, Av Agropolis 34398, Montpellier Cedex 5, France. Tel. +33 4 67615614, fax +33 4 67614415, email bernard.triomphe@cirad.fr, internet www.cirad.fr

Bernard is an agronomist with 20 years' experience in farming and cropping systems research. During the past 15 years he has been combining his interest in participatory approaches with sustainable agriculture, conservation agriculture and cover crops, with direct field experience in Latin America, and more recently in Africa.

Bob Wagner

Editor

PO Box 76406, Nairobi 00580, Kenya. Tel. +254 20 2725297, email bobolink@iconnect.co.ke

Bob earned his MSc in dryland natural resource management with the Institute for Desert Research, University of Beersheba, Israel. As regional coordinator for the Arid Lands Information Network (1993 to 1999), he produced the well-known *Baobab* magazine. Since then, he has worked as a freelance writer and editor for several international organizations, with a focus on documenting sustainable natural resource management projects and practices.

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The following contributed manuscripts but did not attend the writeshop.

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Dominick Ringo

RECODA, Tanzania. Email recodatz@yahoo.co.uk

Johan Rockström

Stockholm Environment Institute, Sweden. Email Johan.Rockstrom@sei.se

Resource organizations and websites

Africa-wide

Africa Conservation Tillage (ACT) Network

Zimbabwe office: No. 9 Balmoral Road, Borrowdale, Harare, Zimbabwe. Tel. +263 4 882107, fax +263 4 885596, email actnetwork@africaonline.co.zw, internet www.act.org.zw. Contact: Martin Bwalya, Coordinator

Kenya office: PO Box 14733 00800, Westlands, Nairobi, Kenya. Email actnairobi@wananchi.com

Promotes and facilitates sharing of information and experiences on conservation farming principles and practices in Africa.

Animal Traction Network for Eastern and Southern Africa (ATNESA)

www.atnesa.org

Access to over 700 documents, many of relevance to conservation agriculture.

CropLife Africa Middle East

www.croplifeafrica.org

Represents manufacturers and distributors of crop protection products (pesticides), seeds and biotechnology products in Africa and the Middle East.

Ecoport

http://ecoport.org

An important database for conservation agriculture practitioners and others.

Green Water Harvesting Network

Contact: Maimbo Malesu, m.malesu@cgiar.org

Eastern and Southern Africa and South Asia.

Regional Land Management Unit (RELMA in ICRAF)

World Agroforestry Centre, ICRAF House, UN Avenue, PO Box 30677, Nairobi 00100, Kenya. Tel. +254 20 524400, 524418, fax +254 20 524401, 524001, email relma@cgiar.org, internet www.relma.org

Supports small-scale farm production management (including conservation agriculture), capacity building, information and documentation, gender, environmental concerns, poverty reduction and efforts to combat HIV/AIDS.

Winrock International

ONFARM, BP E 457, Bamako, Mali. Tel. +223 293880, fax +223 292281, email nhanssens@winrock-mali.org, internet www.winrock.org. Contact: Neils Hanssens, West Africa Coordinator

Conservation Tillage Project (Senegal, Mali and Cote d'Ivoire); On-Farm Agriculture Resources Management (ONFARM) Program

Burkina Faso

Institut de l'environnement et de recherches agricoles (INERA)

Station de Koudougou, BP 10 Koudougou, Burkina Faso. Tel. +226 5044 65 10, 76 59 06 40, email altbarro@yahoo.fr. Contact: Albert Barro

Station de Farako-ba, 01 BP 910, Bobo-Dioulasso 01, Burkina Faso. Tel. +226 70264719, email soul_oueder@hotmail.com, osilamana@yahoo.fr. Contact: Souleymane Ouédraogo

Cameroon

Bimbia Bonadikombo Natural Resource Management Council (BBNRMC)

Tel. +237 935 62 50, email kjerry87@yahoo.com. Contact: Jerome Bekoh Keji

Cotton Development Company (SODECOTON)

PO Box 302, Garoua, Cameroon. Tel. +237 983 3881, email projet.esa@sodecoton.cn. Contact: Abdoulaye Abou Abba, Head officer, Soil Management Division

Soil conservation and water harvesting project monitored by Sodecoton and implementing field activities, training on soil conservation, water harvesting and implementation of conservation agriculture.

Institute of Agricultural Research for Development (IRAD)

PO Box 33, Maroua, Cameroon. Tel. +237 292640, fax +237 292640. Contact: Oin Noé

National research institute which works on conservation agriculture.

Chad

Institut Tchadien de Recherche Agronomique pour le Développement (ITRAD)

Programme Gestion des Ressources Naturelles, ITRAD, BP5400, NDjaména, Chad. Tel. +235 520073, email itrad@intnet.td Contact: Michel Naitormbaide, tel. +235 29 87 66, email naitormbaide_michel@yahoo.fr, damienhh@yahoo.fr.

Ethiopia

Mekelle University

Department of Mechanical Engineering, PO Box 231, Mekelle, Tigray, Ethiopia. Tel. +251 4 41 09 69, 40 75 00, fax +251 4 41 09 69. Contact: Fisseha Meresa, fishmere@yahoo.com, fishmere@mu.edu.et

Adaptation of maresha ploughs.

Ghana

Ministry of Food and Agriculture, Crop Services Directorate

PO Box M 37, Accra, Ghana. Tel. +233 21 665066, email cropserv@ghana.com Contact: J.K. Poku

Conservation agriculture included in work programme.

Guinea

Centre de Recherches Agronomique de Bordo (CRAB)

IRAG, BP 352, Kankan, Guinée. Tel. +224 11 58 42 76, email kourouma_makan@yahoo.fr. Contact: Makan Kourouma

Kenya

Consortium for Scaling up Options for Increased Farm Productivity in Western Kenya (COSOFAP)

PO Box 25199, Kisumu, Kenya. Tel. +254 057 351163/64, fax +254 057 2021234, email icrafksm@cgiar.org, internet www.ugunja.org/cosofap/

Training and provision of starter seeds for cover crops and fertilizer trees.

International Maize and Wheat Improvement Centre (CIMMYT)

PO Box 1041-00621, Village Market, Nairobi Kenya. Tel. +254 20 7224600/05, fax +254 20 7224601, internet www.cimmyt.org. Contact: Fred Kanampiu, fkanampiu@cgiar.org

The project "Conservation agriculture promotion in smallholder agriculture" is implemented in Zimbabwe, Zambia, Malawi and Tanzania. It promotes farmer-to-farmer adoption of proven conservation agriculture technologies and practices.

Kenya Agriculture Research Institute (KARI)

PO Box 57811, Nairobi, Kenya. Tel. +254 2 583301–20, email jwwamuongo@kari.org. Contact: Jane Wamuongo or Joseph Mutua

Operating within the Kenya Conservation Tillage Initiative (KCTI) in Kenya's subtropical and semi-arid environments.

Kenya Network for Draught Animal Technology (KENDAT)

PO Box 2859, 00200, City Square, Nairobi, Kenya. Tel./fax+254 20 6766939, email kendat@africaonline.co.ke, internet www.atnesa.org/kendat/ Contact: Pascal Kaumbutho

Partner (with the Ministry of Agriculture, RELMA, KARI, and the University of Nairobi) in the Kenya Conservation Tillage Initiative. Pilot trials of conservation agriculture, training of farmers and animals, training in handling equipment, field-days, key-stakeholder exposure and media campaigns, and manufacture and marketing of conservation tillage equipment.

Kenya Youth Foundation

PO Box 1894,00200 Nairobi, Kenya. Tel. +254 20 550278, email kyf3@hotmail.com, kenya@youthlink.org. Contact: Bernard Luta

Rural Youth Livelihood Programme in Nyando District, Nyanza Province, involves training of youths on sustainable agriculture, income generation, and support services to the agricultural sector in Nyando.

National School Feeding Council of Kenya

PO Box 49772 00100, Nairobi, Kenya. Tel. +254 20 608960, email nsfck@yahoo.com

Community-based school feeding programme involves training and facilitating schools and communities around them to produce food towards school feeding, implemented in Maragwa, Bondo and Thika districts. Conservation agriculture components introduced in Maragwa District.

Triple W Engineering Ltd.

PO Box 176, Naro Moru 10105, Kenya. Tel. +254 62 62255, fax +254 62 62272. Contact: T.B. Muckle, muckle@africaonline.co.ke

Design and development of hand/animal-drawn conservation agriculture equipment for oxen, donkeys and camels. All equipment can be made by artisans with simple facilities using locally available raw materials. Training of artisans, production of manuals, and design of light equipment suitable for women and young people.

Madagascar

Groupement Semis Direct Madagascar

BP 6039, Ambanidia, Antananarivo, Madagascar. Tel. +261 20 22 27 627, email gsdm@wanadoo.mg, internet www.cirad.mg/fr/scv.php, www.agroecologie.cirad.fr

South Africa

Agricultural Resource Consultants

PO Box 3474, Parklands 2121, South Africa. Tel. +27 486 2254, +27 486 2274, email agrecon@pixie.co.za. Contact: Jim Findlay

Expertise in conservation agriculture throughout Africa, and in registration and legislation of crop protection products.

Department of Agriculture, Western Cape

Tel. +27 21 808 5340, fax +27 21 808 5370, email andrer@elsenburg.com. Contact: Andre Roux

Agricultural research, advisory services and planter modification, especially for farmers who grow wheat and vegetables using conservation agriculture in Western Cape.

Grain Crops Institute

Agricultural Research Council of South Africa (ARC-GCI), Private Bag X 9029, Pietermaritzburg 3200, South Africa. Tel. +27 33 3559410, fax +27 33 3559518, email rmfowler@iafrica.com. Contact: Richard Fowler

Promotion and advice on adoption of conservation agriculture in southern Africa.

Institute for Soil, Climate & Water

Agricultural Research Council of South Africa (ARC-ISCW), Pretoria, Gauteng Province, South Africa. Tel. +27 12 310 2500, fax +27 12 323 1157, email DjBeukes@arc.agric.za or Hjsmith@arc.agric.za. Contact: Danie Beukes or Hendrik Smith

Research and advice on principles and practices of conservation agriculture and the establishment of action research-based conservation agriculture projects, especially among small-scale and emerging farmers.

Small Grains Institute

Agricultural Research Council of South Africa (ARC-SGI), Bethlehem, Free State Province, South Africa. Tel. +27 58 307 3400, fax +27 58 307 3519, email KilianW@arc.agric.za or TolmayJ@arc.agric.za. Contact: Willem Killian or John Tolmay

Research and advice on practice of conservation agriculture, especially by dryland wheat farmers.

No-Till Club of KwaZulu-Natal

PO Box 1052, Howick 3290, South Africa. Tel. +27 33 239 1807, fax +27 33 330 6981, email robin.d@absamail.co.za. Contact: Robin Denny

Farmers in eastern South Africa who meet regularly with one another, universities, researchers, advisers and manufacturers to promote conservation agriculture.

Tanzania

Agricultural Research Institute Uyole

PO Box 400, Mbeya, Tanzania. Tel. +255 25 2510062, 2510363, fax +255 25 2510065, email uyole@ud.co.tz, internet www.drd.mafs.go.tz. Contact: Saidi Mkomwa, Team Leader

Seed supply and advisory services (pests, diseases and management) of cover crops. Training services on conservation agriculture equipment and practices.

Ministry of Agriculture and Food Security

PO Box 4192, Dar-es-Salaam, Tanzania. Tel. +255 22 2862003, +255 744 373395, fax +255 22 2862077, 2862003. Contact: R.M. Shetto, Assistant Director, mshetto@yahoo.co.uk

Technical training services for farmers, farmer-farmer trainers and extension agents in mechanization, including conservation agriculture. Facilitation of mechanization input supply through policy adjustments, credit guarantees for farmers, stockists and manufacturers. Networking of stakeholders and dissemination of information on conservation agriculture and general agricultural mechanization.

Selian Agricultural Research Institute (SARI)

PO Box 6024, Arusha, Tanzania. Tel. +255 27250 3883, fax +255 27 250 3971, mobile +255 748 403921, email wlmariki@sari.co.tz, wlmariki@yahoo.com, internet www.drd.mafs.go.tz/northern.htm. Contact: Ali Bwana or Wilfred Mariki (CA-SARD Facilitator)

Cover crop seed supply and advisory services (pests diseases and management) of cover crops. Training and advice on conservation agriculture equipment and practices; advice on extension methodologies such as farmer field schools and farmer-to-farmer exchange visits.

Uganda

Agricultural Engineering and Applied Technology Research Institute

PO Box 7144, Kampala, Uganda. Tel. +256 41 566161, +256 77 220010, email aeatri@starcom.co.ug

Research and adaptation of conservation agriculture, with focus on conservation agriculture equipment. Training on conservation agriculture for farmers, extensionists and rural artisans. Links with private sector manufacturers and academia.

National Agricultural Advisory Services (NAADS)

NAADS Secretariat, Plot 39A, Lumumba Avenue, PO Box 25235, Kampala, Uganda. Tel. +256 41 345065, +256 77874126, fax +256 41 347843

National Agricultural Research Organization (NARO)

PO Box 295, Entebbe, Uganda. Tel. +256 041 320512

Coordination of research on conservation agriculture, including cover crops, tools and implements, soil and water management and fertility issues.

Zambia

Agriculture Support Programme (ASP)

PO Box 510091, Chipata, Zambia. Tel. +260 62 21284, 21379, email scafe@zamnet.zm, scafeast@zamnet.zm. Contact: R.K. Shula

Conservation Farming Unit, Zambia National Farmers Union

PO Box 30395, Lusaka, Zambia. Tel. +260 1 210112, 264781, 265455, fax +260 1 264781, Contact: Dutch Gibson, email gibcoll@zamnet.zm

The conservation farming unit has been developing and promoting the adoption of the conservation tillage and conservation agriculture technologies with small scale farmers through training; publication of materials to be used, trials and field days.

Golden Valley Agriculture Research Trust

PO Box 50834, Lusaka, Zambia. Tel. +260 1 265455, fax +260 1 264781, email paagaard@zamnet.zm. Contact: Peter Aagaard,

Research trials on conservation farming and conservation agriculture.

Zimbabwe

Agricultural Research and Extension Services (AREX)

PO Box 8117, Causeway, Harare, Zimbabwe. Tel. +263 4 707311/794601, fax. +263 4 730525

Research and extension services on a national scale. Previously known as AGRITEX.

University of Zimbabwe

Dept. of Soil Science, PO Box MP 167, Mount Pleasant, Harare, Zimbabwe. Tel. +263 4 339191, email chuma@africaonline.co.zw, Contact: Edward Chuma

Outside Africa

Alternative Farming Systems Information Center

www.nal.usda.gov/afsic/

Provides access to information on alternative cropping systems, including conservation agriculture.

Confederation of American Associations for the Production of Sustainable Agriculture (CAAPAS)

Email sdrob@idi.com.ar, internet www.caapas.org. Contact: Roberto A. Peiretti, President

Center for Cover Crops Information and Seed Exchange in Africa (CIEPCA)

http://ppathw3.cals.cornell.edu/mba_project/CIEPCA/home.html

Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

TA 74/09, Avenue Agropolis, 34398 Montpellier Cedex 5, France. Email agroeco@cirad.fr, internet http://agroecologie.cirad.fr (French), http://agroecologie.cirad.fr/index.php?rubrique=accueil&langue=en (English). Contact: Christine Casino

For Eastern and Southern Africa: c/o ICRAF, UN Avenue, Gigiri, PO Box 30677-00100, Nairobi, Kenya. Tel. +254 20 722 46 52. Contact: Denis Depommier, denis.depommier@cgiar.org

For West Africa: 5, Av. Kennedy, 01 BP 596, Ouagadougou, Burkina Faso. Tel. +226 50 30 70 70. Contact: Jacques Pages, Jacques.pages@cirad.fr

Development of conservation agriculture-based cropping systems and rotations. Environmental and socioeconomic impact of conservation agriculture systems. Participatory innovation development. Case studies on conservation agriculture adaptation and adoption. Training of researchers and extension officers. Partnerships with donors, national institutions and private sector to develop and implement pilot conservation agriculture projects and programmes.

Cornell University-CIIFAD

http://mulch.mannlib.cornell.edu/CAwebsite/

Useful information and resources related to conservation agriculture.

Cover Crops International Clearinghouse (CIDICCO)

http://cidicco.hn/newcidiccoenglish/

CropLife International

143 Avenue Louise, B-1050 Brussels, Belgium. Tel. +32 2 542 04 10, fax +32 2 542 04 19, email croplife@croplife.org, internet www.croplife.org

Global federation representing the plant science industry. It represents a network of regional and national associations in over 90 countries and is led by companies such as BASF, Bayer CropScience, Dow AgroSciences, DuPont, FMC, Monsanto, Sumitomo and Syngenta.

European Conservation Agriculture Federation (ECAF)

CIFA Alameda del Obispo, Avda Menéndez Pidal, s/n, Apdo 3092, 14080 Córdoba, Spain. Tel./fax +34 957 760797, email conservation.agriculture@ecaf.org, internet www.ecaf.org

Federação Brasileira de Plantio Direto na Palha

Rua 7 de Setembro, 800 - sala – 201, CEP 84.010-350, Ponta Grossa, Paraná, Brazil. Tel./fax +55 42 223 9107, email febrapdp@uol.com.br, internet www.febrapdp.org.br

Food and Agriculture Organization of the United Nations (FAO)

Farm Power and Equipment Group, Conservation Agriculture, Viale Delle Terme di Caracalla, Rome 00100, Italy. Tel. +39 06 57053334, 57052612, email agst-mail@fao.org, internet www.fao.org/ag/ags/subjects/en/farmpower, www.fao.org/ag/ags/AGSE/Main.htm, *Intensifying crop production with conservation agriculture, www.fao.org/ag/ags/AGSE/agse_e/general/CONT1.htm*

Land and water development division, www.fao.org/ag/agl/agll/prtcons.stm

Supports and promotes conservation agriculture worldwide. FAO's "Telefood programme" provides small grants to farmers groups that could be used for cover crop seeds or implements for conservation agriculture. For more information, contact your FAO country office.

German Agency for Technical Cooperation (GTZ)

PO Box 5180, 65726 Eschborn, Germany. Tel. +49 6196 790, internet, www.gtz.de/conservation-tillage

Agriculture sector support and food security programmes.

Land Resources Management, World Bank

http://lnweb18.worldbank.org/ESSD/ardext.nsf/11ByDocName/TopicsLandResourcesManagement

LEISA

PO Box 64, 3830 AB Leusden, Netherlands. Email ileia@ileia.nl, website www.leisa.info

Magazine on low external input and sustainable agriculture

LEXSYS: Legume Expert SYStem

www.iita.org/research/lexsys.htm.

Cover crop database has information on legumes, agroecological zones, plant characteristics, etc.

World Congress on Conservation Agriculture

First World Congress (Madrid, 2001): www.ecaf.org/Congress/Latest_news.htm

Second World Congress (Iguaçu, Brazil, 2003): www.febrapdp.org.br/event.htm

Third World Congress (Nairobi, 2005): www.act.org.zw/congress/index.htm

Major international conference on conservation agriculture, held every 2 years. Papers available online.

World Overview of Conservation Approaches and Technologies (WOCAT)

www.wocat.net, email wocat@giub.unibe.ch

Database on soil and water conservation, including examples of conservation agriculture.

Equipment manufacturers

Many of these manufacturers also provide training and advice on conservation agriculture equipment

Brazil

See also www.fao.org/ag/AGS/agse/planters.htm

Fitarelli Máquinas Agrícolas Ltda.

Rua Etelvino Pes. 30, Bairro Industrial, Aratiba, RS, CEP 9970-000, Brazil. Tel./fax +55 54 376 1198, email fitarelli@fitarelli.com.br, internet www.fitarelli.com.br

IADEL Máquinas e Implementos Ltda

Rua Dona Ana 883, Centro Dona Emma, Santa Catarina, CEP 89155-000, Brazil. Fax +55 47 364 042

Indústria Knapik

Rua Pref. Alfredo Metzler, 480, Bairro Santa Rosa CEP 89400-000, Brazil. Tel. +55 42 522 1819, fax 42 522 2789, email knapik@knapik.com.br, internet www.knapik.com.br

Jahnel Indústria e Comércio de Implementos Agrícolas Ltda.

Rua Benjamin Constant 636, Cuna Porã, Santa Catarina, CEP 89890-000, Brazil. Tel. +55 49 646 0587, email jahnel@cpnet.com.br

Máquinas Agrícolas Jacto SA

Rua Dr. Luiz Miranda 1650, PO Box 35, 17580-000 Pompéia, SP, Brazil. Tel. +55 14 3405 2100, fax + 55 14 3452 1306, email jacto@jacto.com.br, internet www.jacto.com.br

Knapsack sprayers adapted to hand-pulled machines.

Triton Máquinas Agrícolas Ltda

Rua Dois Irmãos 263, Centro, Caixa Postal 31, CEP 89.609-000, Luzerna, Santa Catarina, Brazil. Tel./fax +55 49 523 1144, email triton@tritonmaquinas.com.br, internet www.tritonmaquinas.com.br

Kenya

Lolli

PO Box 63514-00619, Outer Ring Road, next to Hardi, Nairobi, Kenya. Tel +254 20 860782, 802060, fax +254 20 860260

Sametract

Bambur Road, Industrial Area, Nairobi. Tel. +254 20 533081, 533446, 537019, fax +254 20 551475

Techno Plast

Nairobi. Tel. +254 20 551771

Triple W Engineering Ltd

PO Box 176, Naro Moru 10105, Kenya. Tel. +254 62 62255, fax +254 62 62272. Contact: T.B. Muckle, muckle@africaonline.co.ke

See description under *Resource organizations and websites*

South Africa

Afritrac Ltd

South Africa. Tel. +27 11 918 5983 fax +27 11 918 0310, email mike@afritrac.co.za, internet www.afritrac.co.za. Contact: Mike McMaster

Manufacturers and distributors of “Mealie Brand” animal and tractor-drawn planters and other equipment suited for use by small scale conservation agriculture farmers.

Northmec/CSE

PO Box 851, Isando 1600, South Africa. Tel. +27 11 974 2501, 82 896 5236, fax +27 11 392 2889, email stefs@northmec.co.za, internet www.cse.co.za. Contact: Steph Strydom

South African representatives of Case, Baldan, Fitarelli, Jacto and other locally manufactured and imported agricultural machinery for conservation agriculture farmers, large and small.

Tanzania

Nandra Engineering Works

Nguvu Kazi Area, Sukari Road, PO Box 304, Moshi, Tanzania. Tel. +255 27 51542, fax +255 27 50575, email nandra@eoltz.com. Contact: Frank Alfred Lesiriam (Managing Director)

Animal-drawn rippers and subsoilers, spare parts for rippers and tractors, piloting the manufacture of hand jab-planters and no-tillage equipment. Also maize mills, hullers, grain storage tanks, cookers, water tanks.

SEAZ Agricultural Equipment Ltd

PO Box 2607, Mbeya, Tanzania. Tel. +255 744 399599, fax +255 25 2502121, email seaz@yahoo.co.uk. Contact: Vasimbile Sinde

Uganda

Soroti Agricultural Implements and Machinery Manufacturing Company (SAIMMCO)

Cementry Road, Soroti, Uganda. Tel. +256 45 61361, fax +256 45 61361, email saimmco.soroti@alam-group.com, internet www.alam-group.com/saimmco.html

Manufactures tools and implements for agricultural production and processing. Particularly strong in the manufacture of draft animal power implements. Participated in the field introduction of conservation agriculture in Uganda, and makes implements such as including rippers, subsoilers, no-till planter and manually operated sprayers.

Zambia

Zamwipe

c/o Fedex, Nangwenya Road, Rhodes Park, Lusaka, Zambia, or PO Box 44, Fringilla, Lusaka, Zambia. Tel. +260 1 264281, +260 1 230112, email zamwipe@zamnet.zm, gibcoll@zamnet.zm. Contact: Dutch Gibson

Zimbabwe

Mealie Brand

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Equipment development, manufacture and supply for conservation agriculture. Manufactures and supplies rippers and planters for minimum and zero tillage. Product range covers tractor-mounted, animal-drawn and hand-operated equipment.

Resource materials

The following websites have a wide range of information and downloadable documents on conservation agriculture. See the *Organizations and websites* section above for more information:

ACT, www.act.org.zw

ATNESA, www.atnesa.org

CIRAD, http://agroecologie.cirad.fr

FAO, www.fao.org/ag/ags/AGSE/Main.htm

GTZ, www.gtz.de/conservation-tillage

Relma in ICRAF, www.relma.org

CD-ROMs

CropLife International. 2004. *Conservation technologies for sustainable agriculture.* CD-ROM. CropLife International, Brussels. Obtainable from Keith Jones, keith@croplife.org

Presentations from a workshop at the 2004 International Weed Science Congress in South Africa. Presentations from FAO, the World Bank, the Kenya Agricultural Research Institute, the International Crops Research Institute for the Semi-Arid Tropics; Sasakawa Global 2000, as well as Bayer CropScience, Monsanto, Dow AgroSciences, and several others.

FAO. 2004. *Conservation of natural resources for sustainable agriculture: training modules.* Land and Water Digital Media Series no. 27, FAO, Rome.

CD-ROM with training materials. Introduction to conservation agriculture; modules on soil, agronomy, mechanization, pest control, economics, etc.). Useful for training.

Publications

African Conservation Tillage Network. *Information series.* www.act.org.zw/infoseries.html

Series covers various aspects of conservation agriculture.

Ashburner, J., T. Friedrich and J. Benites. 2002. Opportunities and constraints for conservation agriculture in Africa. *LEISA* 18(3):13–14.

Bishop-Sambrook, C., J. Kienzle, W. Mariki, M. Owenya and F. Ribeiro. 2004. *Conservation agriculture as a labour saving practice for vulnerable households.* Study report. IFAD and FAO, Rome, Italy. 80 pp. www.fao.org/ag/ags/programmes/en/enhance/FAO_IFAD_CA_Tanzania.pdf

Study of reduced tillage practices and cover crops for households under labour stress in Babati and Karatu Districts in Northern Tanzania.

Buckles, D. , A. Etèka, O. Osiname, M. Galiba and N. Galiano (eds). 1998. *Cover crops in West Africa: Contributing to sustainable agriculture/Plantes de couverture en Afrique de l'Ouest: Une contribution à l'agriculture durable.* International Development Research Centre, International Institute of Tropical Agriculture and Sasakawa Global 2000. http://web.idrc.ca/en/ev-9393-201-1-DO_TOPIC.html

Calegari, A., J. Ashburner, and R. Fowler. 2005. *Conservation agriculture in Africa.* ISBN 9988-627-04-1. FAO, Rome, Italy. 98p. (in press)

CIDICCO, IITA, and Judson College. 2002. *Food and feed from mucuna: Current uses and the way forward. Proceedings of an international workshop.* CIDICCO (International Cover Crops Clearinghouse), CIEPCA (Center for Information and Seed Exchange in Africa)-IITA (International Institute of Tropical Agriculture), and World Hunger Research

Center, Judson College. www.cidicco.hn/newcidiccoenglish/food_and_feed_from_mucuna.htm

Conservation Farming Unit. 1997. *Conservation farming handbook for small holders in Regions I & II*. Conservation Farming Unit, FAO, Lusaka. www.fao.org/ag/AGS/AGSE/agse_e/3ero/cases1c.htm

Critchley, W., K. Siegert and C. Chapman. 1991. *Water harvesting techniques: A manual for the design and construction of water harvesting schemes for plant production*. FAO, Rome. www.fao.org/docrep/U3160E/u3160e07.htm

CropLife International. 2005 (forthcoming). *Conservation technologies and the plant science industry: Managing natural resources sustainably.* CropLife International, Brussels.

Case studies from around the world showing how the plant science industry is increasing its emphasis on conservation technologies. Draft at www.croplife.org/conservationtech

Dobson, H., G. Matthews, T. Wiles, and P. Baleguel Nkot. 2004. *Pesticide safety and application equipment, sprayer operator pocket book*. FAO, Rome.

Training and reference pocket book, available in English, French and Spanish.

Dobson, H., G. Matthews, T. Wiles, and P. Baleguel Nkot. 2004. *Hints on pesticide use, Hints on spraying, calibration of LK sprayers*. Set of three posters. Yaounde Inititative, FAO, Rome.

Posters with pictograms and simple text to assist in sprayer training. Useful for sprayer training and as a reminder for participants.

Ekboir, J., K. Boa, and A.A. Dankyi. 2002. Impact of no-till technologies in Ghana. *Economic Program Paper* 02-01, CIMMYT, Mexico DF.

Case study of conservation agriculture in Ghana.

Erenstein, O. 2003. Smallholder conservation farming in the tropics and sub-tropics: A guide to the development and dissemination of mulching with crop residues and cover crops. *Agriculture, Ecosystems and Environment* 100:17–37.

Good academic synthesis of conservation agriculture.

FAO. 2000. Manual on integrated soil management and conservation practices. *FAO Land and Water Bulletin* 8, FAO, Rome.

FAO. 2001. Conservation agriculture: Case studies in Latin America and Africa. *FAO Soils Bulletin* 78. ISBN 92-5-104625-5. FAO, Rome. 69p.

FAO. 2004. *Pesticide safety and application equipment: Sprayer operator pocket book*. Agricultural and Food Engineering Technology Service, FAO, Rome.

Groupement Semis Direct Madagascar. Undated. *Le semis direct sur couverture végétale permanente: Enjeux et potential pour une agriculture durable à Madagascar*. Groupement Semis Direct Madagascar, Antananarivo.

Haggblade, S. and G.. Tembo. 2003. Conservation farming in Zambia. IFPRI and MSU, *EPTD discussion paper* 108, Washington DC.

Case study of conservation agriculture in Zambia.

Hercilio de Freitas, V. 2000. Soil management and conservation for small farms: Strategies and methods of introduction, technologies and equipment. Experiences from the State of Santa Catarina, Brazil. *FAO Soils Bulletin* 77, FAO, Rome.

Jonsson, L.-O., E. Mawenya and J. Rockström. Conservation tillage I: Management practices for animal-drawn systems in Tanzania, *Working Paper* 16. RELMA, 2003.

Jonsson, L-O. Conservation tillage II: Handling and care of drought animals under Tanzanian conditions, *Working Paper* 17. RELMA, 2003.

Landers, J. 2001. Zero tillage development in tropical Brazil: The story of a successful NGO activity. *FAO Agricultural Services Bulletin* 147. ISBN 92-5-104672-7. FAO, Rome. 144p.

Liniger, H.P., and W. Critchley (forthcoming 2005). Local responses to global land degradation: Exchange of knowledge for Sustainable Land Management Centre for

Development and Environment (CDE), United Nations Environment Programme (UNEP).

Global overview book with over 30 case studies.

Ministry of Agriculture and Cooperatives. 2000. *Tanzania soil fertility initiative*. Ministry of Agriculture and Cooperatives, Tanzania.

Discussion on soil fertility and related policy issues.

Mutunga, K., and W. Critchley. 2001. *Farmers' initiatives in land husbandry*. Regional Land Management Unit (RELMA), Nairobi.

Farmers' innovations in sustainable agriculture.

Naudin, K., and B. Oumarou. 2002–04. *Raports de synthese campagne*. ESA/SODECOTON, Garoua Cameroun. Annual report of activities.

Pieri, C., G. Evers, J. Landers, P. O'Connell, and E. Terry. 2002. No-till farming for sustainable rural development. *Agriculture & Rural Development Paper*, IBRD, Washington, DC. 65p.

Pieri, C., G. Evers, J. Landers, P. O'Connell, and E. Terry. 2002. A road map from conventional to no-till farming. *Agriculture & Rural Development Paper*, IBRD, Washington, DC. 20p.

Seguy, L., S. Bouzinac, and A.C. Maronezzi. 2001. *Systèmes de culture et dynamique de la matière organique*. CIRAD-CA, Agronorte Pesquisas, Groupe Maeda, ONG TAFA/FOFIFA/ANAE. http://agroecologie.cirad.fr/pdf/dosscv.pdf

Shaxson, F. 1999. New concepts and approaches to land management in the tropics with emphasis on steeplands. *FAO Soils Bulletin* 75. ISBN 92-5-104318-1. FAO, Rome. 125p.

Shaxson, F. and R. Barber. 2003. Optimizing soil moisture for plant production: The significance of soil porosity. *FAO Soils Bulletin* 79, FAO, Rome.

Thomas, D. 1997. *Soil and water conservation manual for Kenya*. Ministry of Agriculture, Nairobi.

Technical manual on soil and water conservation.

Van der Merwe, G.M.E., R.O. Barnard, and D.J. Pretorius. 2004. *Overview of conservation approaches and technologies in South Africa*. Department of Agriculture and Agricultural Research Council, Pretoria.

ZNFU. 2003. *Conservation farming in Zambia*. ISBN 9982-52-005-9. ZNFU, Lusaka, Zambia. 46p.

ZNFU CFU. 2002. *Defeating weeds with the Zamwipe*. Zambia National Farmers' Union, Conservation Farming Unit, Lusaka.

How to use the Zamwipe weed wiper to control weeds.

Videos

Critchley, W. 1991. *Looking after our land*. International Institute for Environment and Development, Oxford and London. Book and video comparing soil and water conservation in West and East Africa.

Monsanto Central Africa Inc. *Growing together: Conservation tillage in Africa*. Video on how partnerships are providing solutions needed to empower small-scale farmer.

1

What is conservation agriculture?

Maria Erro used to struggle to grow enough food on her half-hectare plot in Karatu district, in northern Tanzania. She had no oxen to plough her soil. She had to borrow seed from kind-hearted relatives and her neighbours in Rhotia village. After her husband died, she could not do all the work – planting, hoeing, weeding – by herself.

She managed to grow enough maize and beans to feed her six children and four grandchildren for only four months of the year. The family had to make do with only two meals a day. Sometimes there was only enough food for a single meal. She was late paying school fees. When her children fell ill, she couldn't afford medicine.

It was a tough life.

Maria's life changed dramatically in October 2002, when she learned how to use an approach called conservation agriculture. Instead of hoeing the soil, she left the dried stalks and leaves from the previous crop on the surface. She learned how to plant maize seed directly through this mulch, using an implement called a jab-planter.

Between the maize rows, she planted lablab – a legume that spreads quickly, covers the soil with a dense, leafy mat, and produces an edible seed. The lablab smothered the weeds, freeing her of the backbreaking task of weeding the plot. The lablab also fixed nitrogen in the soil, so her maize crop benefited. She harvested six bags of maize, instead of the two or three she had got in previous years.

She planted beans during the short rains, and for the first time, she was able to harvest enough for her family to eat. There was enough left over for the next season's seed, and some to sell as well.

Thanks to conservation agriculture, Maria has to do less work, her yields have gone up, and she has become an independent, confident member of the community.

"It was a miracle", she says, "I will practise conservation agriculture forever."

CONSERVATION AGRICULTURE aims to produce high crop yields while reducing production costs, maintaining the soil fertility and conserving water. It is a way to achieve sustainable agriculture and improve livelihoods.

Conservation agriculture has three basic principles:

- **Disturb the soil as little as possible**
- **Keep the soil covered as much as possible**
- **Mix and rotate crops.**

We will look at each of these in turn.

Disturb the soil as little as possible

In **conventional farming**, farmers plough and hoe to improve the soil structure and control weeds. But in the long term, they actually destroy the soil structure and contribute to declining soil fertility.

In **conservation agriculture**, tillage is reduced to ripping planting lines or making holes for planting with a hoe. The ideal is to plant direct into the soil, without ploughing.

The three principles of conservation agriculture

- *Disturb the soil as little as possible.*
- *Keep the soil covered as much as possible.*
- *Mix and rotate crops.*

Keep the soil covered as much as possible

In **conventional farming**, farmers remove or burn the crop residues or mix them into the soil with a plough or hoe. The soil is left bare, so it is easily washed away by rain, or is blown away by the wind.

In **conservation agriculture**, crop residues left on the field, mulch and special cover crops protect the soil from erosion and limit weed growth throughout the year.

Mix and rotate crops

In **conventional farming**, the same crop is sometimes planted each season. That allows certain pests, diseases and weeds to survive and multiply, resulting in lower yields.

In **conservation agriculture**, this is minimized by planting the right mix of crops in the same field, and rotating crops from season to season. This also helps to maintain soil fertility.

To gain the full benefit of conservation agriculture, all three principles have to be applied at the same time. This is the case with the ideal practice: direct planting through a soil cover – what Maria Erro does (page 2).

This ideal is not possible everywhere. But farmers should try to go into that direction as far as possible.

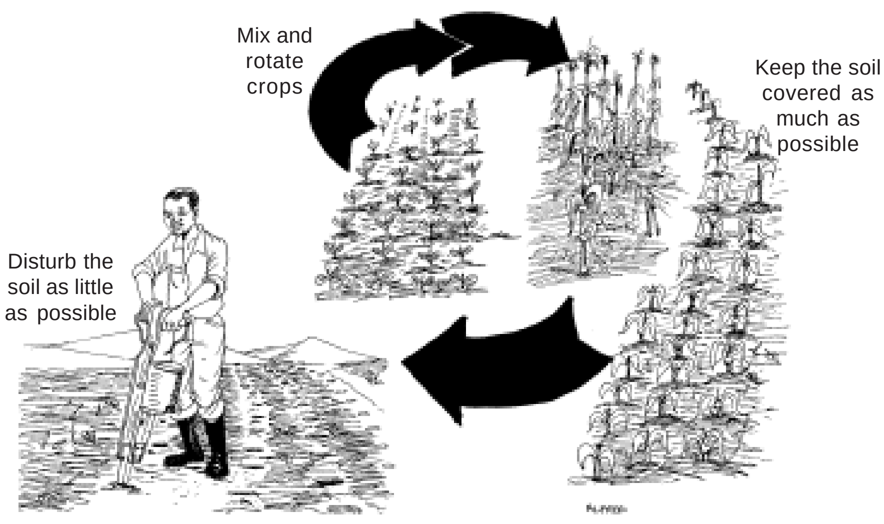
Like a cooking pot

The three principles of conservation agriculture are like a three-legged cooking pot: it works best if it has all three legs!

Because each farmer faces a different situation, this may mean different things. Some farmers may find it best to introduce a cover crop first. Others might gain by reducing their tillage to "ripping" (using a narrow plough-like implement that creates a small furrow without turning the soil over) or "pitting" (digging planting holes with a hoe) as a first step towards conservation agriculture. In a second step, these farmers can leave crop residues in the field and start planting cover crops.

Practising conservation agriculture can be a challenge. It means a different way of farming. Farmers may be reluctant to make the switch, and they need to learn new skills. It also means a new mindset: for example, they have to learn that a "clean" field is not the best.

But the benefits are real. Farmers quickly find that by applying these principles, they can save labour, reduce costs, and improve their soil's fertility and ability to hold water. That means higher crop yields. They can use the time they have saved to expand the area they cultivate, or even to start other enterprises that earn more money. Conservation agriculture may at last give them a chance to break out of the vicious circle that binds them in poverty.



The three principles of conservation agriculture

Why start using conservation agriculture?

You might start using conservation agriculture for many reasons.

To improve your yields

Conservation agriculture produces higher yields

Unlike the rest of the developing world, crop production in Africa is not keeping pace with population growth. Yields in many areas are actually falling. A major cause of this is declining soil fertility, often caused by the way of farming. The rising population has forced farmers to abandon traditional practices that left the land fallow for several years, and to cultivate ever-smaller plots. Intensive tilling and hoeing year after year can produce a hardpan in the soil. That restricts root growth and stunts plants. Rainwater pounds the bare soil, forming a surface crust that the water cannot penetrate. It runs off, taking the valuable topsoil with it. Erosion in some places is so severe that there is little soil left.

To get a good yield, farmers often apply more and more fertilizer. With less moisture in the soil, plants are more vulnerable to drought. They start to wilt after a few days without rain.

Conservation agriculture enables farmers to reverse this trend. It prevents hardpans from forming, protects the soil, increases soil moisture, and restores soil fertility, so stabilizing yields and improving production over the long term.

To reduce your production costs

Conservation agriculture reduces costs

Tilling the soil is expensive. Fuel and fertilizer prices and labour costs rise continuously, while market prices of farm products have fallen. Many farmers cannot recoup their production costs by selling what they produce, so they end up making a loss.

Conservation agriculture helps these farmers cut costs while increasing their yields.

To overcome shortages of labour and farm power

Many farm households suffer from a severe lack of labour and farm power. Hunger and malnutrition combine to make people weak, unable to work hard, and vulnerable to disease. Young people are moving out, and HIV/AIDS and malaria create a severe labour shortage. Many draught animals have died because of disease, or their owners have had to sell them to pay for medical treatment and burials. A lack of farm power forces farmers to look for other ways to farm.

Conservation agriculture enables these people to grow more food with less work. It offers them a real chance to improve their lives.

Conservation agriculture takes less work

How conservation agriculture works in different types of farms

The three principles of conservation agriculture (*disturb the soil as little as possible*, *keep the soil covered as much as possible*, and *mix and rotate crops*) can be applied in a wide range of conditions. How farmers put them into practice will vary from place to place, depending on many factors.

Conservation agriculture can be practised on different types of farms, with different combinations of crops and sources of power. Here are some examples.

Hoe farming

Many African farmers cultivate by hand, using hoes. These farmers can practise conservation agriculture by digging small planting holes in lines, at carefully measured distances, leaving the rest of the soil unturned. If hoeing in previous years has produced a hardpan, the holes must be deep enough to break through this hard layer.

The farmers can put compost or manure in the holes to raise the soil fertility and the water-holding capacity, then sow maize or beans.

They can sow cover crops between the planting holes to protect the soil from erosion and to suppress weeds. They can pull weeds out by hand, or slash them with a machete.

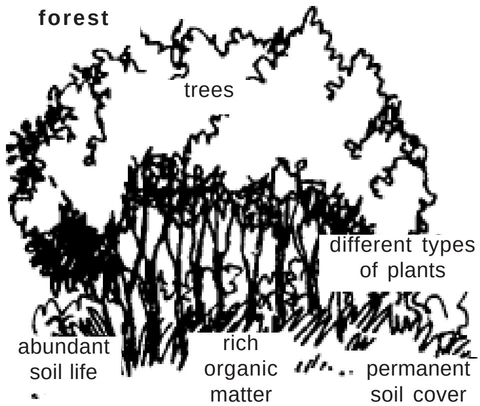
The next season, they can plant different crops in the same holes. It is not necessary to dig through the hardpan again, because the first season's crop roots will have penetrated deep into the soil and will help water to seep into the soil. So it is necessary to do hard work of digging the pits only once.

Farming in harmony with nature

Conservation agriculture means farming in harmony with nature.

In a forest, the ground is covered with a permanent layer of litter. The soil is rich in organic matter and has many earthworms, beetles and other tiny animals. There is a wide range of different plants, all growing together. Worms, beetles and other tiny animals mix the soil and recycle nutrients.

The same is true of conservation agriculture.



Smallholder farming with draught animals

Farmers who own (or can hire) oxen or donkeys to pull implements can use a different set of conservation agriculture practices.

They can use a subsoiler to break up the hardpan (if there is one). This is usually necessary only in the first year.

If there is no hardpan, the farmers can use an animal-drawn ripper to open up a narrow furrow for planting seed. The soil between these furrows is left alone. It is possible to use rippers and subsoilers that sow seeds and apply fertilizer at the same time, so saving time and work.

Before planting the crop, the farmers can use a hoe or knife-roller to kill weeds, or apply herbicide using a sprayer or wiper. They sow a cover crop with the maize crop to smother weeds and to reduce evaporation from the soil surface. When harvesting the main crop, the farmers leave the residues and cover crop on the field. That protects the soil from the sun and rain, and further controls weeds.

Mechanized farms

Farmers with tractors can use conservation agriculture too. They can replace their mouldboard ploughs, disks and harrows with rippers, subsoilers and direct-drill planters.

At the outset of the season, larger scale farmers use a knife-roller, sometimes in combination with herbicides, to kill the previous season's cover crop and weeds. In the first season of conservation agriculture, they may need to use a subsoiler to break up the ploughpan. They then use a direct-drill planter to sow seeds. A post-emergence herbicide kills any weeds that come up after planting and before the crop canopy can cover the surface.

After harvest, the crop residues stay in the field. The farmer then sows a cover crop to protect the soil until the next planting season.

Many farmers are able to use a combination of implements and different types of power. For example, a hoe farmer may be able to hire a neighbour with a tractor to subsoil her field. She can then choose among various options so she gets the full benefits of conservation agriculture (see the table on page 9).

Challenges to agriculture in Africa…

…and how conservation agriculture can help overcome them

African agriculture faces three major challenges:

Lack of labour – or rather, lack of **farm power** Most African farmers cultivate their fields by hand. Unlike farmers in many other parts of the world, they do not have machines and equipment to help them. Many young people do not want to become farmers. They move to town in search of education and less laborious work. The AIDS pandemic and malaria make this labour shortage even more acute.

How conservation agriculture can help Conservation agriculture eliminates ploughing and controls weeds better than conventional farming, so it needs less labour. Farming may become more attractive to young people, and more profitable too.

Low yields African grain yields are low – perhaps no more than 1 ton/ha. That is less than half what is needed to achieve the Millennium Development Goal of halving the number of malnourished and hungry people by 2015.

How conservation agriculture can help It can significantly raise yields and can provide many different types of food and feed.

Environmental degradation Many older farmers remember when their villages were surrounded by trees, and their soils were rich with humus. Today, slopes are bare and rivers run brown with eroded soil.

How conservation agriculture can help Conservation agriculture protects the land and feeds the soil. It can halt and even reverse land degradation. That means cleaner rivers and less sediment to clog reservoirs and irrigation channels.

Different options for conservation agriculture

Options	Land preparation	Planting of main crop	Planting of cover crop	Weeding	Initial investment cost	Remarks
Simple hand tools (smallholder and vulnerable households)	Hoe	Stick , jab-planter	Hoe, stick or jab-planter	Hand hoe for shallow weeding	Low	Most farmers have hoes and sticks. Jab planters may not be readily available. Slashing and spreading of crop and cover crop residues in year 2 and beyond, followed by planting directly through residues. Complete weeding may not be required; roguing and shallow weeding instead.
Simple hand tools with herbicides (smallholders)	Hoe to make planting pits	Hoe or stick	Hoe, stick or jab-planter	Weed wiper	Low	Needs training to use weed wiper. Planting of cover crops is possible after applying herbicide. Weed wiper is commercially available.
Animal driven reduced tillage (small- to medium-scale farmers)	Ripper or subsoiler (rented), and herbicide application	Hoe, stick or jab planter	Hoe, stick or jab-planter	Shallow weeding (scraping), herbicides	Low to medium cost, depending on implements and whether hired or owned by individual or group	Good animal health and husbandry practices needed. Subsoiling may be done once every 5 years. Herbicide application depends on weeds. Cover crops might replace other weed control after few years.
Animal driven no-tillage (small- to medium-scale farmers)	Herbicide application, knife-roller	No-till planter	Hoe, stick or jab-planter	Hand pulling (roguing), knife-roller, herbicides	High cost of no-till planter	Lower power requirement than for ploughing. Knife-roller is needed only for well-established soil cover. Knife-roller used in year 2 and beyond to crush residues before planting. Knife-rollers may not be readily available.
Tractor-operated implements (large-scale farmers)	Subsoiler Herbicide (boom sprayer) before planting	No-till tractor -mounted direct seeder	Tractor -mounted direct seeder	Hoe for shallow weeding, knife-roller, herbicides	Very high initial investment	Subsoiling done every 4–5 years, depending on soil. Small-scale farmers can hire implements rather than buying them.

Different situations

Conservation agriculture can be used in all parts of Africa, except where it is too dry to grow crops. It can be applied in various climatic zones and under different conditions, though it may look very different from place to place.

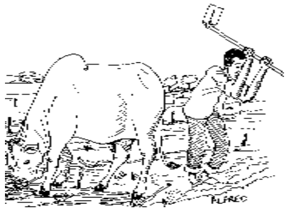
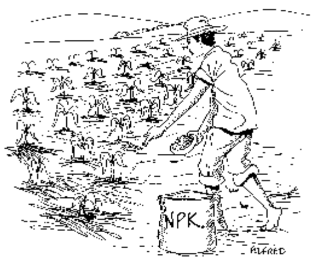
- In **semi-arid** lands, conservation agriculture retains water in the soil, keeps the soil temperature even, and protects the land from erosion during heavy downpours. Maintaining soil moisture is the main challenge in these areas, so rainwater harvesting methods can be very useful to increase the amount of water available for crops. Crops may be planted with wide spacing, and there may not be enough moisture to grow a cover crop, so farmers may have to rely on mulch or residue to keep the soil covered. Livestock are important in these areas. Farmers may have to restrict grazing on their fields to keep as much soil cover as possible.
- In **sub-humid and humid** areas, weeds and erosion are likely to be more of a problem. Crops are planted at closer spacings, and cover crops help suppress weeds and protect the soil.
- On **slopes**, conservation agriculture can be used in association with terraces, contour grass strips and other erosion-control methods. Terraces already exist in many places; conservation agriculture can be used on them.
- Where **labour is scarce**, perhaps because of HIV/AIDS, conservation agriculture enables farmers to produce good yields with less labour.
- In **densely populated areas**, conservation agriculture increases yields on small plots of land under intensive cultivation.
- On **good soils**, conservation agriculture keeps the soil healthy and maintains yields. On **poor soils**, it is a good way to rebuild soil fertility and enhance water-holding capacity, so increasing production.

Conventional vs conservation

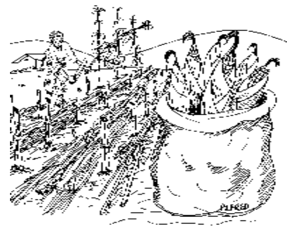
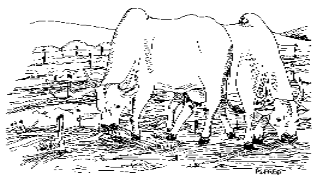
Both conventional farming and conservation agriculture include a very wide range of operations: field preparation, planting, fertilization, weeding, harvesting, and field operations after the harvest. The table on the next two pages compares practices common throughout Africa with conservation agriculture. There are, of course, many variations in both "conventional" and "conservation" approaches, so the descriptions are simplified and may not depict what happens in a particular area.

Conservation agriculture means less work because it is not necessary to plough the soil and weed as many times. It suppresses weeds and reduces erosion. It improves the soil structure, ability to retain water, organic matter content and fertility. All these lead to higher and more stable yields.

Conventional farming vs conservation agriculture

Operation	Conventional farming	Conservation agriculture
Field preparation	 Graze animals on the stover of the previous crop, or burn it. Plough or hoe the soil to turn it over and bury organic matter. Harrow or disk to prepare a seed bed.	 Lay the stover on the soil surface. Control grazing to prevent animals from eating it all. Open a narrow planting furrow with a ripper, without turning the soil. Or use a hoe to make small planting holes, soon after harvest.
Planting	 After rains begin, plough to open a furrow for sowing seed, then cover the seed with soil.	 Planting before the rains is possible in some areas. Sow seed directly into the ripped lines or planting holes, or drill seeds into undisturbed soil using direct planters. Sow a cover crop a few weeks later in the growing season to protect the soil.
Fertilization	 Apply basal dressing before or at planting. Apply top dressing 3–4 weeks after germination. Soil fertility management relies mainly on inorganic fertilizer.	 Apply basal fertilizer, manure and compost long before the rains. Soil fertility management relies on compost, manure and green manure, supplemented by inorganic fertilizers. Legumes are a major source of

Conventional farming vs conservation agriculture (continued)

Operation	Conventional farming		Conservation agriculture	
Weeding		Weed 3–4 times by hand or using hoes or cultivators This causes a lot of soil disturbance. Or use herbicides to control weeds.		Cover crops and mulch prevent most weed growth. Control weeds while disturbing the soil as little as possible. Use slashers to cut weeds, or use herbicides. Remove weeds when they are small to prevent seeding and save work.
Harvesting and afterwards		Harvest by hand or using equipment. Remove the straw and stover from the field and use as livestock feed. Burn residue that		Harvest by hand or using equipment. Leave straw and stover in the field to cover the soil and increase organic matter. Leave cover crops growing as additional cover.
Livestock		Allow livestock onto the field to gaze on stubble. Animals provide manure, but trample and compact the soil and remove the cover, leaving the soil open to erosion.		Control grazing by livestock. Fence land to keep them out completely: graze them elsewhere, cut some of the cover crop to use as feed, or feed them with fodder grown in separate plots. If it is not possible to keep animals out of the field, restrict grazing to keep as much soil cover as possible.

Effects of conventional farming and conservation agriculture

In African conditions, conventional farming can produce high yields in the first few years after a virgin soil is ploughed. But then – all too often – the problems begin. The table on the next few pages summarizes some of these problems, and shows how conservation agriculture avoids them. Again, the descriptions are simplified: not all conventional farming suffers from the problems listed in the table.

Improving food security

Conservation agriculture creates a win–win situation with numerous advantages. Here are two particular ways it can improve food security:

Conserving soil moisture Maintaining cover on the soil protects it from heavy rain and conserves the moisture during dry spells. It reduces the soil temperature under the intense sun. Combining conservation agriculture with measures to prevent erosion and harvest water can raise yields significantly.

Increasing crop diversity The crop rotations and intercropping in conservation agriculture enables farmers to broaden their own diet, and sell a greater variety of produce. Different crops have different rooting depths, so draw nutrients and moisture from different layers. Overall yield levels should rise, even on depleted soils.

Indigenous conservation agriculture practices in Côte d’Ivoire

Many indigenous practices have elements of what we now call “conservation agriculture”. It may be possible to build on or adapt these.

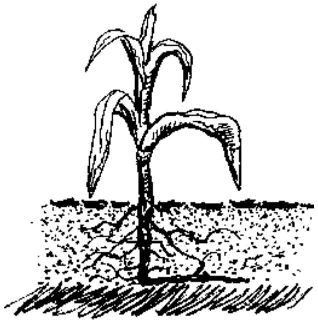
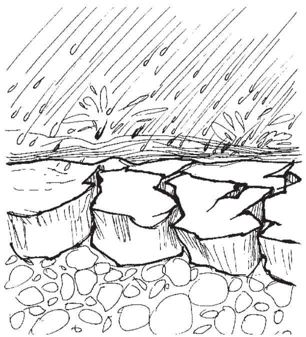
In the rainforest zone of southern Côte d’Ivoire, for example, Ebrié farmers traditionally clear the land, then build small mounds 30 cm high before the rainy season starts. They plant a combination of crops on the mounds: cassava, maize, groundnuts, okra and tomato. The mounds ensure good drainage and enable humus to accumulate, concentrating fertility around the crops. The soil stays covered for 2 years. A bush or tree crop, such as coffee, cacao, palm or rubber, is often introduced later.

Organic matter breaks down quickly in the hot, wet conditions. Heavy rain washes nutrients away, leaving a poor, acidic soil and causing gullying. Farmers often abandon the land after a few years.

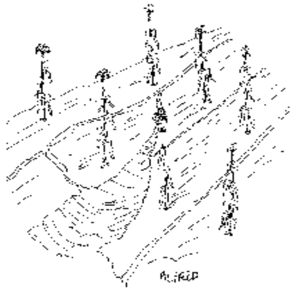
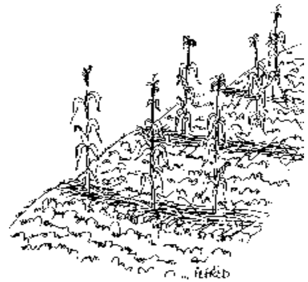
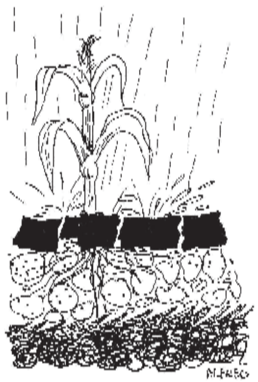
One way to keep land productive is to continue growing cereals, cassava and other crops, closely spaced to cover the soil. Leaving mulch on the surface and growing a permanent cover crop of legumes such as *Pueraria* and *Centrosema* protects the soil and increases the organic matter level. Applying organic and inorganic fertilizer several times during the season (instead of all at once) allows crops to use the nutrients before they are washed away. Planting tree crops can also help protect the soil from heavy rain.

More information: Anne Nomel

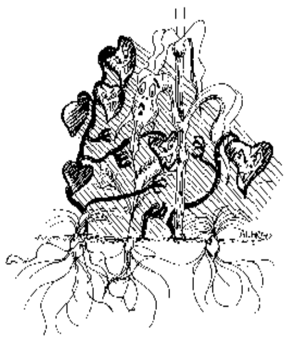
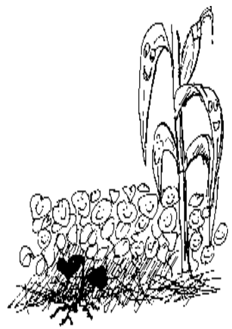
Effects of conventional farming and conservation agriculture

Operation	Conventional farming		Conservation agriculture	
Soil structure		Repeated ploughing, disking, harrowing and harvesting reduces soil organic matter and destroys the soil structure. Very fine, unstable particles result. A hardpan – a hard layer that water cannot pass through – forms at the ploughing depth.		Deep ripping may be necessary to break up a hardpan. Deep-rooted legumes can also break it up. The soil is disturbed very little, so its structure stays intact, and no hardpan forms. Organic matter builds up because crop residues and cover crops stay on the soil. A range of soil particle sizes
Soil moisture		Ploughing destroys many of the pores and cracks in the soil, making it hard for water to seep in. Much of the rain runs off and is lost, instead of being stored in the soil. Ploughing turns the soil over, allowing much of the moisture to evaporate in the air. On flat land, water forms pools on the surface, or is trapped above the hardpan, causing waterlogging and		Organic matter binds soil into stable clumps. Water can soak into the soil easily through pores and cracks. It is stored in the soil, so is available for crops. There is no hardpan, so water can percolate deep into the ground. Mulch and cover crops shade the soil surface, so less water evaporates.

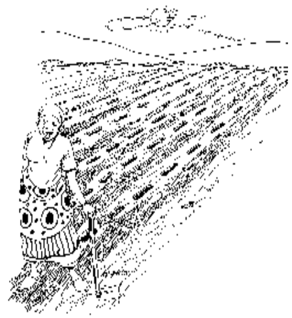
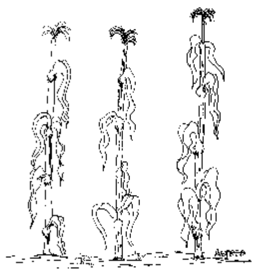
Effects of conventional farming and conservation agriculture (continued)

Operation	**Conventional farming**	**Conservation agriculture**
Erosion	 Heavy rainfall pounds the soil, breaking up lumps of soil into fine particles and creating a crust that seals the surface and prevents water from seeping in. On slopes, water runs downhill, carrying precious topsoil with it. Rills form and develop into gullies, which carry the soil into rivers. The silt clogs reservoirs and irrigation canals, and causes flooding when the next rains come.	 Cover crops and mulch protect the soil surface from heavy rain. Roots bind the soil together, so it is less easily eroded. Less water runs off, so there is less
Soil fertility	 Ploughing buries organic matter and exposes the soil to the sun and rain. It breaks up organic matter into simpler compounds, which are easily washed away. Removing or burning crop residues depletes the soil fertility. Planting a single crop year after year removes valuable nutrients from the soil. There are few earthworms, burrowing beetles, microbes, and other soil life that are vital for a healthy	 Crop residues and cover crops stay on the soil, adding to the organic matter. Adding compost, manure or mulch from outside further improves fertility. There are many earthworms and other forms of soil life. Legumes improve fertility by fixing nitrogen.

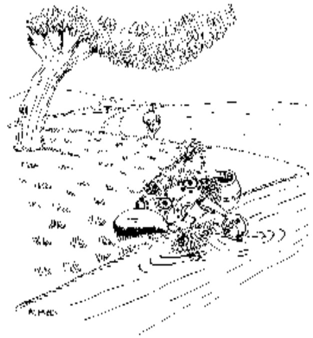
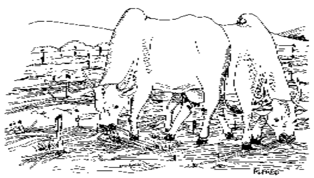
Effects of conventional farming and conservation agriculture (continued)

Operation	Conventional farming		Conservation agriculture	
Yield		Yields fall over time as fertility declines. Farmers are forced to rely on expensive artificial fertilizer – which few can afford. Planting is often late because farmers have to wait until the soil is moist enough for ploughing.		Planting can be earlier because it is not necessary to wait until the soil is moist enough for ploughing. Soils are fertile and contain more moisture, so produce higher and more stable yields.
Weeds		Keeping the soil bare allows weeds to grow unhindered. Planting the same crop year after year encourages certain weeds, pests and diseases.		The cover crop or mulch smothers weeds and prevents them from growing quickly. Careful use of herbicides can also control weeds. Rotating crops breaks the life cycle of pests and disease organisms. A healthy soil helps control pests and diseases that

Effects of conventional farming and conservation agriculture (continued)

Operation	Conventional farming	Conservation agriculture
Costs and labour	 Ploughing and weeding are expensive (if it is necessary to hire workers to do it), take a lot of time, and are hard work. Fuel costs are high, and there is a lot of wear and tear on equipment.	 It is not necessary to plough, so there is no need to buy expensive mouldboard ploughs, disks and harrows (though farmers may have to invest in new equipment such as planters and rippers). Less work is needed for weeding and most other farm operations. The costs of fuel or of hiring animal traction are lower, and there is less wear on equipment. Farmers are able to cultivate a larger area than with conventional farming.
Crop diversity	 Monocropping produces one staple crop, with the risk of failure if there is a drought or pest attack. Farmers' incomes and diets depend on a single crop.	 Crop rotations and crop mixes produce a range of crops. They reduce the risk of ruin if one crop fails, and provide a more diverse diet.

Effects of conventional farming and conservation agriculture (continued)

Operation	Conventional farming	Conservation agriculture
Environment	 Conventional farming is unfriendly to the environment. It encourages erosion, pollutes water supplies, reduces soil fertility, and destroys ecosystems. It releases carbon dioxide (CO_2) into the atmosphere, which changes the climate and contributes to global	 Conservation agriculture is environmentally friendly. It reduces erosion; streams and rivers are cleaner and flow throughout the year. It maintains soil fertility, and conserves natural ecosystems. It raises the amount of organic matter in the soil, so acts as a “carbon sink”, and reduces global warming.
Livestock	 Animals provide manure, but trample and compact the soil and remove the cover, leaving the soil open to	 Controlled grazing prevents trampling and compaction, and leaves the mulch and cover crop to protect the soil and enrich the organic matter. Livestock owners have to find alternative

Other types of sustainable agriculture

Conservation agriculture is not the only type of "sustainable" agriculture and resource management. It overlaps with various other approaches. Here are some:

Sustainable land management (or "land husbandry") is a broad term that includes various types of crop and livestock production that aim to produce good yields year after year, while conserving soil and water resources. It does not necessarily include all three principles of conservation agriculture (don't turn the soil, keep the soil covered, and rotate crops). Conservation agriculture is a type of sustainable land management.

Organic farming involves growing crops and livestock without using agrochemicals. It is possible to do conservation agriculture in an organic way (without using fertilizers, herbicides or pesticides), but many types of conservation agriculture use these agrochemicals – but in small amounts and with care.

Agroforestry is a combination of trees and crops (or livestock), and is a form of "sustainable land management". Agroforestry promotes soil cover and crop rotation, so may contribute to a conservation agriculture system.

History of conservation agriculture

In the 1930s, soil erosion in the **United States** reached crisis proportions. The problem was particularly severe in the Midwest, where millions of tons of topsoil were blown away by the wind or washed into rivers, in what came to be known as the "Great Dust Bowl". Supported by the government, American farmers started abandoning their traditional practice of ploughing. Instead, they left the crop residues on the soil surface, and planted the next crop directly into the stubble.

Faced with similar problems, farmers in **South America** also took up conservation agriculture. They sowed cover crops to protect the soil, and rotated crops in order to maintain soil fertility. Because of the benefits, knowledge passed quickly from farmer to farmer.

By the year 2000, conservation agriculture was practised on about 60 million hectares of land worldwide, mainly in North and South America. Government support has been important: in some states in Brazil, conservation agriculture is official policy. In **Central America**, Costa Rica's Ministry of Agriculture has a Department for Conservation Agriculture. Conservation agriculture is used to cultivate over half the crop land in Paraguay, about one-third of the land in Argentina, one-third in Brazil, and one-sixth in the United States.

The many South American conservation agriculturists are well organized in local and national farmers' associations. They are supported by institutions from North and South America and have links with international agencies such as FAO, GTZ and the World Bank. This support is essential to help farmers to adopt quickly new approaches and technologies that many see as a radical change in the way they farm.

Conservation agriculture in Africa

Conservation agriculture has great potential in Africa because it can control erosion, produce stable yields, and reduce labour needs.

The story of conservation agriculture in Africa is not new. Across wide areas of Africa, conservation agriculture principles used to be normal practice, before ploughs were introduced. Farmers would cultivate by hand, often with hoes, rotating crops and fallowing fields for several years. Rising populations and ploughs changed all that. European settlers and colonial regimes introduced ploughs, and they quickly came to dominate farming because they enabled farmers to open up more land quickly and cheaply. But just as in the United States, the plough has gradually eroded Africa's soils. Fertility and yields have fallen, and many countries now face critical food shortages.

But not all Africa's farmland was put to the plough, or to the deep-till hoe, and pockets of conservation-friendly farming still remain.

Conservation agriculture emerged in several different places around the same time in Africa. The most dramatic story comes from **Zimbabwe** and **Zambia**, where conservation agriculture came to the rescue of the land. Starting on one large-scale commercial estate in Zimbabwe, a combination of zero-tillage and direct planting into deep straw mulch meant a slow but sure recovery for de-

Lesotho's lost soil

The first missionaries arrived in Lesotho in 1833. They introduced ox-ploughs to the Basotho people. The ploughs were a welcome alternative to hand cultivation. They spread very fast, and Lesotho became a breadbasket for South Africa. It exported tons of food.

Soon people believed this was the only way land could be cultivated. Some women would refuse to marry a man who did not own a plough. Tractors followed, and more and more land was ploughed.

But the tractors and ploughs compacted the soil. Rain fell on the bare land, and washed Lesotho's precious topsoil into the rivers. Millions of tons of soil a year are lost now each year. According to one estimate, there will be no topsoil left in Lesotho by 2040 (see Photo 19).

Soil fertility began to fall, and crop yields declined. More and more fields were planted to maize, instead of a variety of crops in rotation. Farmers started to rely on artificial fertilizer and other chemicals as the only way to increase the poor yields.

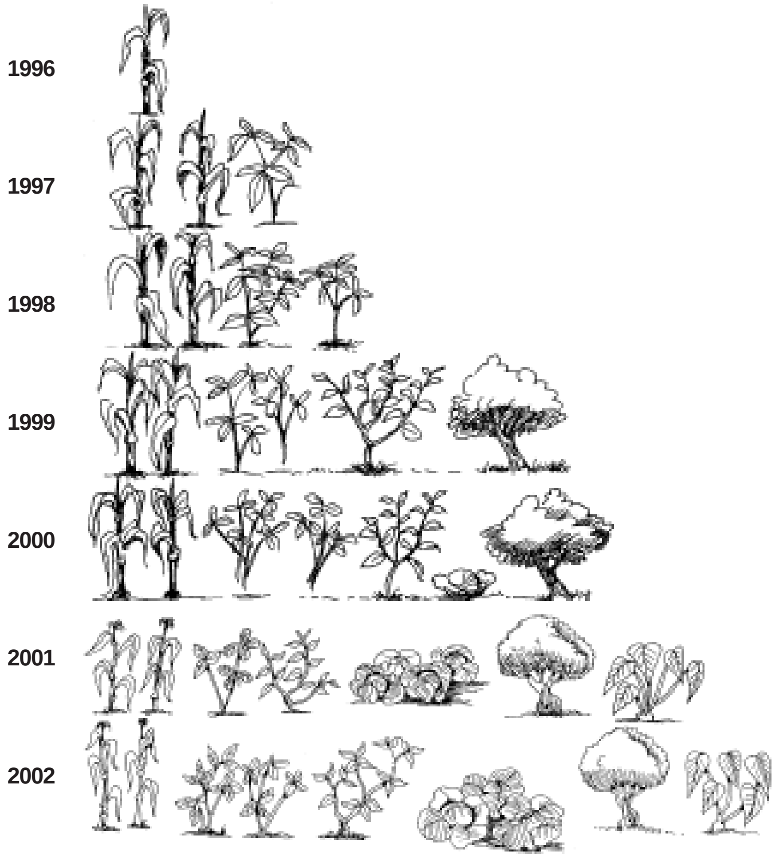
Lesotho can potentially produce an average of 4 tons of maize per hectare, but in 2003 to 2004, it produced less than one-tenth of that.

Recently, a few farmers have begun to practise conservation agriculture. They have found that they can get good yields without ploughing: they dig small planting holes in lines, add manure or compost, and sow maize seeds. They protect the soil surface with cover crops or residues from the previous crop. They have begun to restore the fertility of their soils and to stop erosion. For the first time in decades, there is hope for Lesotho's farmers.

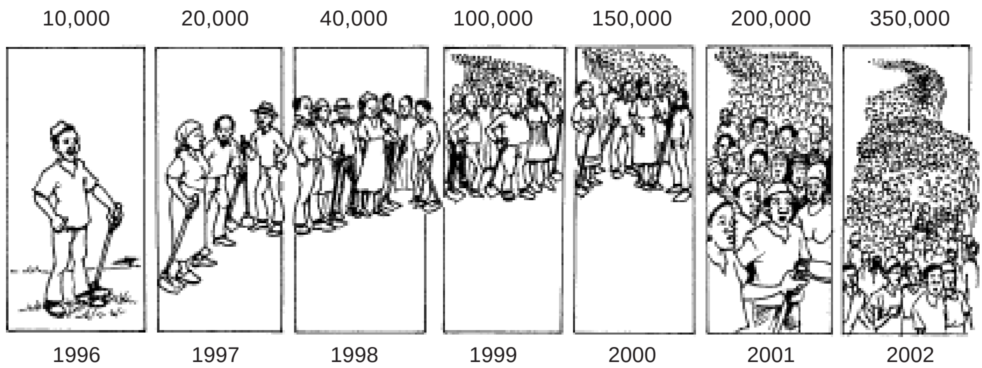
More information: August Basson

Conservation agriculture in Ghana

Conservation agriculture has spread rapidly in Ghana. In 1996, only a handful of farmers grew a single crop – maize – using conservation agriculture. With support from Sasakawa Global 2000, Monsanto and GTZ, their numbers had risen to 350,000 by 2002. They grow a broad range of crops, including root crops, legumes, vegetables and tree crops.



The range of crops under no-till in Ghana has risen from year to year



Number of farmers in Ghana practising conservation agriculture graded land. A moderate use of herbicides was needed to kill weeds. By the mid 1990s, nearly 4000 hectares were under conservation agriculture – all on large-scale farms. Efforts are presently being made to transfer this success to some of the many new small-scale farmers in Zimbabwe.

In Zambia around the same time, a dedicated extension unit, supported by donor funds, spread the message. Here, small-scale farmers found that conservation agriculture worked on their farms too. Currently more than 100,000 small-scale farmers in Zambia have converted to conservation agriculture.

Large-scale farmers in **Kenya**, **South Africa** and **Namibia** also use conservation agriculture practices. In South Africa, no-till farmers' clubs similar to those in South America have been set up. Initiatives by government research and extension agencies, donors and the private sector promote conservation agriculture for smallholder farmers in **Cameroon, Ghana, Kenya, Madagascar, Malawi, Namibia, Tanzania, Uganda, Zambia, Zimbabwe**, and other countries. Various institutions conduct research on or promote conservation agriculture (see Chapter 14 for more information).

The most important researchers and promoters of conservation agriculture in Africa are farmers themselves. Every farmer is a researcher, who experiments every season on his or her farm. Farmers who find something that works are likely to repeat it the next season, and to tell their friends about it.

Challenges for conservation agriculture

Conservation agriculture has the potential to change the face of Africa. But its success is not automatic. It faces various challenges.

Change of mindset Switching to conservation agriculture involves a fundamental change of mindset. For example, farmers must drop their traditional practice of preparing the land with a hoe or plough, and instead rely on "biological tillage" by the plant roots and earthworms. The switch also encourages farmers to begin to see their farms as a business rather than merely a way to feed their families.

Conservation agriculture involves radical changes in what extension services do. An effective way to promote conservation agriculture is through farmer field schools and other approaches that put farmers and their needs at the centre, rather than seeing them as mere recipients of advice.

Such revolutionary changes require teaching, not only on the farm itself but also within schools and colleges. Extension staff will need intensive training so they can learn the necessary technologies. Field demonstrations and awareness-creation campaigns will also be needed. The mass media must be harnessed to support the campaign.

A certification system for conservation agriculture?

In some countries, farmers who grow food organically (without using fertilizers, pesticides and other chemicals) can apply for a certificate. This allows them to sell their produce as "organic" – which fetches a higher price than similar produce grown with chemicals.

Elsewhere, farmers who sign a contract not to plough their land for several years can be given cash rewards.

Could such systems be introduced for African farmers who practise conservation agriculture?

Conservation agriculture increases the organic matter content of the soil – so it stores carbon dioxide rather than releasing it into the air. That helps prevent climate change. Could conservation agriculture farmers someday be rewarded for storing carbon?

Do these ideas sound far-fetched? Farmers in South America are debating them already!

See Chapter 12 for more on changing mindsets, and Chapter 13 for more on promoting conservation agriculture.

Crop residues Keeping the soil covered is important in conservation agriculture. But it can be difficult. Farmers have many uses for crop residues: as fodder, fencing, roofing and fuel. Livestock keepers let their animals graze on stubble. In drier areas, it is impossible to grow a cover crop in the dry season, and crop residues are a vital source of animal feed.

If they are to keep the soil covered, farmers will have to protect their fields and find alternative sources of fuel and fodder. In wetter, sparsely populated areas, this is easy. In drier areas, it is more difficult. Alternatives include fencing animals out, reaching agreements with livestock owners on grazing rights, and growing special plots of fodder and fuelwood.

Land tenure Farmers can go a long way towards adopting the principles of conservation agriculture with a minimum of investment on their farms. But they may be reluctant to do so if they do not have clear rights to the land they cultivate.

The importance, however, of the land tenure issue varies widely throughout Africa. In some countries, lack of guaranteed tenure impedes all agricultural development.

Other challenges It can be hard to find seed (particularly of cover crops), inputs such as herbicides, and equipment. Crops such as tef, which has very small seeds, can be difficult to sow without disturbing the soil. And for various reasons, it can be difficult for farmers to work in groups, form organizations or get the support they need to begin practising conservation agriculture.

2

Converting to conservation agriculture

Converting fully to conservation agriculture may take several years. You should plan carefully what to do. For example, it may be best to begin to grow a cover crop before reducing tillage. If you are lucky, you may see yield increases in the first year. Or improvements may be more gradual, and yields may even decline in the short term before your soil fertility has improved, you can control weeds properly, and other benefits can make themselves felt. It is important to be aware of the potential problems so you do not have false expectations and can plan what to do.

It can be difficult to switch to conservation agriculture. You have to accept new ideas and learn a new set of skills. You may have to overcome some preconceptions about what is "good farming". In order to give the right advice, extension personnel need to know not only about conservation agriculture techniques, but also about how best to work with farmers to introduce them.

This chapter describes in brief the three stages you may go through when you first start using conservation agriculture. Remember: this is a simplified version! You may find yourself following a different set of steps, depending on your own situation. The chapter also lists some questions to ask, and shows where to find some of the answers in this book.

See Chapter 11 for more detailed questions to ask when you are considering adopting conservation agriculture.

Three stages

Converting from conventional farming to conservation agriculture falls into three main stages:

- Before you start
- First season
- Second and following seasons.

Before you start

Choose a field to start conservation agriculture. Select part of a field where you feel able to take a risk, have good conditions for learning, and have a good chance of success. If you start with a field with good potential, you are likely to see results quickly. When you have converted this field to conservation agriculture, you can start on the others – for example, on badly eroded fields on slopes. However, if you have fertile fields on a hillside that are susceptible to erosion, make sure you protect them before starting to use conservation agriculture. See Chapter 8 for how to do this.

Start small Try out what works on one field first. Observe closely and learn what works and what does not. You can then gradually extend what you have learned to other fields and crops.

Get support Get together with friends and neighbours who are also interested in conservation agriculture. Learn from one another, and visit each others' fields to check on the crops, soil, weeds, pests and diseases. It can be difficult to start conservation agriculture if you are alone: get advice from your extension worker or development agent, the local NGO, or other farmers who can advise you.

Before the first cropping season, you may have to do some work to prepare your field. Don't worry – you will have to do this extra work only once!

You may have to do the following (see Chapter 3):

- **If the soil is compacted or has a hardpan** Use an animal- or tractor-drawn subsoiler or a ripper.
- **If the soil has ridges and furrows** Plough once, preferably with a chisel plough with a long log or iron bar pulled behind to remove the ridges and make the surface more even. Remove rocks or stumps that get in the way. This is necessary because direct planters work better on a fairly smooth surface.
- **If the soil is acidic** (has a low pH) Add lime.

First season of conservation agriculture

Cover the soil Here are some ways to do this (see Chapter 5):

- **If there are crop residues nearby** Carry them to your field and spread them on the soil surface as mulch. This takes some work, but costs little. If you do not have any suitable residues yourself, perhaps you can get some from your neighbours.
- **Plant a cover crop during the first season** Choose a cover crop such as lablab with deep roots to improve the fertility and soil structure. Consider using fertilizer on the cover crop to help it grow well. It will produce enough mulch for you to grow food crops on the same field in the second season.

How a Kenyan farmer started doing conservation agriculture

A small-scale farmer in western Kenya had the opportunity to visit Nyanza, the neighbouring province. There he learned about lablab for the first time. He took a bag of lablab seeds home and planted it between the maize rows about 3 weeks after he had planted the maize.

After he harvested the maize, the lablab continued to grow and covered the soil completely during the dry season. The farmer and his family could eat lablab leaves as a vegetable, and mixed the beans with maize.

At the beginning of the next season, he slashed the lablab and left it on the soil surface. He made small holes with a hoe and planted the next crop of maize.

Lesson *This farmer started small, with cover crops: he began with intercropping, then gradually adopted other conservation agriculture practices.*

- **Grow a cover crop on a nearby field**, then cut it and spread it on the soil at the beginning of the second season. This cover crop can also produce seeds for you to sow or sell to neighbours.

Control weeds It is vital to control weeds, especially during the first few years of conservation agriculture. Pull them by hand, slash them, or kill them with herbicide (see Chapter 7). Then sow cover crops to prevent new weeds from growing.

Don't plough Instead of ploughing, direct-plant your crops through the mulch, or dig planting basins (Chapter 3) where you can sow seeds.

Grow crops You can grow the crops you normally do, but add an intercrop or rotate crops if possible. For example, you might grow maize as normal, but add an intercrop of legumes (Chapter 6).

Leave the soil covered At harvest, leave the residue on the field to cover the soil during the dry season. Leave the cover crop growing, or plant another main crop if you can.

Second and following seasons

There should now be enough cover on your field. If not, carry in extra residues from nearby and spread them on your field. It is much simpler to prepare for planting in the second season.

- **Check for weeds** Hand-pull them, slash them, or kill them with herbicide.
- **Crop residues** Decide if it's possible to produce enough crop residues on the field for the third season. If not, grow some cover crops nearby, then cut them and spread them on the conservation agriculture field in the third season.

Questions to ask

Here are some questions to ask yourself when you are thinking about starting conservation agriculture.

Equipment Do you have the right equipment? You can practise conservation agriculture using a just a hoe. But you may want to use other equipment to save you work:

- Jab-planter
- Ripper or ripper/planter
- No-till planter
- Sprayer or weed wiper.

How a research institute introduced conservation agriculture

Farmers in northern Tanzania harvested low yields because their soils were infertile and eroded, and had hardpans caused by repeated ploughing. Extension staff advised them to plant on the contour, and introduced fertilizer and improved seeds. But yields stayed low.

A donor-supported project tried to help by providing subsoiling services. This helped for a few seasons, but as farmers continued to plough the field, the hardpan quickly came back.

Researchers at Selian Agricultural Research Institute learned through an international workshop about how Brazilian farmers use no-till and cover crops. The researchers introduced cover crops and reduced tillage using hoes, and the Tanzanian farmers tested them on their farms. The researchers later showed them how to plant directly through the soil cover – first using a hoe, and later with direct planting equipment.

Lessons *Subsoiling may be necessary to repair the damage caused by ploughing, but alone it is not sufficient. Support from development agencies may be crucial to promote conservation agriculture.*

If you do not own these implements, you may be able to hire them, or get together with a group of neighbours to buy them for the group to share.

Seed Can you get the right types of seed? Especially seeds of cover crops such as mucuna or lablab. You may be able to buy them from dealers or get them from neighbours.

Inputs Will you be able to buy herbicide to control weeds and fertilizer to improve yields? Can you make compost or use manure to help restore the soil fertility?

Labour Conservation agriculture generally saves work. But it may mean more work in the first year – for example for field preparation before the rains, or for weeding. Can you handle this work yourself, or can you get family members or hire labourers to help you when you need?

Storage and markets Conservation agriculture should help you grow more, and will produce a greater variety of crops. Will you be able to harvest these crops, dry them, and store them in your grain store? Will you be able to sell them?

Livestock You should try to keep livestock out of your fields, even after harvesting the crop. Can you find other ways to feed your animals if you do not allow them to graze the stubble? Some possibilities (see Chapter 9):

- Cut the cover crop and carry it to the animal pen.
- Make hay or silage to feed to the animals in the dry season.
- Plant an extra plot of forage to feed to the animals.
- Sell less-productive animals so you have fewer to feed.
- Arrange with your neighbours to graze animals somewhere else.

Information and support Do you have the skills you need to practise conservation agriculture? Where can you get advice if you need it? Consider joining a group of other farmers who are also trying out this new way of farming so you can compare ideas and experiences. If no group exists in your village, perhaps you could start one.

Where to find answers in this book

Conservation agriculture is made up of many different components. You choose those that suit your own situation. This book presents these components separately to make them easier to understand. But in reality, you will combine components into an integrated system. And you will introduce them in a sequence that suits your conditions best.

Field preparation and planting You can prepare the field and plant seed with a hoe, using a jab-planter or an animal-drawn implement, or with tractor power.

See Chapter 3 for more on field preparation and planting.

Keeping the soil healthy Conservation agriculture improves the soil by increasing the amount of organic matter. You can plant legumes that fix nitrogen in the soil. You can improve the soil fertility further by adding manure, compost, green manure, or by applying artificial fertilizers. You may have to add lime or ash to lower the soil acidity.

See Chapter 4 for more on how to improve the soil.

Maintaining soil cover It is important to keep the soil covered throughout the year. You can do this using cover crops or a mulch of residues from the previous crop.

See Chapter 5 for guidance on how to use cover crops and mulch.

Crop rotations and combinations You can choose among many different combinations of main crops and cover crops. You can grow these as intercrops (sowing two crops in the field at the same time), relay crops (sowing one crop before the previous one is harvested), or rotations (sowing a different crop each season).

See Chapter 6 for more on crop rotations and combinations.

Controlling weeds Cover crops and mulch help suppress weeds, but you must still control weeds in conservation agriculture. You can hand-pull weeds, remove them with a hoe or machete, or control them using herbicide. In time, there will be fewer weed seeds in the soil, so weeds will become less of a problem.

See Chapter 7 for more on how to control weeds.

Controlling erosion and harvesting water Conservation agriculture reduces erosion by encouraging rainwater to soak into the soil, preventing runoff. On steep slopes and heavily degraded land, you may have to build terraces, bunds and drains to control erosion. In dry areas, you can use structures such as half-moon basins to harvest water and make it available to the crop. You can combine conservation agriculture techniques with these measures.

See Chapter 8 for ideas on how to combine soil conservation measures and water harvesting techniques with conservation agriculture.

Managing livestock You should try to keep livestock away from your fields throughout the year. You may have to tether animals, fence land to keep them out, or make agreements with the community to limit or prohibit grazing on stubble or on fallow fields. Animals may need an alternative source of feed – such as plots of fodder grasses.

Farmers' choices

You can choose among many different conservation agriculture practices. Here are some things that may affect your choice.

- What is the **soil** type?
- What is the **rainfall**, and at what times of year does it fall?
- What is your **farm size**?
- How much **labour** do you have? Men, women, children, elderly, hired labour…? At what times of year? (Many people migrate in search of work at certain times of the year.)
- What types of **crops** do you want to grow?
- What **implements** do you have (or can you get)? Hoes, planters, rippers, sprayers…?
- What **draught power** is available? Donkeys, oxen, camels, tractors…? Or do you and your family have to rely on your own muscles and sweat? If you do not have access to draught power, you may have no alternative: you may have to turn to conservation agriculture in order to survive.
- What **inputs** are available? Seeds, manure, compost, artificial fertilizer, herbicides, pesticides…?
- How much **financing** is available? Credit for implements, field preparation, inputs, marketing…?
- What **information** is available? You may be able to get advice from extension workers, NGO staff, input suppliers, traders, other farmers, the mass media – and of course, manuals like this.

Because individual circumstances vary, it is not possible to prescribe a single best way to do conservation agriculture. You may decide to use an animal-drawn ripper, followed by direct seeding of maize and a mucuna cover crop. Your neighbour may prefer to make individual planting pits before sowing maize and lablab. Both approaches can produce good yields.

You must be able to choose the practices that suit your conditions. Extension workers and development agents must be ready to advise you so you can make your own decisions.

See Chapter 9 for more on managing livestock in conservation agriculture.

Equipment Conservation agriculture requires different types of equipment from conventional agriculture. You no longer need mouldboard ploughs, disks and harrows. You can continue to use hoes and dibble sticks, but it might be worthwhile to invest in special equipment such as rippers, direct drills and jab-planters. Hand weeding is possible on a small scale, but conservation agriculture generally uses slashers, sprayers and wipers to control weeds.

See Chapter 3 for more on field preparation and planting equipment, and Chapter 7 for weed-control equipment.

Inputs, post-harvest storage and marketing Conservation agriculture uses some of the same types of inputs as conventional farming (such as fertilizers and crop seeds). But it also needs certain other types of inputs that may be new, such as cover crop seeds and herbicide. You may also plant new types of crop in a rotation, and you may have to harvest and sell unfamiliar types of produce. Better yields may lead to extra storage requirements.

See Chapter 10 for more on input supplies and post-harvest activities.

Finance and economics You – and other farmers – have to be convinced that you will benefit from conservation agriculture before you will adopt it. It is a good idea to keep careful records of each farm operation, and work out how much labour and money you put in, and how much profit they earn. You can use simple methods to work this out. You should also see other benefits that are harder to measure in money terms: river water is cleaner, there is more water in wells, and erosion is checked.

See Chapter 11 for details of these methods.

Hope for Tseoa

Tseoa Khoanyane almost gave up hope in 1998. His 1.5 hectare, steeply sloping field in Ha-Mosuoe in Qachas Nek District, Lesotho, was riven by gullies. His maize yield had fallen from 240 kg to just 60 kg. In despair, Tseoa gave up growing crops on the land.

But 5 years later, in 2003, he was introduced to conservation agriculture. Instead of ploughing the land with a tractor or oxen, he dug contour furrows on his deserted field. He put a lot of plant residues into the gullies. The vegetation slowed down the rush of water, and silt started to build up. He built stone bunds on eroded parts of the field, and laid mulch on the ground. He dug basins to collect water in preparation for planting in November 2004.

Animals damaged some of his basins, but he did not give up. He now has a good crop on the land he had earlier deserted.

"I am expecting a very good harvest of maize and beans", he says. "Whenever I walk through the farm and see the crop, I get very excited. I am glad I embraced conservation agriculture."

More information: August Basson

Sociocultural issues Conservation agriculture may have different implications for men and for women. Women may prefer to grow more food crops, while men may want to sell crops for cash. Conservation agriculture requires less labour, so makes it easier for people affected by HIV to grow food. It is also attractive for young people who might otherwise have lost interest in farming. There may be benefits if neighbours also adopt conservation agriculture together, sharing costs of equipment and marketing produce together.

See Chapter 12 for a discussion of these and other sociocultural issues.

Promoting and adapting conservation agriculture Conservation agriculture requires farmers and extension workers to be open to new ideas and to learn a new set of skills. It is ideal for participatory extension approaches such as farmer field schools and farmer-to-farmer extension. Because conservation agriculture is still relatively new to Africa, much research is still needed – both by research institutions and by farmers themselves – to adapt the systems to the specific situations.

See Chapter 13 for more on promoting and adapting conservation agriculture.

What are the risks?

Conservation agriculture can prove very beneficial. But some things might not work right for you at the start – as often happens when trying something new.

Learning All farmers have to learn how to use conservation agriculture before they can reap its full benefits. For example:

- Farmers who are not used to leaving crop residues in the field sometimes make simple mistakes – such as leaving them in bunches instead of spreading them uniformly. That makes it hard to plant the crop correctly, reduces the crop stand, and cuts yields.

Why farmers may be cautious about conservation agriculture

Farmers are often cautious about giving up ploughing. This is what they have learned from their parents and grandparents. They know how to grow crops using conventional methods, and are sceptical about trying new ideas. Most do not have the money available to try out something new. They fear that the new approach will put their food supply and families at risk.

Farmers grow the crops the way they do for a reason. Generations of farmers have found by trial and error whether something works. This indigenous knowledge has enormous value as a basis for development.

Conservation agriculture will succeed best (a) where farmers recognize a problem with what they currently do, (b) they adopt conservation agriculture gradually, and (c) adapt it as they go, using their own skills – and the skills of extension agents.

See Chapter 12 for more on beliefs.

- It can be difficult to learn how to cope with weeds. If you don't control them properly, your workload may actually increase, or weeds may invade your field and you risk losing part of the harvest.

The solution?

- Don't try to do too much too fast! So if you make a mistake, it won't matter too much.
- Look for advice. Some of your neighbours may have learned how to solve a problem already and can tell you about it! Share your experiences with others.
- Learn by doing. Eventually, you will become a seasoned conservation agriculture user, and you will know more than anyone else how to make it work for you, under your own conditions.

Getting support Another problem is finding the quality support and services you need. Many pioneers face this situation. For example:

- If no-till planters or rippers are not yet available commercially, you might have to rely on equipment that arrives too late.
- You cannot find the herbicides you need in local farm supply store.
- The extension agent may not know much about conservation agriculture, or about your specific conditions. His advice may actually be misleading.

There are no real solutions to this in the short term. As a pioneer, you will have to rely more on yourself than on the government services. You can help organize your neighbours to compensate for the lack of services. If you are well organized, it is easier to negotiate with development projects, the government and the private sector for the support you need.

See Chapters 10 and 13 for more on these and other questions.

Saving labour in northern Tanzania

Like many other places in Africa, Karatu District in Tanzania experiences labour shortages during parts of the year. Many people are ill from AIDS or malaria, so cannot work. And many young people go off to work in the cities. There are not enough people left to do the farm work.

Conservation agriculture can help. It eliminates the heavy work of ploughing. Using herbicides and cover crops means less time is needed for the backbreaking task of weeding.

Farmers in Karatu were able to cut their labour needs by as much as three-quarters by practising conservation agriculture. For sowing, they used jab planters or animal-drawn no-till planters. They slashed weeds by hand or crushed them with a knife-roller, as well as spraying herbicide.

Source: Bishop-Sambrook et al. (2004)

3

Field preparation and planting

Conventional tillage – with hand hoes, discs or mouldboard ploughs – damages the soil structure and leaves it exposed to the wind and rain. Farmers plough the soil for various reasons: to prepare a bed where seeds can germinate easily, to loosen and aerate the soil, to incorporate fertilizer, and to control weeds. But tilling at the same depth season after season creates a hardpan in the soil. Erosion results, even on moderate slopes. Tillage also cuts the amount of organic matter in the soil, so reducing soil fertility and crop yields.

Tillage has an impact way beyond the farm. Eroded soil pollutes rivers and is deposited as sediment behind dams. Tillage also releases carbon dioxide (CO_2) into the atmosphere, adding to climate change and global warming.

Conservation agriculture avoids these problems. It reduces the amount of tillage, and can even eliminate it altogether when seeds are planted directly into the soil. It maintains a cover of vegetation or mulch on the surface. It raises the organic matter content of the soil, improving fertility and reducing the amount of CO_2 that is produced. It protects the soil from erosion, so helps keep rivers free of silt.

This chapter describes how to prepare your field and plant crops when using conservation agriculture. It shows how to do conservation agriculture with the simplest equipment (a hoe and a piece of string), as well as with animal-drawn equipment or with a tractor.

- The chapter first describes how to remove problems such as **compacted soil**, **hardpans** and **ridges and furrows** before you start using conservation agriculture.
- It then describes several ways of preparing the field for planting: using **planting basins**, **planting spots**, and **ripping**.
- It goes on to describe various ways to plant seeds: using **planting basins**, a **planting stick**, a **jab-planter**, and **animal- and tractor-drawn planters**.
- Finally, the chapter describes how to make sure you are using the **right amount of seed and fertilizer**.

Before starting conservation agriculture

Before you start with conservation agriculture, you may have to deal with various types of soil problems. Three of the most common problems are:

- **Compacted soils**
- **Hardpans**
- **Ridges and furrows**.

The next few pages tell you how to deal with each of these problems.

You may also want to combine conservation agriculture with other techniques, such as **terraces** and **water-harvesting** methods. For example, if soil erosion is a serious problem in your field, you should deal with it before starting conservation agriculture. See Chapter 8 for some ideas on how to do this.

Compacted soils

Compacted soils have a hard, dense layer at or near the surface. It is difficult for water to move through this layer, and for seedlings to grow in it.

Soils may be compacted when tillage destroys the soil structure by breaking down the natural system of pores and channels. The soil can then be compacted more easily by heavy rainfall, animals' hooves, and wheels of tractors and carts.

- **Heavy rainfall** on a tilled soil compacts the surface and may form a crust. This crust can prevent seedlings from growing and reduces infiltration by rainwater. The water then runs off, causing erosion.
- **Animals' hooves** compact the top 5 cm of the soil.
- **Tractor wheels** compact the soil at a depth of 10–15 cm.

All soils may become compacted. Sandy soils can be compacted over time because they do not swell and shrink like clay soils. But the problem is more serious in clay soils if they are compacted when wet.

Compacted soils make it hard for crop roots to grow and to reach water and nutrients. They prevent water and air from moving into the soil. This can lower yields and make crops more susceptible to drought. If the soil is compacted, it is harder to till.

If your soil is compacted, you should loosen it before starting with conservation agriculture. See below for how to do this.

Mulch protects the soil surface from heavy rain and stops a crust from forming. It also helps reduce compaction by animals and equipment. By not ploughing, the pores and channels made by roots, earthworms and other soil life are preserved. They let water and air move into the soil – which is good for crops.

Hardpans

A hardpan is a dense layer in the soil that is difficult for water and roots to penetrate. Hardpans can form in two main ways:

- If the soil is ploughed or hoed at the **same depth** season after season.
- If the soil is **clayey**, hardpans can form naturally without any ploughing.

Hardpans prevent water from moving downwards in the soil. The water is trapped above the hardpan, resulting in waterlogging. This may damage or kill the crop.

Hardpans also prevent roots from growing downwards. The roots may be shorter than usual or bent sideways. They cannot reach nutrients and water deep in the soil, so the crop may be starved of food and may dry out quickly in a drought.

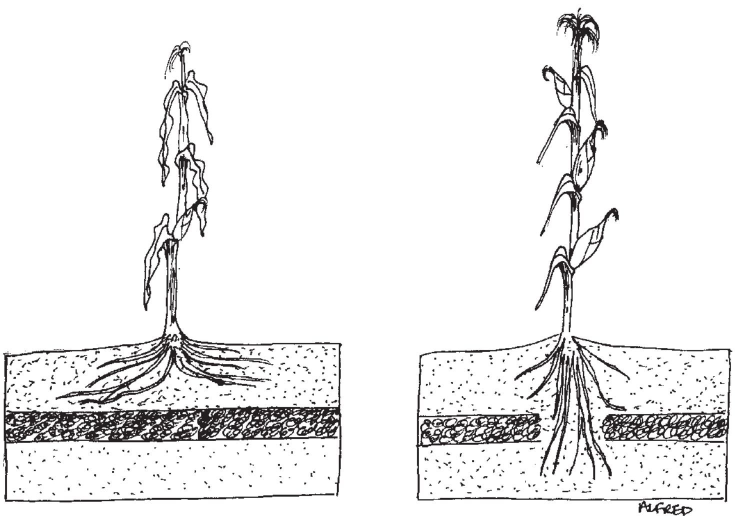
If your soil has a hardpan, you should break it in order to get good yields. See below for how to do this.

How to tell if a soil has a hardpan

Check for the following signs.

- **Stunted, uneven crops** Crops may grow poorly because their roots cannot reach down to nutrients in the soil.
- **Yellow leaves** Yellow leaves and other signs of nutrient deficiencies (purple leaves, stunting, brown leaf edges, etc.) may be caused by poor rooting systems.
- **Rapid wilting** Crops may wilt quickly during dry periods as the surface layers of the soil dry out.
- **Distorted roots** Dig up plants and look at their roots. If they grow sideways at a certain depth, there is probably a hardpan (see Photo 18).
- **Waterlogging** Puddles on the surface after heavy rains mean that water cannot drain down into the soil easily – perhaps because of a hardpan.

To check if a soil has a hardpan, use a hoe or spade to dig a small pit about 30 cm (1 foot) deep. You should be able to tell the depth where it becomes much



Roots deformed by a hardpan (left). The roots cannot reach water and nutrients in the soil beneath the hardpan. The crop is stunted, and wilts easily. Breaking the hardpan (right) enables water and roots to reach down deeper into the soil.

harder to dig. If you find it difficult to dig, roots will probably find it hard to grow downwards too. Push a knife blade into the side of the pit at various depths. A hardpan will make it difficult to push the knife in and pull it out again.

Treating compacted soils and hardpans

Loosening the soil and breaking the hardpan allow crop roots to penetrate deeper into the soil and reach more nutrients and water.

There are four main ways to loosen the soil and break up a hardpan:

- Using a **ripper**
- Using a **subsoiler**
- Using **planting basins**
- Sowing a strong-rooted **cover crop**.

If your soil has a hardpan, make sure you break it up when you first switch to conservation agriculture. If you do not, then your crops will not grow well. You may have to deal with it again in the near future. That can be expensive and take a lot of time.

Ripping

If the soil is fairly light, and if the compaction or hardpan is near the surface, you can use a ripper to loosen the soil.

A ripper is a chisel-shaped implement pulled by animals or a tractor. It breaks up surface crusts and opens a narrow slot or furrow in the soil, about 5–10 cm deep. Unlike a mouldboard plough, a ripper does not turn the soil over. You can rip the soil during the dry season, or at planting time. If you rip at planting time, you can sow seeds in the slot by hand, or using a planter attached to the ripper.

See page 47 for more information on ripping.

Do's and don'ts when ripping and subsoiling

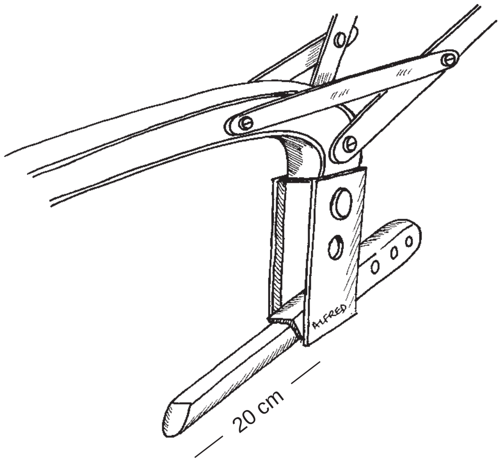
- Use the subsoiler when the ground is dry to crack and shatter the hardpan.
- Follow the contours when subsoiling or ripping. This encourages water to infiltrate into the soil rather than running off.
- Always dig a soil pit to see whether there *is* a hard pan, and how deep it is. Then work with the subsoiler to slightly below this depth.
- Don't use the subsoiler when the soil is wet

Subsoiling

If the hardpan is deeper or if the soil is heavy, you may have to use a subsoiler. A subsoiler is a chisel-shaped implement that looks like a ripper but works at a greater depth and has narrower tines, up to 20 cm long. It is designed to work at a depth of about 20–30 cm, just below the level of the hardpan. It breaks the hardpan and allows water to infiltrate easily into the soil.

You may need at least four strong oxen to pull a subsoiler. Subsoilers can also be mounted on a tractor. Subsoiling deep hardpans in heavy clay soils generally needs a tractor.

You do not have to subsoil every season! You may have to do it only once, when you first switch to conservation agriculture. It may be necessary to do it again periodically, once every few years. Consider hiring someone to do it for you rather than buying the equipment and doing it yourself.



This subsoiler fits on to a standard plough beam (like the ripper shown on page 48)

> **Subsoiling again?**
>
> You may need to subsoil or rip your field every few years if you find your soil becomes compact or a hardpan reforms. That may happen on certain soil types, if you cannot prevent animals from grazing your field, or if you cannot keep the soil covered all the time.

Planting basins

If you do not have draught animals or a tractor, and cannot hire them, then you may have to use a hoe to loosen the soil and break up a hardpan. The easiest way to do this is to use planting basins. Instead of hoeing the whole field, you dig basins only where you want to plant the crops. Dig the basins slightly deeper than the depth to which you normally hoe, so they break through the hardpan.

See the next page for more on planting basins.

Strong-rooted cover crops

Some cover crops have strong roots that can help break up hardpans, especially if they are not yet too hard. These cover crops can be planted after ripping, subsoiling or digging planting basins.

Some examples of strong-rooted cover crops:

- Pigeonpea (*Cajanus cajan*)
- Sunn hemp (*Crotalaria juncea*)
- Radish (*Raphanus* spp.).

Plant these crops as cover crops or in rotation with your main crop to break up a hardpan.

Removing ridges and furrows

If you plan to use a wheeled direct planter, you should try to remove ridges, bumps and furrows from the field before starting conservation agriculture. This is because the planter's drive wheel controls when the seeds are planted. If the wheel hits a bump, it may sow too many seeds, or not enough. That will produce an uneven crop stand. Some types of sprayers may also not work well on uneven ground.

You can get rid of ridges and furrows by ploughing once, before you start conservation agriculture.

You may want to preserve ridges and furrows if you irrigate your crops, of if you use them to conserve water or control soil erosion. Remember, though, that they will make it difficult for you to use a wheeled planter.

Other structures, such as terraces and bunds, can help control erosion on slopes. Usually these structures are very useful – so keep them! See Chapter 8 for more on soil conservation.

Planting basins

You do not need special equipment to start using conservation agriculture. All you need is a hoe and a piece of string!

You do not need a tractor, draught animals or special equipment to practise conservation agriculture. You don't need money. You can do it using just a hoe and a piece of string.

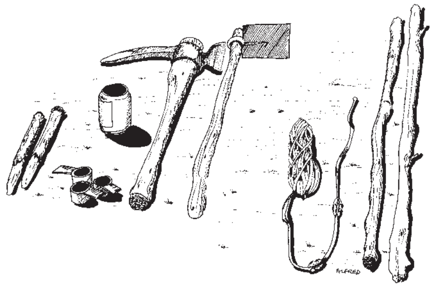
Using planting basins can work under almost all conditions in Africa. You can do it simply and easily, and you can adapt it to suit your own circumstances (see Photos 1 and 2).

Planting basins are small pits in the ground used for planting many types of crops. They are about 15 cm wide, 30–35 cm long, and 15 cm deep – about the size of a man's foot. They are best suited to areas with about 1000 mm of rain a year.

You can dig the planting basins at any time during the dry season, so they are ready for planting at the beginning of the rainy season.

Here are the basic principles. Adapt them to suit your own situation.

Equipment



Basic equipment needed for basin planting

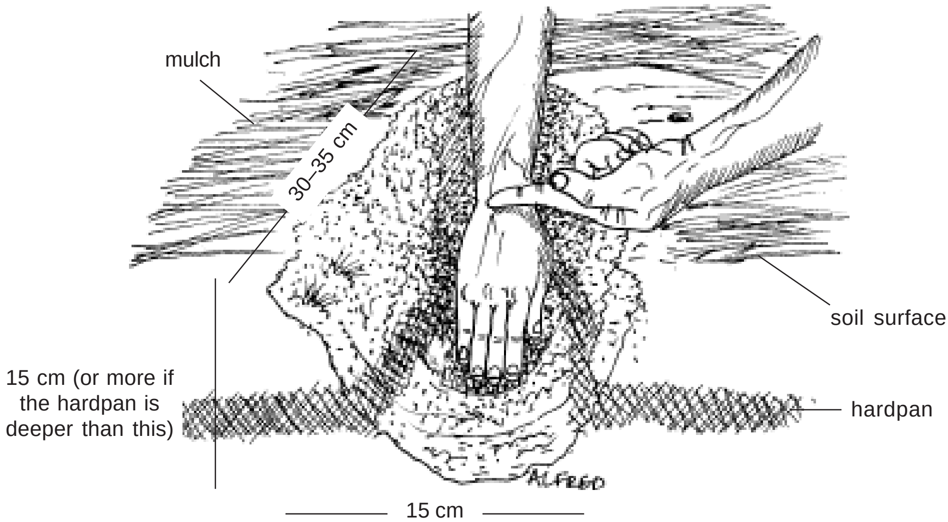
You will need the following tools:

- A **hoe** or *chaka* hoe (a type found in Zambia and Zimbabwe). It should be as narrow as possible (10 cm wide is good size).
- A long **string** (called a "*teren* rope" in Zambia). This is used to measure off the correct distance between the basins. Tie knots in the string at the plant spacing you want. (In Zambia, for example, farmers space their maize plants about 70 cm apart.) Instead of tying knots, you can clamp bottletops to the string at the correct intervals with pliers. Clamp them tightly so that they will not slip.
- Two **sticks** to mark the rows and to make sure the rows are parallel.
- Two strong **pegs** to hold the string at both ends.
- **Fertilizer cups** to apply fertilizer or lime.
- An empty **drink can** to apply manure.

How to make the basins

1. Stretch the rope across the field, at right angles to the slope, and fix both ends in place using the two pegs. Keep the string well clear of the ground so that it stays straight despite any vegetation. The knots or bottletops mark where to dig each basin. They act as guides for accurate spacing, since you will use the same basins again and again in the following seasons.
2. Starting at the first knot or bottletop at one end of the string, dig a rectangular basin about 15 cm wide and 30–35 cm long (about the size of a man's foot). The basin should be about 15 cm deep (about as deep as your hand). If there is a hardpan, make sure you dig deep enough to break through it.

Digging planting basins



Close-up of a planting basin. The hand shows how deep the basin is: it should break through the hardpan.

3 At the next knot or bottletop, dig another basin the same size. Work backwards along the string so you do not tread on the basins you have already dug.

4 When you reach the end of the row, use the sticks to measure the distance to the next row. Move the pegs and stretch out the string again between them. Stagger the holes so they are not directly next to the holes in the previous row. This will help catch more rainwater and stops it from running away downslope.

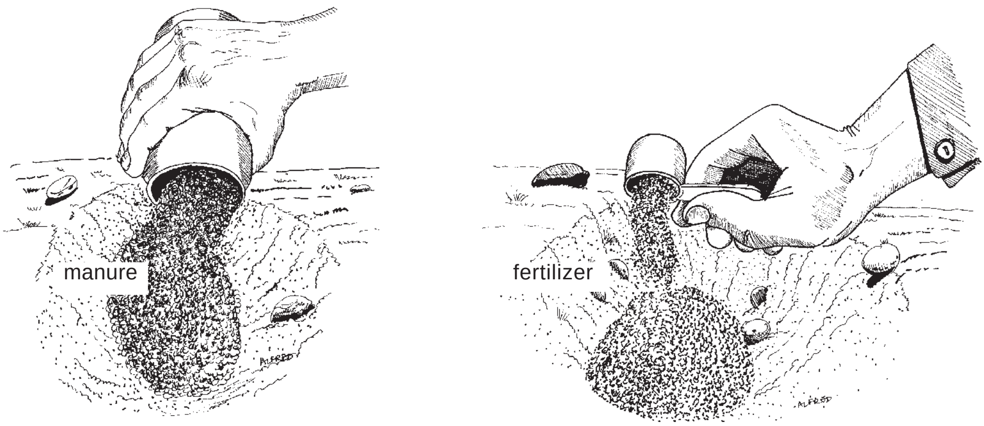
Applying fertilizer, manure and lime

If you have dug the basins properly and spaced them correctly, you can apply fertilizer, manure and lime very precisely to avoids wastage. Do this when you plant, or about 2 weeks before (doing it beforehand speeds up planting).

- **Manure** Put 1–2 drink cans of manure in each basin. This amounts to 3–4 tons of manure per hectare.
- **Compound fertilizer** Put a small container (8 g) of compound fertilizer in each basin.
- **Lime** If your soil is acidic, put in two containers of lime as well.

After you have applied manure, fertilizer or lime, use a hoe to partially fill the basins with soil. Leave the surface about 5 cm (2 inches) lower than the original ground level so water will tend to collect in the basin.

You can also apply compound fertilizer at planting time instead of 2 weeks beforehand.



Use containers to measure and apply organic manure and fertilizer

- **Urea** Apply 2 containers of urea per basin. The best time to apply urea depends on the crop. For maize, apply it as a top dressing when the maize is knee high (make sure the soil is moist when you apply it).

Planting

Deciding when to plant is one of the most important decisions a farmer has to make. The main aim is to make sure the seeds germinate quickly and evenly. Some guidelines:

- Plant seeds during heavy rain, or within 48 hours after it stops.
- Plant only if there is enough moisture for the seeds to germinate evenly. Mulching will improve the moisture level in the soil where you put the seed.
- Plant at the right depth for your crop. This helps the seeds to germinate and emerge evenly.
- Try to finish planting a field in one day.

Correct planting depth = good germination

How many basins, how many seeds?

The key is to know how many plants you need per hectare. Here are 2 examples:

- In **Lesotho**, farmers aim for about 35,000 maize plants per hectare. They do not dig 35,000 basins! Instead, they dig about 17,500 basins at a spacing of 75 x 75 cm. They put 3 maize seeds in each basin. They then thin the plants back to an average of 2 per basin.
- In **Zambia**, farmers aim for 47,000 maize plants per hectare. Their spacing of 90 x 70 cm gives them about 15,500 basins per hectare. They put 4 seeds in each basin, then thin them back to an average of 3 per basin.

What do you need to know?

- What is the average **rainfall** in your area?
- What is the best **planting population** of your crop?

Below are two simple tables to help you. You can use these to calculate the spacing of your basins, and how many seeds to plant in each.

Note: these are only guidelines. Adapt them as needed for your area.

How many basins?

Rainfall (mm per year)	Spacing of basins	Number of basins per hectare (rounded off)
> 1500	60 x 60 cm	27,500
1000–1500	70 x 70 cm	20,100
800–1000	75 x 75 cm	17,500
700–800	80 x 80 cm	15,500
600–700	85 x 85 cm	13,500
500–600	90 x 90 cm	12,500
< 500	100 x 100 cm	10,000

How many seeds per basin?

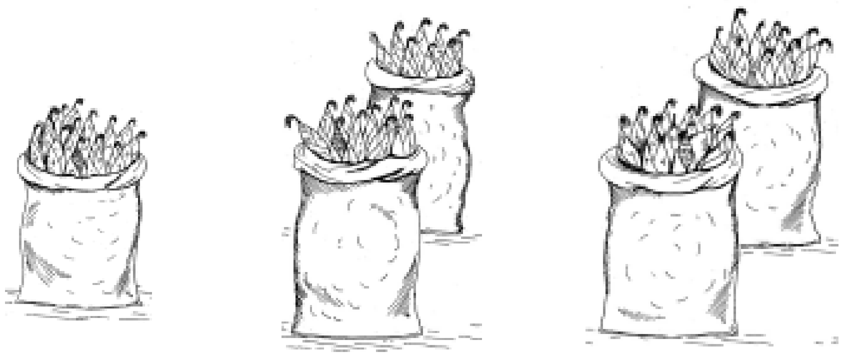
Crop	Number of seeds/basin	Planting depth
Maize	2–4 (then thin one)	2.5 cm
Sunflower	2–3 at each end of the hole	2 cm
Cotton	4–5 on each side	1 cm
Soybeans	8–12	1 cm
Groundnuts	6–10	3 cm
Cowpeas	5–7	2.5 cm
Green gram	6–8	2 cm
Sorghum	8–12	1 cm

Do's and don'ts when using planting basins

- Remember that the basins are permanent, and you will come back to plant the same place next season, and the season after that. So take care the first time.
- Train the whole family to make the basins. Everyone in the family should understand the ideas of conservation agriculture. If they understand why and how, they can help do it.
- Don't plant in a basin which is not nearly filled with soil – the crops will drown!
- Don't dig basins during the rainy season. Hardpans are best dealt with in the dry season.

Higher yields from basins

In an experiment in Zambia, planting basins and ripping gave more than twice the yield of conventional tillage. Over 100,000 farmers in Zambia use basins to plant their crops.



2.7 t/ha	6.1 t/ha	6.9 t/ha
Conventional tillage	**Permanent planting basins**	**Ripping**

Average maize grain yield, 2000–1 season, Zambia

More information: Zambia National Farmers Union, Conservation Farming Unit; Cecilia Ruben

Advantages

- It is easy to make and use planting basins. Elderly people, children and disabled people can all use them to grow the food they need.
- The required equipment (a hoe, string, bottle caps, drink cans) is readily available.
- You can dig the basins in advance, perhaps immediately after the harvest. This spreads the labour needs over a long period and means that planting can be done early – it is not necessary to wait for the soil to be ploughed before sowing the seed.
- Using basins makes it possible to plant early. They make weeding and applying fertilizer easier and quicker.
- Marking out the correct spacing of basins and rows gives the best plant population. Planting basins give better yields than conventional ploughing, and almost as good as rip planting (see the box above).
- Basins allow you to use the right amounts of seed and fertilizer, at the correct time. This avoids waste and saves money.
- You can use the same basins year after year. Plant a different crop in the same basins next season. The soil fertility in the basins builds up, guaranteeing a good yield.

Disadvantages

- Making the basins takes time, especially in the first year. It is a lot more work if the soil is compacted. That may make it difficult if the family has limited labour or if some of the family members are ill.
- There may be lot of weeds in the field. It is important to deal with them promptly (see Chapter 7).

Planting spots

If you do not have the time to dig planting basins, you can just scrape out shallow planting holes in the unploughed soil. Sow the seed in the holes, then cover them over. This approach is common throughout the Sahel (Mali, Niger, Chad, and other countries). The only equipment needed is the hand hoe and a planting stick. You can plant in the dry or just after the rains.

1. Dig small shallow holes at the correct distance from each other. Make the holes just deep enough to plant the seeds.
2. Put the correct number of seeds in the hole, and cover them with soil.
3. About 2 weeks after the crop emerges, use a stick to make a hole about 10 cm away from each plant. Put fertilizer into the hole.

Advantages

- Planting spots require less labour than planting basins or conventional cultivation. That makes them an attractive option for vulnerable households.
- Planting can be done on time: there is no need to wait until the soil is ploughed.
- Planting spots do not require expensive equipment – just a hoe and a stick.

Disadvantages

- It may be difficult to control weeds.
- Planting spots do not break a hardpan caused by hoeing at the same depth year after year. Crop roots may not grow as well as with planting basins, and less water will infiltrate into the soil.

Ripping and planting

Ripping opens a narrow slot or furrow in the soil surface, about 5–10 cm deep. It is often used to break up a surface crust or a shallow hardpan, especially on lighter soils (see page 39). It can also be used to open a furrow for sowing seeds – either by hand or using a mechanical planter attached to the ripper itself.

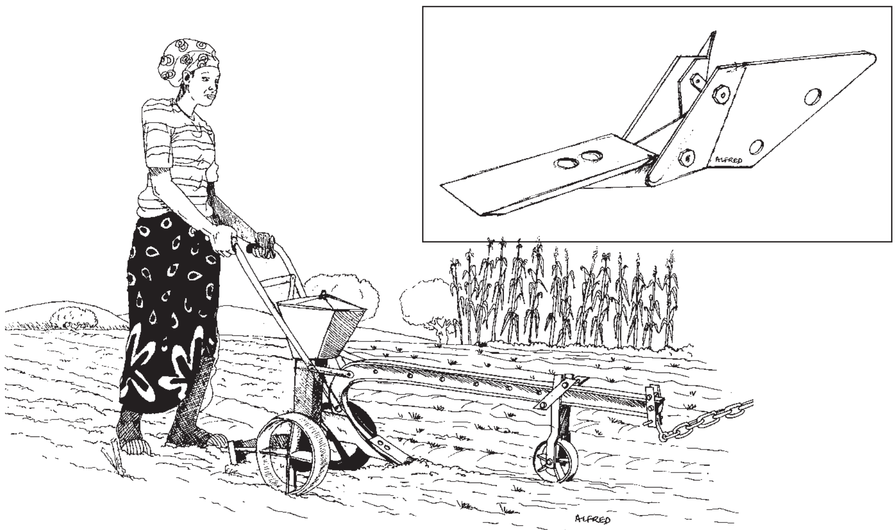
Using the ripper allows you to sow the crop earlier and faster than if you plough the soil and then plant.

If used for planting, ripped lines are usually spaced about 75 cm apart. The ground in between the rows is left undisturbed, except for controlling weeds. Rainwater concentrates in the planting lines and sinks into the soil where the crop roots are growing.

Equipment

You will need the following:

- **A ripper** There are many variations on the basic chisel-point design, and rippers vary depending how they are made. Animal-drawn rippers made by local blacksmiths are popular in eastern Africa.



Animal-drawn ripper with planter attachment. Inset: The Magoye ripper body with wings to make ridges. This body can be replaced by a narrower subsoiler to break up a hardpan (see the drawing on page 40).

Ripper with planter attachment

As the ripper-planter's wheels turn, they drive the delivery of seed and fertilizer. If the wheels skid, or if they hit a bump, the planter will apply too little seed and fertilizer (or too much). That is why it is important to remove any ridges and furrows from the field before starting conservation agriculture. Some makes of planter have wheels with strakes (spikes) to prevent skidding.

One commercially available version (the **Magoye** ripper) consists of a ripper that fits on a standard mouldboard plough beam. It also has a mechanism to sow seed, known as the **Palabana** ripper-planter.

- **Draught animals or a tractor** Ripping takes a lot of power (though not as much as ploughing), so you may need two strong oxen. You may be able to use donkeys to pull the ripper if the soil is light, if the ripper has a narrow blade, and if the ripping depth is shallow. On heavy soils or for deep ripping, you may need a tractor.
- **A planting tool** Some rippers have a planter attachment that can do both ripping and planting in a single pass. The attachment sows the seed (and perhaps applies fertilizer), then covers it over (see Photos 7–14 and the drawing on the previous page). If you do not have a ripper-planter, you can sow seeds in the ripped furrow by hand, or using a machete or planting stick.

How to do ripping and planting

It is best to do ripping when the soil is dry. That avoids compacting the soil further, and ensures that the hardpan is broken.

If the field has a cover crop, slash it (or use a herbicide to kill it). When it has dried out, you can use a ripper though the mulch. The mulch protects the soil surface from heavy rain and prevents weeds from growing.

If your field is on a slope, rip along the contour (at right angles to the slope). This will help control erosion.

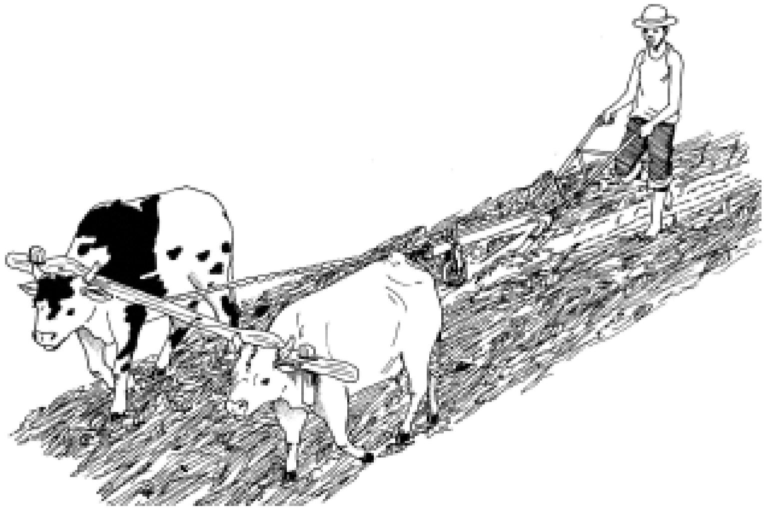
Heavy clay soils will be difficult to rip when they are dry. If you are using draught oxen, feed them well beforehand so they are strong enough to pull the ripper easily. You may have to rip the field twice to make sure the soil is loosened enough. If you use four animals, you may need to make only one pass.

Ripping heavy clay soils will produce large clods, especially if the soil has been compacted. It is a good idea to leave these soils until the first rains have moistened them a little before ripping them. You can plant seeds at the same time. If clods are formed, someone should follow behind to make sure the seeds are well covered.

How far apart to space the ripped slots? This depends on the optimum row width for the crop you want to plant; about 75 cm is a common distance. Animals are generally trained to follow the previous furrow, so the row width will be determined by the length of the yoke between the animals. See Photo 10 and page 58 for how to adjust this.

As soon as you have ripped the soil, you can sow seeds in the ripped opening. You can use any suitable method: by hand, using a planting stick or machete, or with a planter attached to the ripper. Cover the seed after sowing so it is not eaten by birds or animals.

You can rip along the same lines season after season. If possible, plant a different crop in the row in the next season to rotate the crops.



Animal-drawn ripper

Tractor ripping

Medium- and large-farmers often use tractors to rip the soil. Some small-scale farmers hire a tractor to rip their fields.

Tractor ripping is faster than with draught animals, but it needs a larger area to be profitable. Tractor ripping produces better results in heavy soils. Some tractor-rippers also have a planter attachment.

Advantages

- Ripping attachments that fit on a normal plough beam are cheaper than complete implements.
- Rippers can be used to make planting slots in dry soil. This allows you to plant early and gives you a head start for other field operations.
- Ripping disturbs the soil less than ploughing. It reduces soil erosion and encourages water infiltration into the soil.

Disadvantages

- Ripping needs strong draught animals or a tractor.
- Ripping is difficult if there is a lot of residue on the surface, because the residue wraps around the ripper shaft. You may have to clear it away from the lines to be ripped, or cut it into pieces to stop it from tangling around the ripper.
- Ripping disturbs quite a lot of the soil surface: up to 30%.
- It may be difficult to control weeds between the rip lines. You may need to use hoes or herbicide to get rid of weeds.

Horticulture

You can use conservation agriculture to grow vegetables. Many vegetable crops grow well without tillage.

- **Root crops (such as carrots)** Use a pick to break the soil and make a hole so the root can grow down. Put in the seed and cover it with soil.
- **Tomatoes** These grow very well under conservation agriculture. Make a hole in the soil and put compost or manure in it. Cover the compost with a little soil, and plant your seedling in the hole.
- **Potatoes** Spread a lot of manure on the area to be planted (say, 5 m x 5 m). Place your potato seed at 30 cm intervals on top. Cover the seed with a thick layer of mulch (up to knee height). The plant and tubers will be able to grow well.

Try to apply the principles of minimum soil disturbance, soil cover and rotation in your garden. Try growing other vegetables on a small scale. Do not be afraid to make mistakes: you will quickly learn what works.

Controlling weeds and the cover crop before planting

Conservation agriculture tries to keep the soil covered with a cover crop or with crop residues. Before you plant, you may have to kill the cover crop, along with any weeds. If you do not, they will smother your crop before it has had a chance to grow.

You can do this in many different ways:

- **Hand-pull** weeds or use a **hoe** to kill them.
- Slash weeds and the cover crop with a **machete** or **billhook**.
- Use an animal- or tractor-drawn **knife roller**.
- Apply **herbicides** with a wiper or sprayer.

See Chapter 8 for how to use these different methods.

Planting methods

You can plant seed in various ways:

- By hand in **planting basins**.
- Using a **dibble stick** or **machete**.
- Using a **jab-planter**.
- Using an **animal-drawn planter**.
- Using a **tractor-drawn planter**.

All these methods disturb the soil as little as possible, and help maintain a permanent soil cover (two of the three principles of conservation agriculture).

No-till planters are designed to plant seed in the soil through the surface mulch. This makes them different from conventional planters, which are designed to work in tilled soil without surface residues.

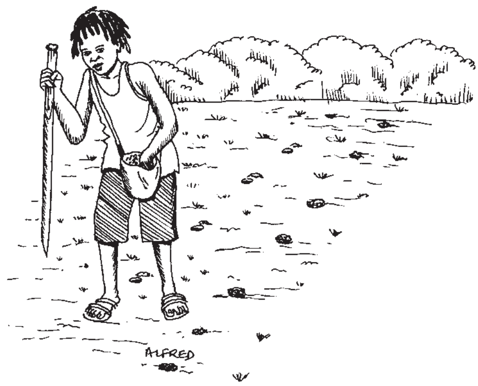
Hand-planting in basins

If you are using planting basins, plant seeds in the basins, add fertilizer, then cover with soil. See page 41 for more information.

Using a dibble stick or machete

You can use a planting stick or machete to make holes to plant the seed. Cut a hardwood stick from the bush, sharpen the point, and use it to make planting holes. Make the holes in lines at evenly spaced intervals. That makes it easier to weed and apply fertilizer or manure.

Adding a sharpened steel tip to the planting stick makes it last longer and easier to use. Such sticks are often available from the village blacksmith.



A simple planting stick is all you need to direct-plant your crops

Reduced tillage for tef

Tef, a major grain crop in Ethiopia, has very small seeds. It cannot be planted in rip lines because the tiny seeds do not come into enough contact with the soil. Farmers often plough as many as five times in a crisscross pattern to produce a very fine seedbed. This repeated tillage encourages erosion.

One alternative is to rip the field once, in rows 75 cm apart, before the rains. This allows water to infiltrate into the soil easily. Subsoiling along the ripped lines is used to break a hardpan. On heavy black soils, subsoiling is not needed because deep cracks form on these soils in the dry season, breaking the hardpan.

The farmers then plough just once, 2–3 weeks before planting, using a *maresha* plough modified to turn the soil to one side only. They can then plant tef seeds using a sweep: an implement like a winged cultivator or a blade harrow that operates at a depth of 5 cm.

More information: Melesse Temesgen

If you are planting into ripped lines, you may need a machete to open a hole for the seed and to cover it over again with soil.

Using a jab-planter

A jab-planter makes planting seed easier and quicker. A jab planter is a simple device that is operated by hand. It has two shafts made of metal or wood, with handles at the top and a steel beak at the bottom. A hopper on one of the shafts holds the seed (Photos 4–6).

Using a jab-planter is easy, but does require practice:

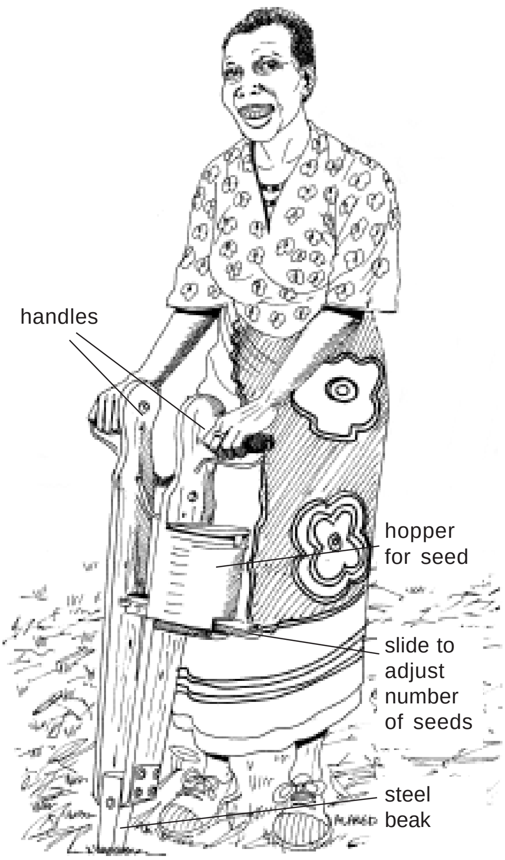
1 Hold the handles apart. This opens a slide and allows a seed to fall into the closed beak.

2 Jab downwards so the beak pushes into the soil.

3 Push the handles together. This opens the beak, so the seed falls into the hole you have made.

4 Keeping the handles together, lift the jab-planter out of the soil. The soil will fall back into the hole, covering the seed.

Some jab-planters have two hoppers, one for seed and one for fertilizer. You can control the number of seeds and the amount of fertilizer that is applied by moving a slide at the bottom of the hoppers.



A simple jab planter. Some models have two hoppers: for seed and fertilizer

Make sure you plant at the correct spacing for your crop. As a guide, a man's normal stride is about 60 cm long. If you want to plant at a spacing of 70 cm, you will have to take a long stride between "jabs". Test yourself with a measure until you can judge the right distance.

You can keep in a straight line by sighting on a tree or hill in the distance, and head towards it while planting. You can keep the right distance between rows by checking the marks you made in the previous row.

Using an animal-drawn planter

Animal-drawn planters open up a narrow slot in the soil, plant the seed, then cover the seed over with soil. There are several types.

Hand-operated planters

With the simpler, cheaper types such as those designed by **Triple W Engineering** (Photos 7–8), the operator drops seed down a tube into the slot cut by the ripper. Wings on the ripper cover the seed with soil. The operator must drop the seed down the tube at the right rate in order to get required seed spacing and plant population. Again, this takes practice.

The planter can plant any type or size of seed without adjustments. These planters can be made locally using inexpensive raw materials, such as used car springs. The planter equipment can be taken off the frame and replaced by other tools, such as a weeder.

Automatic planters

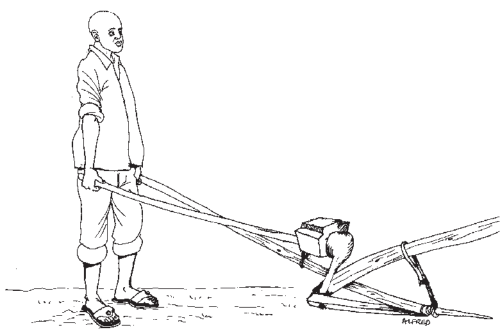
More sophisticated models have a seed hopper and metering system that sows the right number of seeds automatically, and perhaps a second hopper for fertilizer. Some planters can be attached to a ripper (see page 49).

The **Fitarelli No. 12 planter**, for example, is attached to a yoke pulled by draught oxen. A disk cuts through vegetation and mulch on the surface, and a chisel point opens a furrow for the seed and fertilizer. The rear wheel drives a mechanism that drops seeds and fertilizer through tubes just behind the chisel. The rear wheel then covers the seed with soil. The operator can correct the seed spacing in the row by adjusting the gears on the wheel.

Other planters (e.g., **Knapik**, **IADEL** and **Triton**: see Photos 13–14) are attached to a chain that is pulled by draught animals. Like the Fitarelli machine, they have a vertical disc to cut through mulch, and a chisel point or a pair of inclined discs to open a furrow. They have hoppers for seed and fertilizer, and a mechanism to control how much of each is applied.

Semi-automatic planters

One problem with automatic planters is that their wheels may sometimes skid, especially on stony or muddy ground. The wheels control the release of seed and fertilizer, so leave unplanted gaps if they do not turn.



A semi-automatic row planter, developed by the Ethiopian Agricultural Research Organization. More information: Melesse Temesgen

A semi-automatic row planter, developed by the **Ethiopian Agricultural Research Organization**, avoids this problem. The operator moves a handle back and forth to release seeds and fertilizer. The planter has no wheels, so can be used in fields where other planters would be hard to manage.

> **Equipment suppliers**
>
> African farmers can choose from several makes of animal-drawn planters and fertilizer applicators. See Chapter 14 for a list of manufacturers and suppliers.

Tractor-mounted planters

Tractor-mounted planters can plant and fertilize several rows at a time. They have several hoppers for seed and fertilizer (typically 3–6 for small and medium tractors), mounted side-by-side (Photo 12). They work in a similar way to the animal-drawn equipment described above, but are faster and more accurate – and of course, more expensive.

It is possible to use a hand-tractor to pull a ripper or planter. Such tractors may be useful if draught animals are scarce – for example if there is not enough fodder in the dry season to feed livestock.

Using the right amount of seed and fertilizer

When using equipment that plants seed or applies fertilizer, it is important to make sure that the right amount is being applied. If you do not, you will end up with the wrong plant spacing, plant population and fertilizer dosage. You risk getting lower yields and wasting money.

Working out how many kilograms of seed you need

You want to know how many kilograms of seed you will need to plant your field. You will need to know how big your field is, and what the recommended seeding rate per hectare is.

1 Borrow some scales (from a shopkeeper?) and weigh out 10 grams of the seeds. Then count the number of seeds you have weighed.

2 Work out how many kilograms of seeds you need for your field:

$$\textbf{Number of seeds in 1 kg} = \text{Number of seeds in 10 grams} \times 1000$$

(Equation A)

$$\textbf{Kilograms of seeds needed} = \frac{\text{Number of seeds needed per hectare} \times \text{Size of field (hectares)}}{\text{Number of seeds in 1 kg}}$$

(Equation B)

Example

You count the number of seeds in 10 grams, and find there are **23 seeds**.

The recommended seeding rate for this crop is **50,000 per hectare**.

You want to plant a one-fifth of a hectare (**0.2 hectare**).

Number of seeds in 1 kg = 23 x 1000 = 23,000 seeds

$$\text{Kilograms of seeds needed} = \frac{50{,}000 \text{ seeds} \times 0.2 \text{ hectare}}{23{,}000}$$

$$= 0.43 \text{ kg}$$

You will need **0.43 kg** of seed.

Adjusting a jab planter

You have to adjust the settings of a jab planter so it delivers the right amount of each. There is a slide at the base of the hoppers that determines the amount of seed and fertilizer that drop through when you pull the planter handles apart. How many seeds drop through depends on how big the seeds are.

Move the slide until the right number of seeds crop through – for example, two or three maize seeds each time. Check this by opening and closing the handles 10–20 times, then counting the number of seeds that drop.

You can open and close the jab planter over someone's hands to show how much seed and fertilizer it delivers.

Calculating the planting distance and plant population for a jab planter or planting stick

If you know **the number of plants you want per hectare**, you can use this equation to calculate the planting distance within the row:

$$\textbf{Planting distance within row (m)} = \frac{10{,}000 \text{ m}^2}{\text{Number of plants per hectare} \times \text{Distance between rows (m)}} \times \text{Number of seeds per hole}$$

(Equation C)

Example

You want **35,000** plants per hectare at a row spacing of 75 cm (**0.75 m**) and **2 seeds** per hole. How far apart should you space the planting holes?

$$\text{Planting distance within row (m)} = \frac{10{,}000 \text{ m}^2}{35{,}000 \text{ plants} \times 0.75 \text{ m}} \times 2 \text{ seeds per hole}$$

= 0.76 m

= about **75 cm**

If you know the **planting distance**, you can calculate the number of plants per hectare using this equation:

$$\textbf{Number of plants per hectare} = \frac{10{,}000 \text{ m}^2}{\text{Planting distance within row (m)} \times \text{Distance between rows (m)}} \times \text{Number of seeds per hole}$$

(Equation D)

Example

You want to use a planting distance of 75 x 75 cm (**0.75 x 0.75 m**) and **2 seeds** per hole. What will your plant population be?

$$\text{Number of plants per hectare} = \frac{10{,}000 \text{ m}^2}{0.75 \text{ m} \times 0.75 \text{ m}} \times 2 \text{ seeds per hole}$$

= 35,555

= about **35,000 plants**

Calculating the amount of fertilizer to apply with a jab planter or planting stick

How much fertilizer should you apply in each hole? You need to know the **planting distance within the rows,** the **distance between the rows,** and the **fertilizer recommendation** per hectare. You can then use this equation:

$$\textbf{Grams of fertilizer per hole} = \frac{\text{Planting distance within row (m)} \times \text{Distance between rows (m)} \times \text{kg of fertilizer per hectare}}{10}$$

(Equation E)

Example

You want to apply 100 kg of fertilizer per hectare. Your planting distance is 0.75 x 0.5 m. How much fertilizer should you apply in each hole?

$$\text{Grams of fertilizer per hole} = \frac{0.75\text{ m} \times 0.5\text{ m} \times 100\text{ kg}}{10}$$

$$= \mathbf{3.75\ g}\text{ per hole}$$

If you are using a jab planter with a fertilizer hopper, fill the hopper, adjust the fertilizer delivery slide, then open and close the jab planter until a constant amount of fertilizer falls to the ground. Open and close the jab planter 20 times, then weigh the fertilizer that has fallen through. If it is more (or less) than 20 times the amount you need, close (or open) the slide a little and test it again.

Adjusting the distance between rows with an animal-drawn planter

If you are using draught animals, how can you make sure your planting rows are spaced the right distance apart?

Draught animals are trained to follow the previous furrow or planting line. So the distance between the rows will be half the distance between the animals – which is determined by the length of the yoke (crosspiece) between them.

For a row spacing of **75 cm**, the animals must be **150 cm** apart. Use a yoke a little longer than this so it is long enough to harness the animals to it.

Adjusting an animal-drawn planter

You can adjust the number of seeds that a planter delivers in different ways. How to make this adjustment depends on the particular planter you are using.

Here is how to work out the planting distance and number of seeds per hectare for planters that use a wheel to control the seeding.

1. Make sure you are using the right seed plate for your seed. Seed plates are designed for graded seed. If your seed is ungraded (if the seeds are different sizes), you will get different numbers of seeds in each planting hole. Choose a plate that gives you the best number on average for your needs.
2. Mark one point on the drive wheel (the wheel that runs the seed and fertilizer feed). Put the planter in the gear you will use, then pull it in a line along the ground, counting how many times the drive wheel turns. Pull it

until the wheel has gone round 10 times. Now measure the distance you have pulled it.

3 Now fix a plastic bag over the bottom of the seed spout. Put some seeds in the hopper and hold the planter up so the drive wheel is clear of the ground. Without moving the planter, turn the wheel 10 times. Turn the wheel at the same speed as if animals were pulling the planter.

4 Count the number of seeds that are collected in the plastic bag.

5 You can now work out the **planting distance** for this seed size and planter setting:

$$\textbf{Distance between seeds (m)} = \frac{\text{Distance covered in 10 wheel turns (m)}}{\text{Number of seeds dropped}} \qquad \textbf{(Equation F)}$$

Example

You pull the planter along and count drive wheel turning 10 times. You measure the distance, and find you have pulled it **15 m**.

When you rotate the drive wheel 10 times, you collect **37 seeds** in the plastic bag. What is the planting distance?

$$\text{Distance between seeds (m)} = \frac{15\text{ m}}{37\text{ seeds}}$$

$$= \text{about } 0.4\text{ m}$$

$$= \mathbf{40\ cm}$$

6 You can also work out the **number of seeds per hectare**:

$$\textbf{Number of seeds per hectare} = \frac{10{,}000\text{ m}^2}{\text{Planting distance within row (m)} \times \text{Distance between rows (m)}}$$

(Equation G)

Example

Using the same planter settings as above, you want to plant at a distance of 75 cm (**0.75 m**) between rows. How many seeds will you plant per hectare?

$$\text{Number of seeds per hectare} = \frac{10{,}000\text{ m}^2}{0.4\text{ m} \times 0.75\text{ m}}$$

$$= \mathbf{33{,}333}\text{ seeds}$$

7 Test the planter on a sandy piece of soil to demonstrate where it places the seeds. Measure the distance between the seeds to make sure your calculations are correct.

8 You can adjust the seeding rate by changing the gears or sprockets on the planter. The settings are different on each machine.
   - On the **Fitarelli** planter, slide the gears along the drive shaft until the one you want is engaged.
   - On other planters (e.g., **Knapik**, **IADEL**, **Triton**), remove one sprocket and replace it with a large or smaller one to get the seed rate you want (Photos 15–16).

Adjusting fertilizer amounts

The best amount of fertilizer depends on the type of fertilizer, the soil and the crop type. You will have to adjust the planter for each situation.

You can calculate the fertilizer application rate in a similar way to the seeding rate:

1 Tie a plastic bag over the fertilizer spout, raise the wheel off the ground, and turn it 10 times. Weigh how much fertilizer is collected in the bag.

2 Calculate the fertilizer delivered per hectare using this equation:

$$\textbf{Kilograms of fertilizer per hectare} = \frac{\text{Amount of fertilizer delivered in 10 wheel turns (grams)} \times 10}{\text{Distance covered in 10 wheel turns (m)} \times \text{Distance between rows (m)}}$$

(Equation H)

Example

Your planter delivers **70 g** of fertilizer when you turn the wheel 10 times. When you pull the planter so the drive wheel turns 10 times, it travels **15 m**.

Your row spacing is **0.75 m**. How much fertilizer will you apply per hectare?

$$\text{kg of fertilizer per hectare} = \frac{70\text{ g} \times 10}{15\text{ m} \times 0.75\text{ m}}$$

$$= \textbf{62 kg} \text{ per hectare}$$

3 Adjusting the fertilizer rate is different on different planters.
   - On the **Fitarelli No. 12 planter**, you can change the star wheels. There are two of these wheels, one half the width of the other. The smaller wheel will deliver half the amount of fertilizer. You can use more than

one wheel, and you then slide a metal plate along to prevent fertilizer from leaking.

- On the **Knapik planter**, you can change the drive sprocket to set the amount of fertilizer delivered. You can fine-tune the amount by adjusting the cover on the fertilizer spout.
- On the **IADEL planter**, you can change the drive sprocket, and raise or lower the hopper to allow more or less fertilizer to be fed into the delivery tube.

Used to acres?

If you are more used to acres rather than hectares, you can use these equations. The equation letters (**B**, **C**, etc.) are the same as in the preceding pages.

$$\textbf{Kilograms of seeds needed} = \frac{\text{Number of seeds needed per acre} \times \text{Size of field (acres)}}{\text{Number of seeds in 1 kg}}$$

(Equation B)

$$\textbf{Planting distance within row}\ \text{(m)} = \frac{4{,}048\ \text{m}^2}{\text{Number of plants per acre} \times \text{Distance between rows (m)}} \times \text{Number of seeds per hole}$$

(Equation C)

$$\textbf{Number of plants per acre} = \frac{4{,}048\ \text{m}^2}{\text{Planting distance within row (m)} \times \text{Distance between rows (m)}} \times \text{Number of seeds per hole}$$

(Equation D)

$$\textbf{Grams of fertilizer per hole} = \frac{\text{Planting distance within row (m)} \times \text{Distance between rows (m)} \times \text{kg of fertilizer per acre}}{4}$$

(Equation E)

$$\textbf{Number of seeds per acre} = \frac{4{,}048\ m^2}{\text{Planting distance within row (m)} \times \text{Distance between rows (m)}}$$

(Equation G)

$$\textbf{Kilograms of fertilizer per acre} = \frac{\text{Amount of fertilizer delivered in 10 wheel turns (grams)} \times 4}{\text{Distance covered in 10 wheel turns (m)} \times \text{Distance between rows (m)}}$$

(Equation H)

Useful numbers

Weight

1 kg = 1000 grams

1 soft drink bottle cap of fertilizer = about 3–4 grams

1 soft drink can of compost = about 150 grams

Distance and area

1 m = 100 cm

1 m = 3.28 ft

1 hectare = 10,000 m^2

1 hectare = 2.47 acres

1 acre = 4048 m^2

1 acre = 43,560 sq ft

4

Keeping the soil healthy

Many of Africa's soils are sick. Yields in many places have fallen over the last 20 years. Fields that used to produce 20 bags of maize might now produce less than 10 bags.

Many farmers face crop failure, and their families are hungry. Countries that used to export maize now depend on food aid.

Conservation agriculture can make these soils healthy again. And if the soils are healthy, yields will go up. Farmers will be able to feed their families and have extra to sell.

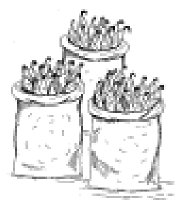
What makes soils hungry and sick?

Virgin soils under forest, bush or grasslands have a lot of organic matter. This rich, black material has built up over many years. It is very fertile. When farmers clear the natural vegetation, they at first get very good yields.

But ploughing the land and removing the crop residue leaves the land bare. The plant nutrients are washed away. The fine particles, clay and valuable organic matter are eroded first, leaving a poor, hungry soil (Photo 17).

When the soil is turned, the organic matter decomposes quickly. It turns into lifeless minerals or into carbon dioxide gas, which disappears into the air. Within 10 years after opening virgin land, more than half the organic matter is lost.

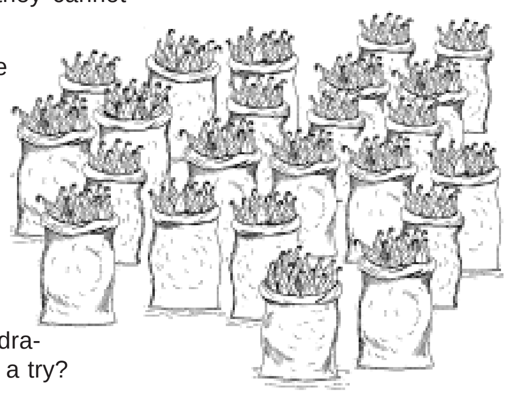
Which would you prefer?



Three bags of maize from your acre of land.

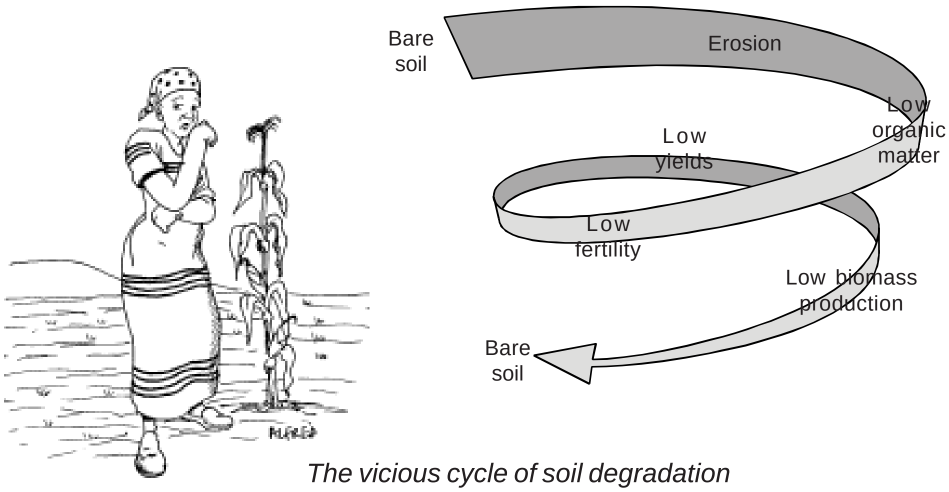
Or 22 bags?

Farmers in Lesotho harvest just three bags of maize per acre: 375 kg per hectare. They plough their fields with oxen or with tractors. They plant the same crop year after year. The soils are poor, compacted and eroded. And three bags are all they can harvest. People are leaving the land because they cannot make a living.



But if they manage their soil well, the same farmers can produce 22 bags of maize per acre – or 4 tons per hectare. By using conservation agriculture – avoiding ploughing, keeping the soil covered, and rotating crops – they can rebuild their soil fertility. The soil will repay them many times over with higher yields, year after year.

Of course, not all farmers can get such dramatic increases – but some can! Worth a try?



The vicious cycle of soil degradation

Organic matter holds onto water and plant nutrients. Once the organic matter is gone, the water drains away or runs off easily. Nutrients are washed deeper down into the soil, where plant roots cannot reach them.

Earthworms, termites and other tiny animals normally make burrows in the soil and break down the organic matter into simpler forms that plants can use. But they cannot live if there is no organic matter. Without them, the soil becomes hard and lifeless.

Ploughing destroys the soil structure. Below the ploughed layer, a hardpan develops. Crop roots cannot push through this hard layer, so they cannot reach water and nutrients beneath it. The shallow layer above the hardpan dries out quickly during dry spells, so the crops go thirsty too.

The soil has become seriously sick. It has lost its ability to produce a good crop.

What makes a soil sick?

- "Mining agriculture": farming for many years, taking away nutrients without giving any back to the soil
- Soil erosion
- Loss of organic matter
- Loss of soil life
- Breakdown of soil structure
- Compaction of the soil
- Bare soil exposed to the rain and sun

What effects does a sick soil have?

- Low crop yields
- High levels of inorganic fertilizers needed to produce a good crop
- Crops are short and stunted
- Bare soil
- Yields vary widely from year to year.
- Yields tend to fall year after year

How to tell your soil is sick

You probably already know if your soil is sick. Here are some things to look for:

Organic matter	Is the topsoil colour lighter than it used to be?	**Yes**	☐	**No**	☐
Soil structure	Does the soil feel hard? If you press a piece of soil in your hand, does it break apart completely?	**Yes**	☐	**No**	☐
Runoff	Are there rills caused by water on the soil surface? On flat ground, does water take a long time to seep into the soil?	**Yes**	☐	**No**	☐
Soil moisture	Does the soil get dry quickly after a good rain?	**Yes**	☐	**No**	☐
Soil life	Do you rarely see earthworms or beetles?	**Yes**	☐	**No**	☐
Crops	Do the crops look unhealthy? (yellowed leaves, purple stripes, poor growth)	**Yes**	☐	**No**	☐
Yields	Are your yields falling year after year?	**Yes**	☐	**No**	☐
Roots	Are the crop roots stunted? Are they shallow? Do the taproots bend sideways rather than going straight down?	**Yes**	☐	**No**	☐
Weeds	Are there a lot of the type of weeds that like to grow on infertile soil? Especially woody weeds and *Striga*?	**Yes**	☐	**No**	☐

If you answered *Yes* to any of these questions, your soil may be sick.

Organic matter

A healthy soil has a lot of organic matter. Organic matter provides a home and food for earthworms and other beneficial soil organisms. It binds soil particles together and improves the soil structure. It helps the soil hold water. It improves the soil fertility and leads to higher yields.

Conservation agriculture aims to keep the soil alive

A healthy soil is a living soil. It must be full of earthworms and other soil organisms. These organisms loosen the topsoil better than a hoe or a plough. They break up dead leaves and stalks, carry it down into the soil, and mix it in. They speed up the decomposition of organic matter and release of plant nutrients. They compete with harmful organisms that may cause crop diseases.

How fast the organic matter **breaks down** depends on three things:

- **Soil organisms:** animals (earthworms, beetles, termites, other insects), microorganisms (bacteria and fungi too small to be seen with the naked eye), and plants. (If there are many of these organisms, the organic matter will decompose quickly.)
- **The physical environment:** the soil texture, temperature, moisture and air. (Organic matter decomposes slowly if the soil is dry, for example.)
- **Quality of organic matter:** Woody stems and waxy leaves break down slowly.

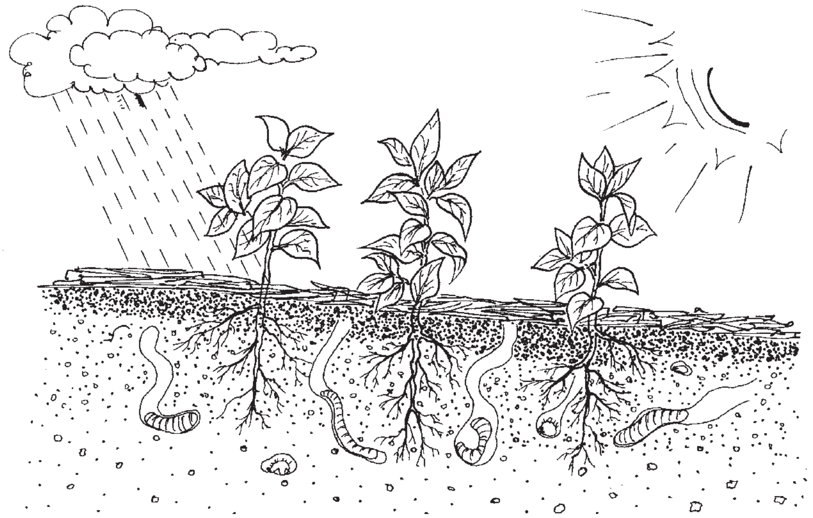
The soil can **lose organic matter** in several ways:

- It is broken down into minerals and carbon dioxide gas. This happens quickly if the soil is turned over by ploughing and if it is exposed to the sun and rain.
- Erosion: it is washed away by water, or carried off by wind.
- It is carried out of the field as crops or fodder.

What is a healthy soil?

A healthy soil is a living soil.

- It has many different animals in it: earthworms, beetles, and many tiny animals that are so small they cannot be seen with the naked eye.
- It is high in organic matter.
- It is rich in nutrients that plants can use as food.
- It is deep enough for plant roots to grow properly.
- It has a mixture of fine (clay) soil particles and coarse particles (sand and silt).
- It contains lumps and clumps of different sizes.
- The surface does not seal after rain.



A healthy soil has lots of organic matter, earthworms and other tiny animals in it.

You can do many things to **prevent organic matter from being lost**:

- Don't plough or hoe.
- Use mulch or a cover crop to protect the soil from sun and rain.
- Prevent erosion: plant along the contour, use bunds and microcatchments, etc.
- Don't take the crop residues out of the field. Leave them on the ground.
- Do not allow animals to graze on the field.

You can **add to your organic matter bank** in several ways:

- Leave crop residues in the field.
- Plant cover crops.
- Bring in mulch from outside.
- Add compost and manure.

Making the soil healthy again

Fortunately, it is possible to make a sick soil healthy again. Here are the steps:

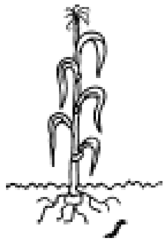
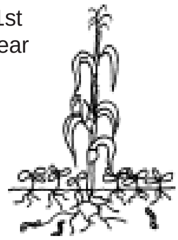
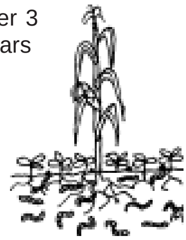
1. If your soil has a hardpan, **break it with a subsoiler**. This allows water to sink into the soil, and lets crop roots reach nutrients and water deeper in the soil.
2. **Stop ploughing** and hoeing the soil. Instead, you can use a hoe to make planting basins, open planting lines with a ripper, or plant directly using a jab planter.
3. **Do not remove crop residues**, and do not allow animals to graze on them. Leave them on the ground so they protect the soil and add to the organic matter.

How to tell if your soil is getting healthier

Here are some things to look for:

Organic matter	Is the soil getting darker?	**Yes** ☐	**No** ☐
Soil structure	Is the soil getting softer underfoot? Is it easier to work?	**Yes** ☐	**No** ☐
Runoff	Does rain soak into the soil quickly? Rain infiltrates fast and water does not stay on the surface	**Yes** ☐	**No** ☐
Soil moisture	Does it stay moist for longer after rain?	**Yes** ☐	**No** ☐
Soil life	Does the soil have many earthworms? Are there many holes in the soil, and worm casts on the surface?	**Yes** ☐	**No** ☐
Crops	Do your crops look vigorous and healthy?	**Yes** ☐	**No** ☐
Yields	Are crop yields improving?	**Yes** ☐	**No** ☐
Roots	Do the crop roots grow well? Are taproots deep and straight?	**Yes** ☐	**No** ☐
Weeds	Are there the type of weeds that like to grow on fertile soil?	**Yes** ☐	**No** ☐

If you answered *Yes* to these questions, congratulations! Your soil should be getting healthier.

	Conventional tillage, no cover crop	Conservation agriculture, lablab and maize stover	
Number of worms in 1 m^2	 1 worm	1st year  12 worms	After 3 years  28 worms

Karatu District, northern Tanzania. Source: TFSC/SARI, Arusha

Using conservation agriculture can increase number of earthworms and other small animals in the soil very quickly

4 **Keep rainwater in the field** When it runs off, the water carries plant nutrients and organic matter with it. Build microcatchments or bunds along the contour to prevent it from running away.

5 **Add organic matter** and plant nutrients: compost, manure, mulch brought in from outside the field, and inorganic fertilizer.

6 **Plant cover crops** to protect your soil and produce more organic matter. If your soil is compacted, you can loosen it by planting strong-rooted cover crops such as pigeonpea or sunn hemp (see Chapter 5).

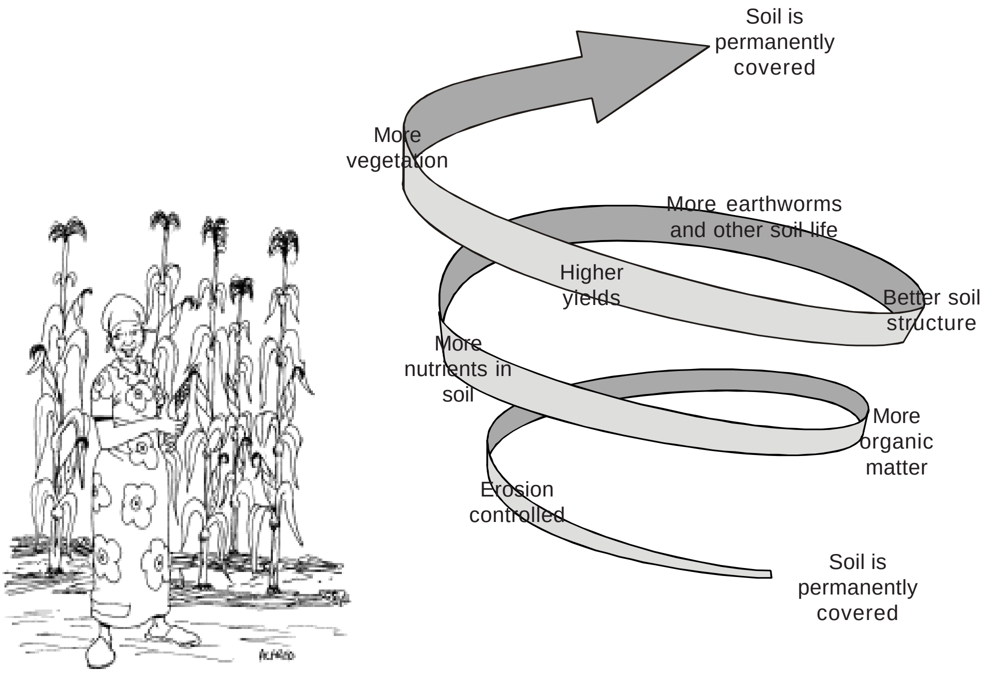
Keeping the soil healthy

It is not enough to apply inorganic fertilizer to keep the soil healthy.

In conventional farming, it is necessary to apply more and more fertilizer to get the same yield.

Conservation agriculture, on the other hand, produces more yield for the same amount of fertilizer. It does this because the soil structure is better and there is more organic matter. Crop roots can go much deeper, and more water can sink into the soil. There are more living organisms to recycle organic matter and make plant nutrients available.

Conservation agriculture keeps the soil healthy. Only a healthy soil can produce a good yield.



Recycling of organic matter and plant nutrients keeps the soil healthy

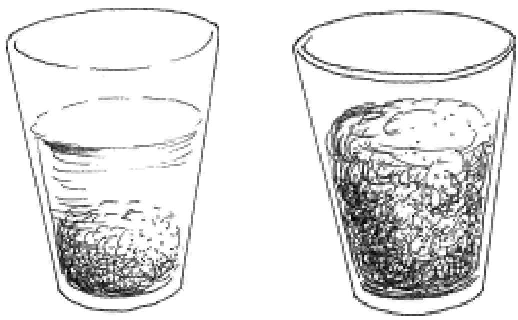
How rich is your soil?

Here's one way to check the organic matter in your soil.

1 Take a handful of soil from a field that has been ploughed for several years. Put it in a glass of water.

2 Now take a handful of the best soil you can find – a soil full of organic matter. Put it in another glass of water.

3 Compare what you see in the two glasses.



Many worms make light work

Earthworms are the farmer's best friend. They break down organic matter into simpler materials that plants can use. They mix organic matter into the soil, and they help bind soil particles together, improving the soil structure. Their burrows allow water and air to get into the soil. They also allow roots to penetrate the soil easily.

Let earthworms till the soil. They do it better than a plough or hoe.

Organic matter is food for earthworms. If there is a lot of organic matter, earthworms can multiply. The more worms, the healthier the soil.

Important plant nutrients

Plants need many different types of nutrients. The most important are nitrogen (N), phosphorus (P) and potassium (K) (see the table below).

Soil nutrients and why they are important

	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Why important	Helps plants grow	Helps plants produce roots, flowers and grain	Helps plants resist disease
Problems caused in maize if not enough of this nutrient	Maize leaves are pale green or yellowish Plant is stunted and leaves are small Tips of leaves are yellow Ears are small and kernels are not filled	Leaves are purplish Roots are few and short Ears are short and twisted, with under-developed kernels	Browning or bronzing and scorching of leaf edges Plant is stunted, with nodes on stem close together Tips of ears are poorly filled
Organic fertilizers with this nutrient	Animal manure Compost Mulch Legumes (intercrops, rotations, cover crop, mulch, compost)	*Tithonia diversifolia*	
Inorganic fertilizers with this nutrient	Urea Ammonium nitrate Calcium ammonium nitrate (CAN) Ammonium sulphate Diammonium phosphate (DAP) NPK	Single superphosphate (SSP) Triple superphosphate (TSP) Rock phosphate (RP) Diammonium phosphate (DAP) NPK	Muriate of potash (KCl) Sulphate of potash (K_2SO_4) NPK

Organic fertilizers

Only a living and healthy soil can produce a good crop

There are many different types of organic fertilizers:

- **Crop residues**
- **Cover crops**
- **Mulch** brought in from outside
- **Animal manure**
- **Compost**

Organic fertilizers have two big advantages: they add organic matter to the soil directly, and they are free! You can grow or make them yourself. If you have more than you need, you can also sell them to your neighbours.

Unfortunately, most organic fertilizers do not contain much phosphorous. Plants need this nutrient to grow. You can improve the quality of organic fertilizer by adding plants that are high in phosphorus, or by adding phosphate fertilizer (see page 75).

Crop residues, cover crops and mulch

Keeping a permanent soil cover is a good way to replenish the organic matter in the soil. You can use various types of cover:

- **Crop residues** The stalks and leaves of crops are good as mulch. Stover from maize and sorghum breaks down slowly, so stays on the surface for a long time and protects the soil. The stalks and leaves of legumes are rich in nitrogen and break down quickly, so the nutrients can soon be used by the following crop.
- **Cover crops** Plant these when they fit in your cropping system and allow them to grow and cover the soil. Slash them or kill them with herbicide just before planting the next crop and leave the dead material on the ground as mulch. Leguminous cover crops are especially valuable because they fix nitrogen from the air and make it available for other crops.
- **Grasses and weeds** You can cut grasses and weeds from the edges of the fields or from outside. Spread them on the soil as mulch. Do not bring in vegetation that contains seeds, as you will spread weeds.
- **Prunings from shrubs and trees** You can trim branches and use them as mulch. You can harvest the branches at any time during the year. Leguminous trees and shrubs are high in nitrogen.

Some plants decompose quickly, while others break down more slowly. Try to use several different types of materials to get the best combination of soil cover and decomposing vegetation when you need it.

See Chapter 5 for more information on crop residues, cover crops and mulch.

Animal manure

Animal manure makes good-quality fertilizer. Leave it to decompose before applying it to crops, as it will "burn" the plants if it touches them.

Poultry droppings make the best manure, followed by goat droppings, then sheep and cattle dung.

Animals fed on good-quality feed produce the best-quality manure.

Compost

You can make compost from leaves, weeds, manure, ash, kitchen waste, and any other organic material available.

Try to use materials that rot easily, such as grass and leaves. Woody materials such as tree branches and maize stalks, and shiny leaves such as eucalyptus, do not make good compost.

You can make compost in a pit (best in areas with low or medium rainfall), or in a pile (best in high-rainfall areas).

Nutrients in animal manure and green manure

Type of manure	Kilograms of nutrients in 1 ton of manure		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Poultry manure	48	18	18
Goat manure	24	7	14
Sheep manure	13	5	6
Cattle manure	13	2	15
Tithonia (wild sunflower) (dried)	33	2.6	33

Inorganic fertilizers

There are many different types of inorganic fertilizers. They contain nitrogen (N), phosphorus (P) or potassium (K), or some combination of these three nutrients. They may also contain other nutrients that plants need in smaller amounts. If you know what nutrient your soil needs, you can choose the right type of inorganic fertilizer that provides that nutrient (see the table on page 72).

Making compost, Swazi style

There are many ways to make compost. Here is how farmers in Swaziland do it.

1. Choose a shady place under a tree or a thatched roof to protect the compost from the sun and rain.
2. Push four sticks (1.5 m long) into the ground, one at each corner of where you want to make your compost pile. Push in a fifth stick in to mark the centre of the pile.
3. Start the pile with a layer of sticks or maize stalks, 30 cm thick. This layer lets air circulate in the pile.
4. Add a layer of dry grass or other vegetation. Make this layer about 10 cm thick.
5. Add a layer of manure, also about 10 cm thick.
6. Add a layer of dry straw from legumes, also about 10 cm thick.
7. Sprinkle a thin layer of ash on top.
8. Add more layers of grass, other vegetation, manure, straw and ash until the pile is about 1.5 m high – as tall as the sticks. A well-made compost pile has almost vertical sides and a flat top.
9. Cover the pile with a layer of topsoil.
10. Water the pile about three times a week. If it has been raining, you do not need to water it.
11. After 4 weeks, turn the pile over to mix the different layers. Do not add any fresh materials. Water the pile for another week, then leave it for 6 weeks.
12. After the 6 weeks, the compost is ready for use.

Fortified compost in western Kenya

Some farmers in western Kenya have learned how to make “fortified compost”. They add a little rock phosphate (about 2–5 kg) to the compost pile, or leaves and stems of the wild sunflower (*Tithonia diversifolia*).

Tithonia decomposes very fast. It contains high levels of nitrogen and potassium, and a reasonable amount of phosphorus (see the table on page 74). It is common in western Kenya, and is found on roadsides and farm boundaries.

Lantana camara, Vernonia and *Acanthus* are also good compost fortifiers.

The farmers say that carrying these materials to the compost pile takes some work, and some are hard to harvest because they are thorny.

Compost in conservation agriculture

“In our farm, we practise conservation agriculture. We intercrop maize and beans. We introduced a cover crop by planting lablab between the maize and beans rows. Since lablab forms a big canopy, we plant at a wider spacing. At harvest time, we cut the maize with a *panga*, and spread it low to avoid smothering the cover crop.

My brother and I help my parents make improved compost near our homestead. When the compost is ready, we carry it to the field and spread it evenly without disturbing the soil.

When we plant the crop, we move the crop residue a little to make room for planting.”

Renatha Patrick Allay, Karatu, Arusha, Tanzania

Inorganic fertilizers are much more concentrated than organic fertilizers. A bag of inorganic fertilizer may contain as much nitrogen as a tonne of compost! You need only a small amount of inorganic fertilizer for each plant. That makes inorganic fertilizers easy to use.

> *Feed your soil*
>
> *If you work your oxen day after day, but feed them nothing, they will die!*
>
> *If you keep taking from your soil without feeding it, it will die!*
>
> *What have you fed your soil lately?*

Inorganic fertilizers do not contain organic matter themselves. But they do add organic matter to the soil in an indirect way: they help crops grow better, so you will have more crop residues to leave on the soil at the end of the season. They also replenish nutrients (especially phosphorus) that compost and other organic fertilizers have only in small amounts.

Inorganic fertilizer can be expensive and hard to find. If you cannot afford a whole bag of fertilizer, it may be worth getting together with your neighbours to buy a bag between you.

What's in a fertilizer?

Inorganic fertilizers usually contain 3 main elements: nitrogen, phosphorus and potassium. Some have only nitrogen, some have only phosphorus, and some have only potassium.

Some types of inorganic fertilizer have two or all three of these nutrients, and are called "compound fertilizers".

Check the label on the fertilizer bag to see what it contains. A bag of **diammonium phosphat**e should say something like this:

NPK 18–46–0

This means that 18% of the fertilizer is nitrogen (N), 46% is phosphorus (P), and there is no potassium (K) (0%).

There are many different combinations of fertilizer. For example:

- **Urea** is 46–0–0 (46% nitrogen, no phosphorus or potassium).
- **TSP** (triple superphosphate) is 0–45-0 (no nitrogen, 45% phosphorus, no potassium).

If possible, get your soil tested to find out what nutrients it needs. Then choose the type of fertilizer that your soil and crop need.

Combining inorganic fertilizers and organic manures

Inorganic fertilizers are expensive, and organics are sometimes poor quality and contain little nitrogen. So it is best to combine inorganic fertilizers with organic manures – perhaps at half the recommended rates of application. This combination also improves the fertilizer use efficiency. You can combine the two types of fertilizers by fortifying compost or by applying them both directly to the field.

How to apply fertilizer

When you apply both organic and inorganic fertilizers, disturb the soil as little as possible, and try not to interfere with the soil cover.

- **Planting basins** Mix the fertilizer with soil before planting. Use bottle caps or cans to measure the amount of fertilizer you put into each basin.
- **Ripped lines** Apply the fertilizer into the ripped lines. Apply DAP, TSP and compound fertilizer in the line before planting. Apply urea as top-dressing to maize and sorghum plants at the tasselling or flowering stage.
- **Cover crop and direct planting** Make a hole with a small hoe or planting stick, and put in the fertilizer by hand. Cover the fertilizer with soil and

Combining inorganic and organic fertilizer

"I used manure and inorganic fertilizer before I learned about conservation agriculture. But I wasn't using the right amounts, and I didn't apply them the right way. I was using low-quality manure. I spread it over my whole farm and ploughed it in. Then I made planting holes and put in a very small amount of fertilizer (1 handful of fertilizer for more than 10 holes). I used to get only 5 bags of grain per acre.

I was introduced to conservation agriculture through my farmers group in late 2002. We trained how to do it on a group farm in 2003.

I started practising conservation agriculture on my own farm in 2003. But I didn't have enough materials: I didn't use any crop residue, and I didn't have enough fertilizer. I used the same amounts as I was using before. But I didn't plough the soil. My maize yield doubled from 5 to 10 bags.

I was well-prepared this year. I left three-quarters of the maize stover in the field as mulch. I cut the top quarter to feed my livestock. I also grew lablab as a cover crop in the field. And I have learned how to make compost to improve the quality of manure.

When I plant maize, I make a row of holes with a hoe. I put a handful of manure and a teaspoonful of fertilizer in each hole. I mix them and put the seed beside the mixture to keep the fertilizer from scorching it.

When the maize is knee-high, I top-dress it with calcium ammonium nitrate (CAN). I apply CAN on the surface when the soil is wet, in a circle around the plants."

Bernice Kamotho, Kikapu farmer field school, Njoro, Kenya put the seeds on top. Apply urea to the planting stations, for maize at tasselling, for sorghum at flowering.

- **Using a jab planter or animal-drawn planter** Some planters have two containers: one for seeds, and one for fertilizer. See page 53 for details.

Converting to conservation agriculture

Switching from ploughing or hoeing to direct planting through a soil cover will help degraded soil recover. The fertility will go up. Your soil health will gradually improve from year to year.

But you need to be careful. Many crop residues, especially straw from maize, sorghum and wheat, are low in nitrogen. When they decay, they make soak up nitrogen (and maybe phosphorus) from the soil. So you may have to add

More with less in Brazil

Farmers in Brazil used to have very similar problems to those faced by many African farmers today: heavy rain washed away their fertilizer and eroded their soil. For every kilogram of soybeans harvested in Brazil, 10 kg of precious topsoil was lost.

Frank Dijkstra was one of the first farmers to use conservation agriculture in Brazil. He switched to conservation agriculture in the late 1970s. Twenty years later, his maize yields had doubled, and his soybean yields had risen by 75%.

More inorganic fertilizer?

No. In fact, less. Frank now uses only half the amount of fertilizer on soybean, and two-thirds of the amount on his maize.

With conservation agriculture, he produces much more yield, with much lower inputs, and has stopped erosion.

That's good for the environment, good for the future, and good for his pocket.

More information: Rolf Derpsch, rderpsch@telesurf.com.py

Precision placement with a string

Farmers working with the IMPALA project (see box on page 110) in western Kenya use a string to sow seeds and apply fertilizer.

The farmers plant leguminous shrubs as part of their crop rotation. These shrubs provide enough nitrogen for their maize crop. But the soil is short of phosphorus.

When they plant maize, beans or legumes, the farmers take a long string with a knot every 25 cm. They make a small hole with a *panga* (large knife) or hoe next to each knot. They put a pinch of TSP fertilizer (the amount that would fit on the tip of a teaspoon) in the hole, followed by two seeds. They then cover the hole with their foot.

This precision placement saves seeds, fertilizers and work.

More information: Anja Boye

extra inorganic fertilizer to make up for this. You should, of course, add nitrogen in other ways too: rotate with legumes, plant leguminous cover crops, leave mulch on the surface, and apply compost or animal manure.

Once the soil is healthy again, you can slowly reduce the amount of fertilizer you apply. In the long run, conservation agriculture can produce higher yields than conventional farming, but needs less inorganic fertilizer.

Over time, the amount of organic matter builds up in the soil. Yields increase steadily over time.

5

Soil cover

A PERMANENT YEAR-ROUND soil cover is central to conservation agriculture. It is important for several reasons:

- It **protects** the soil from rain, sun, and wind.
- It reduces **soil erosion** and protects the fertile topsoil, so preventing the silting of rivers and lakes.
- It stops the soil surface from **sealing**, and reduces the amount of precious rainwater that runs off.
- It suppresses **weeds** by smothering their growth and reducing the number of weed seeds. This reduces the amount of work needed for weeding.
- It increases the **soil fertility** and the organic matter content of the soil.
- It increases **soil moisture** by allowing more water to sink into the ground and by reducing evaporation.
- Decomposing vegetation and the roots of cover crops improve the **soil structure** and make the clumps and lumps in the soil more stable – making it harder for rain to break them up and wash them away.
- **Earthworms** and other forms of life can prosper in the cover as well as in the soil.
- Soil cover stimulates the development of **roots**, which in turn improve the soil structure, allow more water to soak into the soil, and reduce the amount that runs off.

Like an umbrella

Soil cover protects the soil and micro-organisms that live in it from the heat of the sun and the impact of rain. A good farmer gives her soil an umbrella to keep it healthy. Only a healthy soil can produce a good crop.

There are two main types of soil cover:

- **Living plant material**: crops and cover crops.
- **Mulch**, or dead plant material: crop residues and prunings from trees and shrubs.

You will often use a combination of mulch and living plants to keep the soil covered.

To obtain a good soil cover, you should leave **crop residues** such as maize and sorghum stalks in the field. You might also be able to add **mulch** from outside the field: for example, you can cut grass from nearby, or bring in leaves and prunings from trees and shrubs. They will decompose after a while, so you will have to replace them regularly.

In addition, you can plant a **cover crop**, either during the cropping season (to cover the area in between the crop rows), or afterwards to cover the whole field. During the cropping season itself, the **crops** themselves act as soil cover. An intercrop of tall plants (such as maize) and low-growing plants (such as beans) makes a good cover.

It can be difficult to keep the soil covered, especially in semi-arid areas. It may be necessary to compromise: some cover is better than none.

Feed the soil to feed the people

Cover crops are the food of the soil. Only a healthy soil can provide the necessary food to the people. Soil has life, which needs to be fed.

Farmer slogan, Swaziland

Cover crops

Cover crops are planted to provide a soil cover, improve soil fertility and produce food and feed. They are normally grown during the dry season or as intercrops. They may be allowed to grow throughout the cropping season, or they may be killed and left on the soil surface as mulch.

Africa has many different cover crops. They fall into four main groups: legumes, shrubs, grasses, and other. The type of cover crop you choose influence the quantity and quality of mulch it provides. The most common cover crops in Africa are listed in the table on the next page (see also Photos 21–27).

Some farmers already intercrop maize with beans, where the beans may act as a cover crop for part of the year.

How to choose the right cover crop

Small-scale farmers prefer a cover crop which fits into their normal cropping system and which has multiple purposes:

- Edible seeds and vegetables
- Soil fertility
- Animal fodder
- Firewood/fencing material
- Weed suppression
- Medicines.

First, check **which cover crops grow well** in your area. This depends on the soil type, rainfall, temperature and altitude. If you live in an area with little rainfall, select a cover crop that grows quickly, such as cowpea, desmodium, lablab, lucerne, mucuna, or pigeonpea.

Then check **how much work** each cover crop will need: for land preparation before planting, weeding, and producing and harvesting the seeds. Species with big pods and grains (such as pigeonpea and mucuna) are easier to deal with than species with small pods (such as vetch and grasses). Most farmers prefer species that cover the soil quickly and completely, and which can also be used for food and fodder.

Characteristics of cover crops

Cover crop	Botanical name	Climate	Altitude	Uses (apart from cover)	Characteristics
Legumes					
Butterfly pea	*Clitoria ternatea*	Semi-arid to sub-humid	Low to medium	Fodder	Climbing and shrubby legume. Range of soils. Tolerates salinity and acidity but not flooding
Centro	*Centrosema pubescens*	Sub-humid to humid	Low to high	Fodder	Trailing legume. Wide range of soils, sandy to clay
Cowpea	*Vigna unguiculata*	Semi-arid and sub-humid	Low to medium	Food	Legume has both creeping and erect types. Sandy to clayey soil. Long-maturing varieties best for intercropping with cereals
Crotalaria	*Crotalaria retusa, C. ochroleuca, C. paulina*	Semi-arid to sub-humid	Low to medium		Erect legume. Wide range of soils. Deep roots break compact soil layers. Adapted to infertile soils. *C. ochroleuca* can be eaten as a vegetable
Desmodium	*Desmodium intortum*	Sub-humid to humid	Medium to high	Fodder	Trailing and climbing legume. Wide range of soils
Jackbean	*Canavalia ensiformis*	Semi-arid to humid	Low to high	Food, fodder	Erect legume that can grow to 1 m high. Slow growth at first. Drought-tolerant and immune to most pests. Dry before using a fodder. Young pods can be used as food

Characteristics of cover crops (continued)

Cover crop	Botanical name	Climate	Altitude	Uses (apart from cover)	Characteristics
Jugo bean, bambara groundnut	*Vigna subterranea*	Sub-humid to humid	Low to medium	Food	Wide range of soils. Drought-resistant. Beans high in protein
Lablab, hyacinth bean	*Dolichos lablab*	Semi-arid and sub-humid	Low to medium	Food, fodder	Creeping legume that spreads quickly. Sandy to clayey soils. Suited for intercropping with cereals and sugarcane. High in protein
Lucerne, alfalfa	*Medicago sativa*	Semi-arid to sub-humid	Low to medium	Food	Erect legume. Wide range of soils
Mucuna, velvetbean	*Mucuna pruriens*	Semi-arid and sub-humid	Low to medium	Food	Creeping legume that spreads quickly. Sandy to clayey soils. Suited for intercropping with cereals and sugarcane. More sensitive to soil fertility than lablab. Excellent soil cover, suppresses weeds
Mungbean, green gram	*Vigna radiata*	Sub-humid to humid	Low to medium	Food, fodder	Wide range of soils. Edible beans and leaves
Pigeonpea	*Cajanus cajan*	Semi-arid to humid (depends on variety)	Low to high	Food, fodder, firewood	Erect legume. Grows in sandy to clayey soil. Deep roots break compact soil layer (biological plough). Good at recycling phosphorus. Rich in protein
Siratro	*Macroptilium atropurpureum*	Semi-arid and sub-humid	Low to medium	Fodder	Creeping/trailing legume. Range of soils. Tolerant to drought

Characteristics of cover crops (continued)

Cover crop	Botanical name	Climate	Altitude	Uses (apart from cover)	Characteristics
Stylo	*Stylosanthus guianensis, S. hamata*	Semi-arid to humid (depends on species)	Low to high	Fodder	Creeping coppicing legume. Does well on coarse textured soils and can tolerate acid soils. Takes 1–2 rainy seasons to cover the soil
Tropical kudzu	*Pueraria phaseoloides*	Humid	Low to high	Fodder	Creeping/trailing legume that spreads quickly. Wide range of soils. Not drought tolerant
Wild groundnut, peanut	*Arachis pintoi*	Semi-arid to sub-humid	Low to medium	Fodder	Coppicing legume, permanent green cover crop. Does well on coarse textured soils. Takes 1–2 rainy seasons to cover soil
Leguminous shrubs					
Calliandra	*Calliandra* spp.	Semi-arid to sub-humid	Low to medium	Fodder, firewood, mulch	Wide range of soils, often on contours
Gliricidia	*Gliricidia sepium*	Semi-arid to sub-humid	Low to medium	Fodder, firewood, mulch	Coppicing shrub
Sesbania	*Sesbania sesban*	Semi-arid to sub-humid	Low to medium	Fodder, firewood, mulch	Wide range of soils

Characteristics of cover crops (continued)

Cover crop	Botanical name	Climate	Altitude	Uses (apart from cover)	Characteristics
Sunn hemp	*Crotalaria juncea*	Semi-arid to humid	Low to high	Fodder, firewood	Wide range of soils. Dry before using as fodder
Tephrosia	*Tephrosia candida, T. vogelii*	Sub-humid to humid	Low to high	Fodder, pesticide, firewood	Wide range of soils. Does not tolerate acidity
Grasses					
Andropogon, gamba grass	*Andropogon gayanus*	Semi-arid to sub-humid	Low to medium	Fodder	Wide range of soils
Brachiaria	*Brachiaria ruziziensis*	Semi-arid to humid	Low to medium	Fodder	Grass with multiple tillers. Wide range of soils
Cenchrus	*Cenchrus ciliaris*	Arid to sub-humid	Low to medium	Fodder	Grass with multiple tillers. Takes time to establish. Wide range of soils
Finger millet	*Eleusine coracana*	Semi-arid to sub-humid	Low to high	Food, fodder, thatch	Grass with multiple tillers. Wide range of soils

Characteristics of cover crops (continued)

Cover crop	Botanical name	Climate	Altitude	Uses (apart from cover)	Characteristics
Pearl millet	*Pennisetum glaucum*	Arid to semi-arid	Low to medium	Food, fodder, thatch	Grass with multiple tillers. Wide range of soils
Sunn hemp	*Crotalaria juncea*	Semi-arid to humid	Low to high	Fodder, firewood	Wide range of soils. Dry before using as fodder
Other cover crops					
Pumpkin	*Cucurbita* spp.	Semi-arid to humid	Low to high	Food	Creeping edible plant
Watermelon	*Citrullus lunatus*	Semi-arid to sub-humid	Low to medium	Food	Creeping edible plant

Men and women choose different cover crops

Men and women may have different reasons for choosing a cover crop. Farmers in northern Tanzania gave these as their top priorities:

Rank	Women	Men
1	Source of food	Source of food
2	Reduce time for weeding	Market
3	Moisture conservation	Soil cover
4	Soil fertility	Soil fertility
5	Erosion control	Moisture conservation

Source: FAO/IFAD, 2001–3

Make sure that the cover crop does not **interfere with the main crop**. For example, avoid growing a tall cover crop that might shade the main crop. You can also prevent the cover crop from interfering with the main crop by planting it later (see page 92).

If you cannot prevent **livestock** from getting into your fields, you might want to choose a cover crop that they do not like to eat, such as jackbean (*Canavalia*) or sunn hemp (*Crotalaria*).

When they die, some cover crops rot quicker than others. Legumes decompose more quickly than grasses. This means that the next crop can use nutrients such as nitrogen from the legumes quickly. A mixture of legumes and grasses is best to ensure a lasting soil cover.

Seed supply

It can be difficult to get hold of good quality seed – especially for cover crops. You may be able to find seeds from these sources:

- **Research institutes or the extension service** Ask extension agents or researchers if they can get seeds for you. Research stations may have a collection of varieties and be willing to let you have some seed.
- **Seed dealers and farm supply stores** Good seed companies provide only certified seed, which has been treated with fungicide and insecticide to prevent problems in germination and early growth. If the seed seller doesn't have any seed in stock, perhaps they can get some from elsewhere. Don't be afraid to ask!
- **Wild sources** Leguminous trees such as calliandra, sesbania or gliricidia may grow wild in your area, or they may be planted as hedgerows or windbreaks. Collect the seed, dry it and store it ready for planting.
- **Farmer groups** You can organize a group of neighbours to produce seeds for the group members. You may be able to sell any extra seed to other farmers.

Cover crops improve the soil

"Since I stopped ploughing and started growing cover crops, the colour of my soil has changed. It has become much darker, and when I walk across the fields, I feel that the soil is no longer hard and has become soft."

Farmer from Karatu, Tanzania

- **Grow your own** If you already have some cover crops, you can harvest your own seed and plant it again in the next season. You may be able to sell surplus seed to neighbours. If there is a lot of demand for seed in your area, it may be worthwhile to plant a special field with a pure stand of a cover crop so you can harvest and sell the seed. Ask your extension agent for training on how to produce good-quality seed.

If you do not know the quality of your seed, you can test it for germination before planting. Count out a certain number of seeds (e.g., 50 or 100). Plant them in a container of soil. After the seeds have started to sprout, count how many germinate. If only a few germinate, you can either increase the amount of seed you plant, or try to get new seed.

Seed treatment

Inoculation

Legumes are valuable because they fix nitrogen from the air and make it available for other crops. They do this in nodules (bumps) on their roots that contain special bacteria. Most types of legumes can make nodules by themselves, but some types may need some help. If you are planting a particular legume for the first time, you may need to inoculate the seeds first.

Growing your own seed

1 During the growing season, walk through the fields and mark with a piece of cloth or string good, healthy plants that have the characteristics you want. Be careful! Select only from pure stands of a single variety, where there is no mixing with other varieties, and no chance of cross-pollination. Do not collect seed from hybrids, as the result will usually be very poor.

2 Harvest the marked plants separately, before harvesting the rest of the crop.

3 Dry the seed carefully. Treat it with suitable fungicides and pesticides recommended in your area. You may be able to use natural insecticides such as neem extracts.

4 Store the seed in a safe place.

5 Dry seeds at regular intervals to prevent them from getting damp.

Spreading mucuna in Benin

Mucuna (velvetbean, *Mucuna pruriens*) is one of the most promising cover crops in West Africa. Soils here are fairly infertile, farmers use little fertilizer, and the soil degrades easily if it is used intensively. Farmers traditionally use shifting cultivation, clearing land to grow crops, and then allowing it to lie fallow for several years so the fertility can recover. However, rising populations mean that farmers can no longer leave the land fallow for long enough for the soil to rebuild its fertility.

Researchers and extensionists first tested mucuna with farmers in southwestern Benin in 1988–1992. Farmers in densely populated areas were interested in adopting the crop because they could no longer practise shifting cultivation.

The farmers like using mucuna as a fallow crop because it suppresses speargrass (*Imperata cylindrica*), a major weed in this area. They are more likely to adopt the crop in areas with a long growing season (7 months or more), where the soil fertility is declining, inorganic fertilizers are expensive, and where weeds such as speargrass are a problem. Mucuna can also provide livestock feed, and suppresses *Striga* weeds and nematodes in intensified cereal cropping. Close contacts between farmers and development organizations are needed encourage the spread of mucuna, as are markets for the seed.

Source: Vissoh et al., in Buckles et al. (1998)

Inoculation is easy. Here's how to do it.

1 Sterilize some soil by pouring boiling water on it and letting it cool.
2 Find a good plant (or tree) of the species you want to inoculate (It has to be the same species, as there are different bacteria for each species of legume.) Dig to the roots and look for a nodule – a bump on the root. Squeeze it and check that it is pink inside. Collect several nodules from the plant or tree.
3 Gently crush the nodules and mix them with the sterile soil.
4 Mix your seeds with the soil before planting them. For seedlings, gently rub the soil over the roots before planting.

For some legumes such as soybeans and some tree species, it is possible to buy ready-made inoculant from farm supply stores. Make sure you get the right type of inoculant for the species you want to plant.

Note: In many cases, inoculation is often not necessary (and does not always work). If you are considering growing a legume, try growing a few plants in the field first, then check the plant roots for nodules. If there are nodules, you probably do not need to inoculate.

Speeding up germination

You do not need to treat most types of cover crop seeds. But if you need stylo and some types of sunn hemp seeds to germinate quickly, put them in hot water for 5–15 minutes before planting them. This is a good idea only in areas with reliable rainfall: if they don't get enough moisture to germinate, soaked seeds will rot.

When to plant cover crops

You can plant cover crops in many ways. Here are some possibilities:

Intercropping

Planting at the same time as the main crop. This is easy because you can plant both crops at the same time. It is suitable for sub-humid and humid areas. A possible problem is that the cover crop might grow so quickly that it smothers the main crop. Also, you cannot plant a cover crop this way if you are already intercropping a cereal (e.g., maize) with beans.

Relay cropping

Planting when you weed the main crop. This is suitable for sub-humid and humid areas. You can plant the cover crop when you do the first weeding (usually about 4 weeks after planting the main crop). Or if you are intercropping maize and beans, you can plant the cover crop when you harvest the beans.

Sequential planting

Planting after you harvest the main crop. In dry areas, you can plant the cover crop when you harvest the main crop. This prevents the cover crop from com-

A question of cover

Here are some questions to help you decide when to plant the cover crop.

Questions about the cover crop itself

- How much **moisture** will the cover crop need to grow and produce enough mulch and seed?
- At what **time of year** will there be enough moisture for the cover crop to grow?
- What **other factors** (temperature, frost) will favour or hinder its growth? Is it sensitive to the day length? To frost? To drought?
- How easy will it be to **manage** the cover crop while it is growing and afterwards (mulch management)?

Questions about the cropping system

- When will cover be most **needed?**
- How **fast** will the cover crop grow and provide the required cover?
- How **long** will the cover last?
- Might anything (grazing by animals, burning, etc.) **reduce** the amount of cover?
- How to stop the cover crop and main crop from **interfering** with each other?

peting for moisture with the main crop. You can use the cover crop to provide extra mulch and to produce livestock feed. Harvest water to make sure there is enough moisture to grow the cover crop (see Chapter 8).

If you live in a semi-arid area with only one rainy season, you can plant a drought-tolerant cover crop such as lablab between your rows of maize. Leave the cover crop in the field after the maize harvest so it covers the soil and suppresses weeds. Before the next season's rains, slash it or roll it, and leave it on the ground as mulch.

See Chapter 6 for more information on different types of cropping systems.

How to plant cover crops

You can plant a cover crop as an intercrop (or relay crop) or in a pure stand.

For cover crops with large seeds, plant with a hand hoe, jab planter or animal-drawn direct planter (for pure stands).

You can broadcast cover crops with small seeds (such as finger millet), provided the soil cover is not too thick. If the soil cover is thick, sow the seeds in lines by hand or use a seed drill.

The plant spacing and number of seeds per hole depend on several factors.

- Use a narrower spacing in pure stands, and a wider spacing in mixed (intercropped) stands.
- Use a wider spacing in drier areas, so the plants don't compete with each other for moisture.
- The number of seeds per hole depends on the amount of moisture available: fewer seeds per hole in dry areas; more in wetter areas. In general, plant 2–4 seeds per hole.

Is there a market for cover crop seeds?

In 1998, a project in Uganda introduced farmers to lablab, mucuna, tephrosia and crotalaria. These cover crops were popular: demand for the seed was far greater than the supply. Some farmers and farmer groups agreed to multiply the seed. They sold the seed to local farmers and people in the neighbouring district. Lablab seed sold for the highest price.

But as more and more farmers produced seeds, the local market became saturated, and selling seed began to be difficult. Local community organizations and NGOs helped to market the seed in other districts and even abroad.

It is fairly easy for farmers in an area to produce enough cover crop seed for their own use, but they may need outside help if they are to market their seed successfully elsewhere.

Do cover crops need weeding?

Yes! You will need to weed cover crops at least once while they are becoming established. Once they have covered the soil well, they will prevent most weeds from germinating.

If you are intercropping or relay cropping your cover crop with maize or sorghum, plan to weed according to the requirements of the cereal crop. Make sure the cover crop does not tangle with the cereal crop.

Controlling pests and diseases

In parts of Kenya and Tanzania, farmers plant lablab as the only cover crop. In some villages, quite large areas are covered with the same crop. Farmers in these villages risk a pest outbreak that may ruin their cover crop.

How to reduce the danger of pests and diseases:

- **Rotate** the types of crops grown: food, cover and cash crops.
- Select cover crops that are unlikely to be attacked by **pests**.
- Plant various **different types** of cover crops.
- Use **chemical spray**.

Harvesting and seed storage

Harvest the seeds before you slash a cover crop to make mulch. You may need to harvest the seeds for several reasons: so you can plant the cover crop next season, if you want to use the seeds as food or fodder, or if you want to sell them to other farmers.

Store cover crop seeds well. Here are a few tips on how to handle them:

- Collect seeds from **several plants** so you get a range of seeds.
- Dry the seeds and treat them with **insecticide**. If you want to use the seeds for food, make sure that the insecticide is not harmful.
- Keep seeds for planting in partly opened bags or in containers in a **well-ventilated** store.
- Take the seeds out and **dry them again** regularly. Throw out any bad seeds.

Preparing to plant the main crop

At the beginning of the next season, your field may have a cover crop, stalks still standing from the previous main crop, and of course, weeds. You need to prepare the field so you can plant the next main crop. You can do this in several ways: by slashing the cover crop and weeds with a machete or hoe,

Cover crop pros and cons

Farmers in northern Tanzania tried various cover crops. Here is what they thought of them.

Cover crop	Advantages	Limiting factors
Lablab *Dolichos lablab*	Grows fast, so covers soil and controls weeds effectively Easy to manage Tolerates drought Fodder for livestock Good market	Farmers not using it as food Needs special management before the next season Susceptible to pests; needs spraying with insecticide
Mucuna *Mucuna pruriens*	Grows fast, so covers soil and controls weeds effectively Easy to manage Dries off in a long dry season, so no need to kill it before planting the next crop Fodder for livestock Produces many seeds, which are easy to collect Some farmers grind seeds and mix with corn bran to feed oxen	Use as food not recommended (under research) Seeds not widely available and fairly expensive Weak market Not seen as a crop, so livestock owners may allow their animals to graze Not liked by cattle
Pigeonpea *Cajanus cajan*	Cash and food crop Protects land from grazing Market available (Asia) Seeds easily available Stems used for firewood	Erect type, so poor weed suppression Little impact on soil erosion
Pumpkins *Cucurbita* spp.	Traditional food crop intercropped with maize Covers soil and suppresses weeds Seeds easily available and affordable	Does not fix nitrogen in the soil

Source FAO/IFAD, Case study northern Tanzania, 2001–2

using a knife roller to bend over and crush the standing vegetation, or by using a herbicide.

It may be better to use a knife roller to crush the vegetation rather than slashing it, because equipment such as rippers and planters can easily drag pieces of vegetation along with them.

See Chapters 3 and 7 for more information on how to prepare the land for planting.

Using cover crops for food and feed

Cover crops are new for many farmers who switch to conservation agriculture. Some (such as *Canavalia* and sunn hemp) need to be dried or processed before they can be fed to livestock. As more and more farmers take up conservation agriculture, you may be able to sell cover crop seeds to your neighbours or in the market.

Various cover crops can be used as food and feed. Livestock can be fed forage from many cover crops directly, though it is necessary to dry some, such as jackbean and sunn hemp, before giving then to animals.

Seeds from cowpeas, lablab, lucerne and pigeonpea can be cooked and eaten as part of a nutritious diet. Mucuna seeds need special treatment to remove poisonous substances (see the boxes below).

Making mucuna fit to eat

Mucuna seeds are very nutritious and can be fed to cattle, sheep and goats without processing. But they contain a substance that is **poisonous** to people, chickens or pigs. This poison can be removed in several ways:

- Soak the seeds for at least 48 hours, changing the water every 12 hours.
- Crack the seeds and soak them in running water (from a faucet) for 36 hours.
- Put the seeds in a cloth bag and leave them in a flowing river for 3 days.
- Crack the seeds, boil them for 90 minutes, take the hulls off, then grind them and make a soup.

Lablab recipes

Lablab seeds are used for food in the same way as dry beans. They are rich in protein and are especially suitable for HIV/AIDS patients, nursing mothers and old people. Some recipes from Tanzania and Kenya:

- Mix lablab seeds with shelled maize and cook for at least 1 hour. Then mix with sour milk. Serve hot or cold.
- Cook the seeds for 1 hour and serve with cooked banana and rice.
- Boil the seeds for 30 minutes. Give the soup to women early in their pregnancy to reduce bleeding.
- Cook lablab leaves and serve as a vegetable.

More information: Thomas Loronyo and John Odingo

Mulch

Mulch may come from different sources:

- **Cover crops**, slashed, crushed or sprayed to kill them.
- **Crop residues** from the field itself.
- Prunings from **trees and shrubs**.
- **Other plant materials** brought in from outside the field.

Mulch requires management for land preparation and planting of crops.

Mulch from a cover crop

Some types of cover crop produce a thick layer of living and dead plant material on the ground. Before you plant a new crop, you have to flatten this mass and kill the living plants so they do not compete with your crop. You can do this in several ways:

- Slashing the cover crop with a machete.
- Breaking the stems with an animal- or tractor-drawn roller-chopper
- Applying herbicides.

You can plant the new crop directly through the mulch layer (see Chapter 3).

Mulch from crop residues

Many annual crops are good sources of mulch after harvesting. Cut the stalks of cereals and lay them on the ground to cover the soil. If you have not yet planted a cover crop, this may be the only source of soil cover.

In some areas, it may not be possible to grow a cover crop. For example, in semi-arid areas, there may not be enough water to grow a cover crop in the dry season. Leaving crop residues in the field is a good option in these areas.

Residues from different crops decompose at different rates. Cereal stalks decompose slowly, so stay on the soil for longer. Legumes rot quickly (so quickly release their nutrients, which can be used by the next season's crop).

To keep the soil covered for a long time, a mixture of legumes and grassy species is best.

Farmers in many areas remove as many of the residues as possible so they can use it as livestock feed or thatch. Or they allow animals into the field after harvest to graze on the stubble. Here are some better alternatives:

- Leave as much residue on the land as you can, given your other needs. Consider collecting some of the leaves (which are more palatable to livestock) but leaving the rest of the leaves and the stalks on the field.

- Control grazing to prevent animals from trampling and compacting the soil, and to stop them from eating all the crop residue.
- Find other sources of livestock feed and building materials. For example, plant a forage plot to feed to animals, and plant a woodlot for building poles.

Mulch from trees and shrubs

Trees and shrubs produce a lot of leaves and twigs that can be used as soil cover and as animal fodder. They also have many other advantages:

- Leguminous trees and shrubs fix nitrogen, improving soil fertility.
- Trees and shrubs improve the structure of the soil and reduce compaction.
- They shade the soil and act as windbreaks, so reducing the soil temperature and help to conserve moisture.
- They prevent erosion.
- They provide fodder (see Chapter 9), food, medicine, firewood, timber, thatch and fencing.
- They produce fruit and attract bees that can be used for honey.

Farmers can choose from many different trees and shrubs:

- **Multipurpose trees** Various types of trees provide timber, fruit, fodder, and shelter. Rows of trees planted along the contours reduce runoff and erosion. You can prune the branches or collect the leaf litter and spread it on the ground in between the rows to protect the soil.
- **Living fences** Species such as *Acacia*, *Ziziphus*, *Grevillia* and *Cassia* can be planted as live fences and windbreaks. You can prune them to produce fencing, firewood and fodder, as well as mulch.
- **Leguminous shrubs** Shrubs such as *Crotalaria*, *Tephrosia*, *Sesbania* and *Gliricidia* replenish the soil by fixing nitrogen from the air. You can grow them in rotation with maize and sorghum, then cut them to produce material for mulch, fencing and fodder. None of the leguminous shrubs are edible, but most can be used as fodder and firewood. When these shrubs flower, they attract bees – perhaps you can use them to produce honey?

Leguminous shrubs produce seeds 8–12 months after planting – longer than a single season. The seeds can be hard to find. You may be able to obtain them from the same sources as for cover crops (see page 89). It may be a good idea to set up a nursery, either by yourself or with a group of other farmers. Some farmers make money by selling seeds and firewood. You may be able to collect seeds of certain shrubs from the bush.

Farmers may be reluctant to plant leguminous shrubs because they cannot use the land to grow a food crop during the short rainy season. However, in most cases the legume will improve the soil fertility so much that the higher yields in

Crop rotation with leguminous shrubs

In western Kenya, many farmers leave their fields fallow for one or more seasons. They grow maize intercropped with beans in the long rainy season. When they harvest the beans, they plant leguminous shrubs in the former bean rows, and leave them to grow in the short rainy season. The most common shrubs are *Crotalaria grahamiana*, *Crotalaria paulina*, *Tephrosia candida*, *Tephrosia vogelii*, *Sesbania sesban* and *Gliricidia sepium*.

When they prepare the land in February or March, the farmers cut the shrubs. They use some of the leaves and twigs as fodder, and leave the rest on the ground as mulch. They use the stems as firewood, for fencing, or as stakes to support tomatoes and passion fruit.

Some farmers like to plant *Crotalaria grahamiana* and *Tephrosia candida* because they flower early and attract bees, so increasing honey production.

More information: Anja Boye

the long rains more than make up for the loss of output in the short rainy season. Another attraction is that growing leguminous shrubs takes little work.

Pruning trees and using the leaves and branches as soil cover is common, but it can be a lot of work. To reduce the amount of work, plant trees on your farm and as living fences close to your conservation agriculture fields.

Mulch from other plant materials

If you do not have enough mulch from crop residues or a cover crop, consider bringing in extra materials from outside. You can slash vegetation growing around the field or nearby, and spread them on your field. You can also grow trees and shrubs especially to use as mulch (see the section above).

Bringing in mulch from outside takes a lot of work, but it may be possible to do it when you first start conservation agriculture, to protect the soil before you have been able to plant a cover crop.

Make sure you do not spread weeds or cause other problems when you bring in this vegetation.

- Do not use ***Striga*** or **couchgrass** (*Cynodon dactylon*) as mulch. Burn them instead.
- Do not use weeds that have already flowered and produced **seeds** as mulch. Slash them before they have had a chance to produce flower, or use them to make compost (composting kills most seeds).
- Do not use mulch that can spread **diseases** to your crop.
- You can use sawdust or rice husks as mulch, but be careful: they can cause **soil fertility** problems. For example, they can soak up nitrogen from the soil, leaving less for your crops.

Challenges for maintaining soil cover

Here are some problems you may encounter with soil cover, and ways to overcome them.

Semi-arid areas

In semi-arid areas, where there is little rain and most of it falls in one season, establishing a cover crop may be difficult. Crops, shrubs and trees produce few residues, and farmers often need them for feed or building materials. Cover crops use precious water.

- It may be impossible to maintain soil cover for the whole year. You may have to rely on crop residues and prunings from trees and shrubs as the main source of soil cover.

Diseases and pests

Diseases and insect pests might attack the cover crop and will require special attention. Farmers often use fire to destroy pests and diseases. But this leaves the soil bare and destroys valuable organic matter.

- Rotate crops rather than burning them to control pests and diseases. Consider using insecticides if necessary.

Rats

A dense cover crop may encourage rats, which may attack the crop.

- Slash the live cover crop as close to the ground as possible before planting the crop. It may also be necessary to trap rats or bait the rats with poison. Caution: Keep poisons out of reach of children!
- Rotating crops helps to control rats because it interrupts their food supply and disturbs their living conditions.

Termites

Many farmers fear that soil cover will attract termites.

- Termites are important because they break down plant material on the surface and carry into the soil, where it adds to soil organic matter. They also help aerate the soil and improve infiltration by water.
- Most types of termites are beneficial: only a few types attack crops. They may eat the stems or damage the grain. This normally happens towards harvest time. Leave plant material (such as cover crops) on the surface so

the termites attack this rather than the crop itself. The crop can be harvested before they do any damage to it.

Fire

Bushfires or uncontrolled fires on neighbouring fields can spread into a conservation agriculture field and destroy its soil cover. To prevent this, you can leave a buffer zone around your field.

- Once many farmers in the area practise conservation agriculture, burning will be less of a problem. Bylaws and education are needed to reduce damage by uncontrolled fires.

Livestock

Livestock need to be fed. Farmers often allow them to graze on stubble or on fallow fields, and other livestock owners may not keep their animals out of a field planted to a cover crop. This may especially be a problem in dry years or in semi-arid areas, where few alternative sources of feed are available.

- You can keep livestock out of your fields by planting living fences, by spraying the field boundaries with cattle urine, or by planting fences or cover crops that cattle do not like to eat.
- You can also try to negotiate with your neighbours (or persuade the village leaders) to find alternative grazing arrangements – such as identifying alternative sources of forage or pasture. Or you may be able to restrict grazing to those times when the soil cover is dense and the soil is not too wet.

See Chapter 9 for more on livestock.

Information

Farmers need information and training on how to maintain soil cover.

- Try to get information and training from extension workers, non-government organizations, or nearby research institutes. Visit other farmers to find out how they maintain cover on their soil.

6

Crops and cropping systems

YOU PROBABLY have many different combinations of crops on your farm, and you manage each combination in a different way. For example, you may grow vegetables close to your house, using manure and supplemental irrigation, with a fence around the plot to protect it. You may plant cereals in fields further away, without irrigation but using chemical fertilizer and herbicides.

Farmers have many reasons for making these choices. Fields are different sizes, have different types of soil, and may be on a slope or on flat land. Some are close to the house, while others are further away. Perhaps you don't have the time to plant or weed at certain times of year. Or maybe different members of your family want to grow different things. What you plant depends on how much moisture is in the soil and whether the rains are early, on time, or late. And of course it depends on what you want to grow for your own use and to sell.

Cropping systems

You can choose from many different types of crops, and you can plant them in different combinations. Here are some options:

Monocropping

Example Planting maize year after year in the same field.

This is where the field is used to grow only one crop season after season. This has several disadvantages: it is difficult to maintain cover on the soil; it encourages pests, diseases and weeds; and it can reduce the soil fertility and damage the soil structure. So avoid monocropping if you can. It is much better to rotate crops, or use intercropping or strip cropping.

Crop rotation

Example Planting maize one year, and beans the next.

This means changing the type of crops grown in the field each season or each year (or changing from crops to fallow). Crop rotation is a key principle of conservation agriculture because it improves the soil structure and fertility, and because it helps control weeds, pests and diseases (see page 106).

Sequential cropping

Example Planting maize in the long rains, then beans during the short rains.

This involves growing two crops in the same field, one after the other in the same year. In some places, the rainy season is long enough to grow two crops: either two main crops, or one main crop followed by a cover crop. Growing two crops may also be possible if there are two rainy seasons, or if there is enough moisture left in the soil to grow a second crop. If the crops are different, this is a crop rotation (see above).

Intercropping

Examples Planting alternating rows of maize and beans, or growing a cover crop in between the cereal rows.

Mixed intercropping: no rows

This means growing a two or more crops in the same field at the same time. It is possible to do this in different ways:

- Broadcasting the seeds of both crops, or dibbling the seeds without any row arrangement. This is called **mixed intercropping**. It is easy to do but makes weeding, fertilization and harvesting difficult. Individual plants may compete with each other because they are too close together.
- Planting the main crop in rows and then broadcasting the seeds of the intercrop (such as a cover crop).
- Planting both the main crop and the intercrop in rows. This is called **row intercropping**. The rows make weeding and harvesting easier than with mixed intercropping.

Row intercropping with alternate rows of maize and beans

A possible problem is that the intercrop may compete with the main crop for light, water and nutrients. This may reduce the yields of both crops.

Row intercropping with alternate rows of a cereal and a grass cover crop

Strip cropping

Example Planting alternating strips of maize, soybean and finger millet.

This involves planting broad strips of several crops in the field. Each strip is 3–9 m wide. On slopes, the strips can be laid out along the contour to prevent erosion. The next year, the farmer can rotate crops by planting each strip with a different crop.

Strip cropping has many of the advantages of intercropping: it produces a variety of crops, the legume improves the soil fertility, and rotation helps reduce pest and weed problems. The residues from one strip can be used as soil cover for neighbouring strips. At the same time, strip cropping avoids some of the disadvantages of intercropping: managing the single crop within the strip is easy, and competition between the crops is reduced.

Relay cropping

Example Planting maize, then sowing beans between the maize rows four weeks later.

This is growing one crop, then planting another crop (usually a cover crop) in the same field before harvesting the first. This helps avoid competition between the main crop and the intercrop. It also uses the field for a longer time, since the cover crop usually continues to grow after the main crop is harvested.

Crop rotation

Rotating crops is one of the key principles of conservation agriculture. It has many advantages:

- **It improves the soil structure** Some crops have strong, deep roots. They can break up hardpans, and tap moisture and nutrients from deep in the soil. Others have many fine, shallow roots. They tap nutrients near the surface and bind the soil. They form many tiny holes so that air and water can get into the soil.
- **It increases soil fertility** Legumes (such as groundnuts and beans) fix nitrogen in the soil. When their green parts and roots rot, this nitrogen can

Unhappy marriages

Make sure that your crops will grow together well. Here are some examples of some unhappy marriages:

- A climbing cover crop may clamber up tall crops such as maize and cotton. If it grows too well, it may shade the taller crop and reduce its yield. (Choose a creeping variety of the cover crop instead.)
- Intercropping lablab with cotton may contaminate the cotton fibre, so lower its price.
- Mucuna can take over a maize field too quickly and make it difficult to harvest the maize. (Plant the mucuna later so it does not have a chance to smother the main crop.)

be used by other crops such as maize. The result is higher, more stable yields, without the need to apply expensive inorganic fertilizer.

- **It helps control weeds, pests and diseases** Planting the same crop season after season encourages certain weeds, insects and diseases. Planting different crops breaks their life cycle and prevents them from multiplying.
- **It produces different types of output** Growing a mix of grain, beans, vegetables and fodder means a more varied diet and more types of produce to sell.
- **It reduces risk** A single crop may fail because of drought. It may be attacked by pests. Or its market price may be low when time comes to sell it. Producing several different crops reduces these risks.

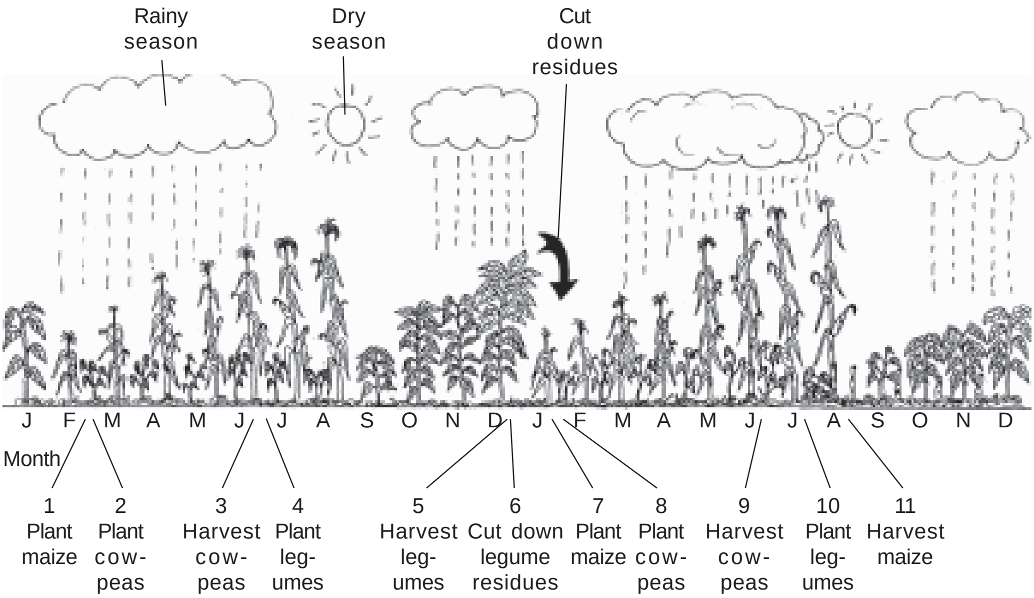
In some ways, crop rotation takes the place of ploughing the soil: it helps aerate the soil, recycles nutrients, and helps control weeds, pests and diseases.

Intercropping, **strip cropping** and **relay cropping** bring many of the same advantages as rotation. Even so, it is a good idea to rotate crops even if you use these approaches.

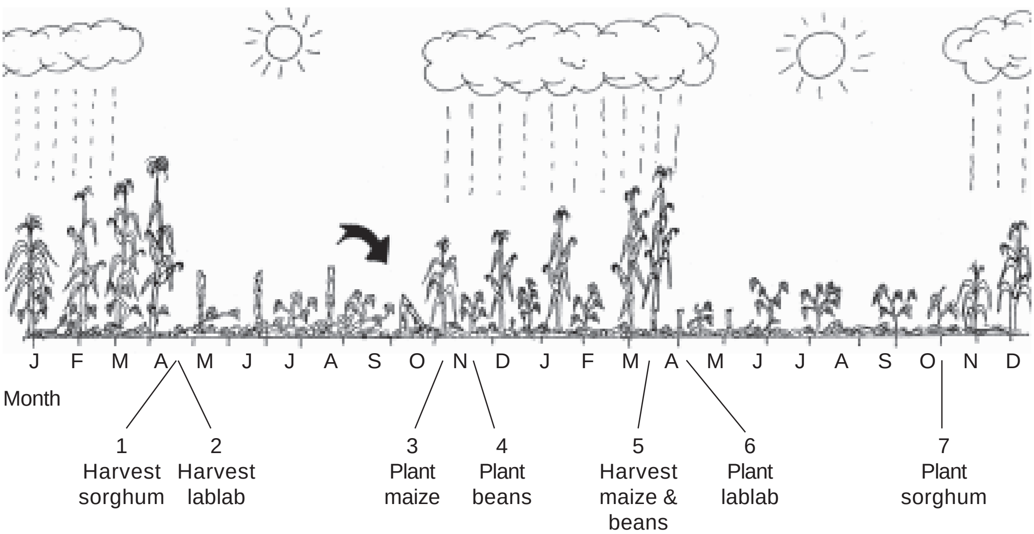
	Year 1	Year 2	Year 3
Swaziland	Maize + cowpea or lablab	Sorghum + lablab	Maize + cowpea
Cameroon	Sorghum + cowpea	Cotton	Sorghum + cowpea
Kenya	Maize + lablab	Maize + cowpea or beans	Maize + lablab
Tanzania	Maize + lablab	Sorghum + cowpea	Maize + lablab

Examples of crop rotations in different countries

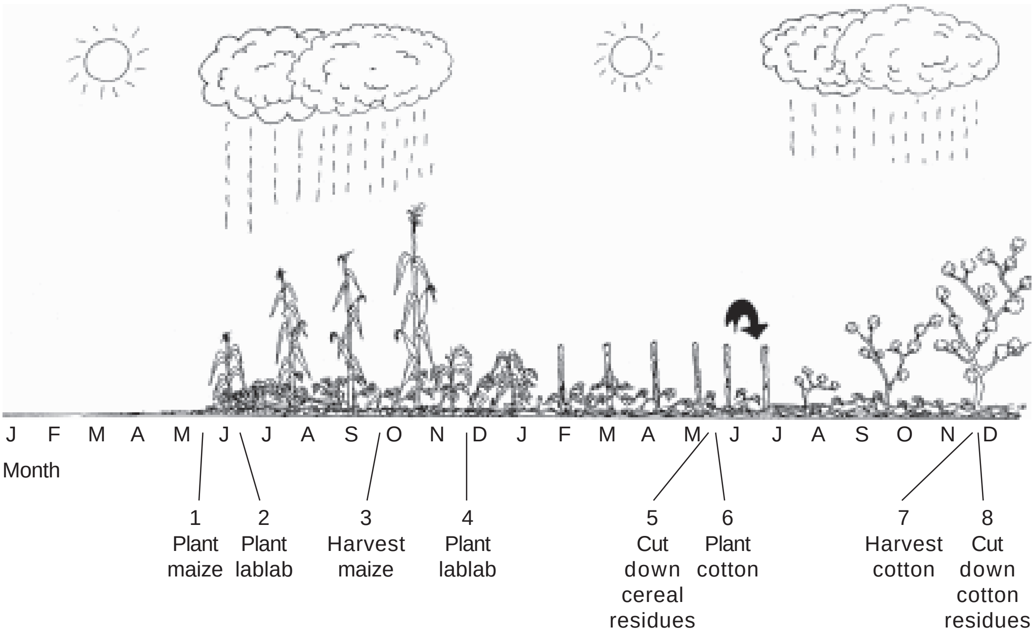
These drawings show some conservation agriculture cropping systems in different parts of Africa. Each diagram shows the crops growing in each month over 2 or 3 years. Note that the soil is never bare!



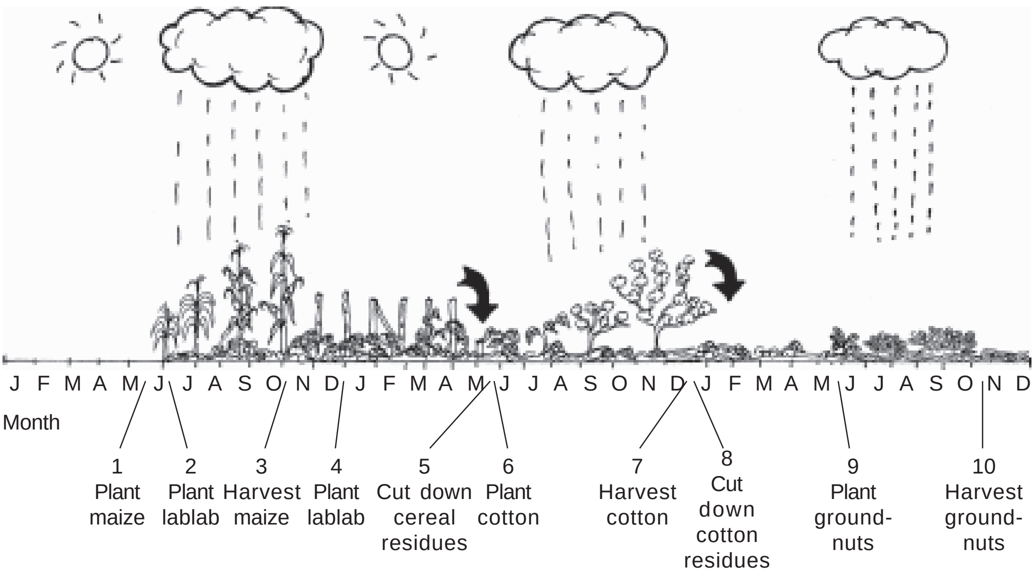
2-year rotation of cereals, cowpeas and legumes in Kenya



2-year rotation of maize, beans, sorghum and lablab in Swaziland



2-year rotation of cereals and cotton in Cameroon



3-year rotation of cereals, cotton and groundnut in northern Cameroon

Healthy soil from crop rotations

Farmers in Busia and Vihiga districts, western Kenya, are using leguminous shrubs to increase the fertility of their soils.

The farmers used to grow maize year after year, with few inputs. Their soils were compacted and infertile, and were eroding away. Maize yields were less than 1 t/ha.

Beginning in 1999, an ICRAF project known as IMPALA has worked with the farmers to find a solution to these problems. The project introduced zero-tillage and various leguminous shrubs (*Crotalaria* spp., *Tephrosia* spp., *Gliricidia sepium* and *Sesbania sesban*). The farmers intercrop maize and beans in the long rains, then plant the shrubs and let them grow in the short rainy season.

Towards the beginning of the long rains, they slash the shrubs and leave them on the surface as mulch. Two weeks later they plant maize and beans again through the mulch.

In 2001, just 2 years after starting conservation agriculture, one farmer harvested 1.9 tons of maize per hectare. By 2004, the same farmer was harvesting 3.2 t/ha.

The shrubs and mulch controlled weeds and smothered the most aggressive grasses. *Striga* infestation has fallen. The soil is now darker and softer, and has more organic matter.

The benefits do not stop there. Farmers can produce enough firewood for their own use and can sell bundles of wood at KSh 20 each. The shrubs attract bees, so one farmer was able to make KSh 18,000 worth of honey. Another produced 90 kg of *Tephrosia* seeds, which he sold for KSh 15,000.

More information: Anja Boye

Selecting crops

Choosing the right crops and crop combinations

You probably already know which main crops you want to grow. You probably want to plant maize (or whatever the staple food in your area is), beans (nutritious and a good source of protein), vegetables (needed for a healthy diet) and some fodder for your animals.

But you may want to grow other crops too. You may have several fields, and you can try different crops on each. And which cover crop should you choose?

Some things to consider when choosing crops:

- **What does it produce?** Crops produce many different things: food, fodder, firewood, fence poles, thatch and medicines. Farmers grow some crops (such as cotton) only for cash. For other crops, such as cereals or vegetables, you may be able to sell what you do not use yourself. Make sure there is a market for the output.
- **Will it grow well?** This depends on many things: the amount of rain or moisture in the soil, the season (some crops and varieties do not grow well at certain times of year), the soil fertility, and so on.

Questions about crops

Choose one of the crops that you grow, and think about it for a few minutes. How would you describe it?

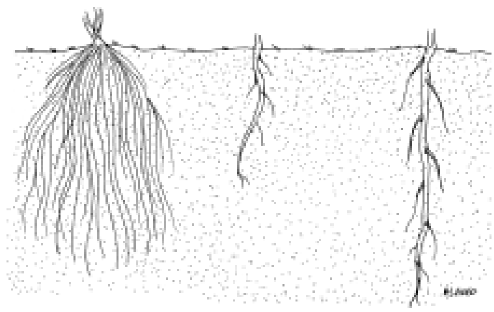
- Is it a food crop? Forage? A cash crop?
- Is it short or tall?
- How many days or weeks does it grow in the field?
- Can it withstand drought well?

All these are important. But did you think of these things?

- How well does it cover the soil?
- What type of roots does it have?
- Does it improve the soil fertility?

These are important questions to answer if you want to make the best possible use of different crops under conservation agriculture.

- **What inputs are needed?** How much work does it take to grow the crop? Can you get seed? Do you need other inputs, such as fertilizer or insecticide?
- **What are the roots like?** Tall cereals (millet, maize, sorghum), finger millets and some legumes (e.g., pigeonpea and sunn hemp) have strong roots that penetrate deep into the soil – up to 1.2 m for tall cereals. Their roots improve the soil structure and porosity, so are a good choice if the soil is compacted (see Chapter 3).



Different crops have different types of roots

- **Does it improve the soil fertility?** Legumes improve the soil fertility by fixing nitrogen from the air. They use part of it for their own needs, and leave the rest in the soil. Cereals and other plants can use this nitrogen if they are intercropped with the legume, or if they are grown as the next crop in the rotation.
- **Does it cover the soil well?** Tall cereals do not cover the soil well because they have upright leaves and they are planted far apart. Short grasses (*Brachiaria*, *Cenchrus*, *Andropogon*) and many legumes (lablab, groundnut, cowpea, beans) cover the ground very quickly after they are planted. When their main use is indeed to provide cover, we call them **cover crops**. If their main use is to provide food, we call them **food legumes** (beans, groundnuts).
- **Does it work with other crops?** Try to find combinations of crops that complement each other well. For example, cereals grow well with legumes

New rice varieties around Lake Alaotra, Madagascar

Farmers around Lake Alaotra usually do not plant rice in rainfed or poorly irrigated areas because their traditional varieties do not grow well there.

Researchers introduced two varieties (Sebota 281 and Agronorte 147) from Brazil. These new varieties can produce more than 6 tons/ha under normal irrigation, and still yield around 2 ton/ha under poor irrigation or in rainfed conditions, where traditional varieties would fail to produce a harvest.

The new varieties can be planted directly in the mulch of winter legumes, without field preparation. This means that more moisture is available during years when little water is available for irrigation.

More information: Olivier Husson, CIRAD

(either food legumes or cover crops): the cereals benefit from the nitrogen fixed by the legume. Two different legumes or two different cereals do not usually work well together. If you have problems with *Striga* in your field, you may want to grow **trap crops** such as *Crotalaria* or *Tephrosia* to encourage the *Striga* to germinate and die when they do not find any suitable plants (such as maize or sorghum) they can live off.

It may be more difficult to find the right combination of crops for your situation. You and your neighbours can try out new combinations to see which ones work. Or you can check with extension workers, researchers or farmers in other villages to see what they suggest.

Choosing the right varieties

Farmers all know that not all sorghum is the same. Some varieties grow quickly and produce a yield in a short time. Others take longer until harvest. Some are taller than others, or produce more leaves. Some respond better to fertilizer, some are more tolerant to drought or *Striga*.

The same is true for other crops. For example, some varieties of cowpeas can be harvested in 55 days; others take more than 100 days. Some climb, while others crawl on the ground.

- Choose a variety that has the characteristics you want. Make sure you get the right seed.
- If you find a variety that you like, consider producing your own seed to sow in the future (see page 91).

Choosing a crop rotation

What crops should you plant next year, and the year after that? That depends on many things – see the questions above about crops and crop combinations.

Adapting an existing cropping system

It may be easy to convert an existing cropping system to conservation agriculture.

- In conventional maize cropping in humid western Kenya, farmers can start by planting lablab as a cover crop between the maize rows, 2–3 weeks after planting the maize
- In northern Cameroon, farmers can plant *Brachiaria*, a grass cover crop, at the same time as cotton (see the next page).

Both of these are easy because they adapt what farmers already do.

Here are some extra considerations.

- See if you can **modify** your existing cropping system so it is better suited to conservation agriculture. It is easier to adjust an existing system than to come up with one that is a completely new.
- Consider changing the **main crop** in your field. For example, if you normally grow maize, consider planting sorghum next year. If you have several fields, you can use a different one each year to plant your main crop.
- Change the **cover crop** you grow. If you planted lablab this year, you might sow mucuna next year.

Challenges in cropping systems

Here are some problems you may encounter with cropping systems, and some ways to overcome them.

Pests and diseases

Certain insect pests and diseases may spread easily from one crop to the next through the crop residues.

- **Avoid crop combinations** where this is a problem.

Markets

Markets do not always exist for new crops you may want to plant as part of your rotation. It may be hard to find seed, you can't find anyone to buy the yield, or prices are too low to make it worthwhile growing the crop.

- **Check the source of seeds and price of the output** before you decide which crops to plant. It may be worthwhile getting together with your neighbours to grow a certain crop, then transport it to a market in a bigger town.

From conventional to conservation: Cereal/cotton rotations in northern Cameroon

Farmers in northern Cameroon grow cereal and cotton in rotation. Here is how they can switch to conservation agriculture.

Year 1 Cereals

1 If necessary, plough to remove any ridges and furrows left from the previous season This is necessary in the first year only. If the ground surface is even, do not plough.

2 Treat the fields with a pre-emergence herbicide such as atrazine. (Do not use atrazine if crotalaria is growing because atrazine will kill it.) If there are many weeds, it may be necessary to apply gramoxone or glyphosate along with atrazine. Make sure that you control weeds well at this stage: it is difficult to do so once the cover crop is growing.

3 Plant the cereal in rows using the same methods and plant spacings as usual.

4 Plant the cover crop between the cereal rows using the guidelines in the table below. (These recommendations are for northern Cameroon. Adapt them for your own area.)

5 Grow and harvest the cereal crop.

6 Leave the crop residues on the field. Prevent animals from grazing on them.

Year 2 Cotton

1 Control weeds. Use diuron (a pre-emergence herbicide). If weeds are already growing, use paraquat or glyphosate to control them.

2 Sow cotton through the residue as early as possible. Use treated seeds to prevent attacks by insects. Sow the cotton seeds in the rows previously used for the cover crop. Sow at the same plant spacing as usual.

More information: Oumarou Balarabe

Cover crop	Plant spacing	Amount of seed per ha	Number of seeds per hole	Date of sowing
Brachiaria	25 cm	8 kg	5–10	At the same time as the cereal
Crotalaria	25 cm	6 kg	5	After first weeding of cereal
Brachiaria + *Crotalaria*	25 cm	4 kg of each	5 *Brachiaria* 3 *Crotalaria*	After first weeding of cereal
Mucuna	80 cm	12–20 kg	2	When cereal reaches knee height
Lablab	80 cm	8 kg	2	When cereal reaches knee height
Cowpeas	50 cm	10 kg	2	For millet, at the same time as planting. For other cereals, when the cereal reaches knee height

Knowledge, skills and labour

Managing rotations properly requires more skills than a single crop. It also needs work at different times of year. People may be reluctant to try out new crops because they are not used to growing or eating them.

- **Try out the new crops on a small scale** first so you can learn from your mistakes. Visit other farmers who are already growing the crop, or ask an extension worker for advice. Ask about ways to use or sell the output, or recipes for how to cook it.

Conservation agriculture fuels firewood production

Firewood is perhaps not the first thing most farmers would think of when they consider switching to conservation agriculture.

But for farmers in western Kenya, it is one of the main ways they benefit from this new approach. They rotate their maize with *Tephrosia candida* and *Sesbania sesban*. They have found that growing these leguminous shrubs for 8 months can supply three-quarters of their firewood needs. And if they leave them in the field for 18 months, they have lots of wood to sell.

Firewood is scarce in western Kenya, and farmers and their children spend a lot of time searching for it. Conservation agriculture is saving them the effort and making them money at the same time. And it is helping conserve the area's remaining forests too.

7

Controlling weeds

Weeds are any plants that grow where they are not wanted. They compete with the cultivated crops for nutrients, moisture, sunlight, and space. They shelter pests and diseases that attack the crop. They reduce crop yields and farmers' incomes. Controlling weeds can be a lot of work.

In conventional farming, tillage (turning the soil over) is a major way to control weeds. Farmers plough repeatedly in order to suppress weeds and have a clean field when they plan their crop. Ploughing buries many weed seeds, but it also brings other seeds back to the surface, where they can germinate. Burning crop residues may also stimulate the growth of some types of weeds.

Conservation agriculture reduces weed numbers in several ways:

- **It disturbs the soil less**, so brings fewer buried weed seeds to the surface where they can germinate.
- **The cover on the soil** (intercrops, cover crops or mulch) smothers weeds and prevents them from growing.
- **Rotating crops** prevents certain types of weeds from multiplying.

How to manage weeds

Controlling weeds is vital in conservation agriculture. If you do not control weeds properly, they may take over your field, and you will be left with little or no yield! It is important to control weeds at the right time, before they become a problem. Do not allow them to compete with the crops, and do not let them grow long enough to produce seeds. You may have to slash weeds even after harvesting the crop in order to prevent them from producing seeds.

Weeds are thieves

- They take light, water and food away from your crops.
- They push the crops out of their living space.
- They shelter pests and diseases that attack the crop.

The longer you leave them, the harder they are to control. Control them before they steal your yield!

Weeds can be a big problem when you first start using conservation agriculture. You may have to work hard in the first couple of years to control weeds. Be patient! If you do it properly, weeds will become less of a problem later on.

You can manage weeds in many different ways (see also Photos 28–34):

- Using crops and other forms of **soil cover.**
- By **hand weeding** or using **equipment** to cut or crush the weeds.
- Using **herbicides**.

We will discuss each of them in turn.

You will probably need to use a **combination** of these methods to control weeds. It is best to prevent weeds from growing by using various forms of soil cover. These methods are cheap and avoid disturbing the soil. You can then kill any weeds that do grow by using a hand hoe or machete, or with herbicides.

Managing weeds with soil cover and crops

There are various ways to control weeds using crops and other forms of soil cover. They include planting the main crop and intercrops at the right spacings, planting cover crops, using mulch, rotating crops, and intercropping.

Crop spacing

You can plant crops closer together to shade weeds that try to grow in between. The best crop spacing suppresses weeds but avoids competition between individual crop plants. The ideal spacing depends on:

- **Soil moisture and temperature** Weeds grow quickly in hot, wet areas, so closer spacing is needed to smother them.
- **Soil fertility** Weeds grow fast in fertile soil, so closer crop spacing is recommended.

Cover crops

Good cover crops spread over the soil quickly and suppress weeds before they can grow.

Select cover crops that have several uses (food, fodder, fuelwood, etc.), and that produce a lot of green matter that covers the surface rapidly. Cover crops such as lablab can cover the soil completely 2 months after planting.

You may have to weed once to give the cover crop a chance to get established. You can also use a pre-emergence herbicide after planting maize and lablab to stop weed seedlings from emerging.

If the rainy season is long enough, consider planting the cover crop as a relay crop. It will spread over the soil and smother weeds after you harvest the main crop.

Some cover crops (such as black oats) control weeds by producing chemicals that prevent weeds from growing.

See Chapter 5 for more information on cover crops.

Mulch

Weed seeds germinate easily if the soil is bare. Leaving the crop residue on the surface as mulch makes it hard for weeds to grow because they do not have enough space or light. Take care that the mulch does not smother emerging crop seedlings. See Chapter 5 for more information on mulch.

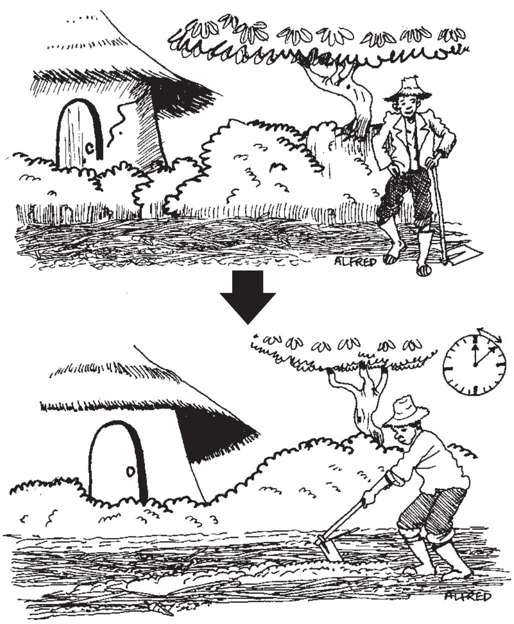
In some cases (such as in semi-arid areas) it is difficult to get enough mulch to cover the soil. Consider bringing in mulch from other fields. This takes more work, but is probably worthwhile. The mulch will not only manage weeds; it will also reduce the soil temperatures, conserve moisture, encourage water to sink into the soil, and add organic matter.

Take care not to bring in mulch that can spread weed seeds! Do not use as mulch plants that have flowered and produced seeds.

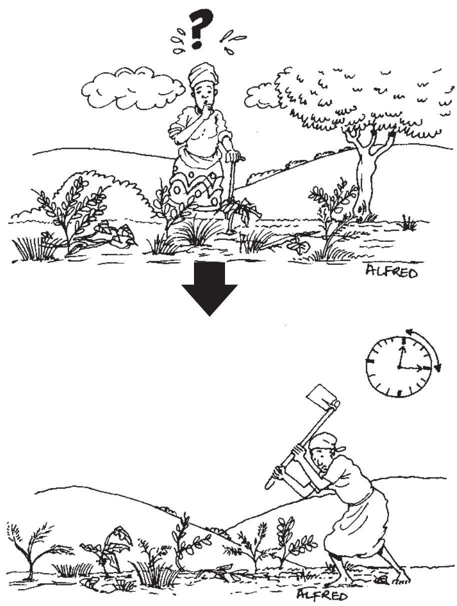
Crop rotation

Planting a different crop on each field breaks the life cycle of weeds. There are fewer weeds, and they are easier to control. A good crop rotation prevents the buildup of weed populations. If you cannot rotate your main crop, try to plant a different cover crop or intercrop each season.

See Chapter 6 for more information on crop rotations.



Mulch suppresses weeds, so saves time when you prepare the field for planting



No mulch? Get ready to spend a lot of time preparing the field and fighting weeds!

Intercropping

Intercropping helps cover the soil and smother weeds that grow between the rows of the main crop. Choose a crop that spreads quickly and produces a lot of vegetation. Legumes, pumpkins and sweet potatoes are a good choice.

Weeding by hand or with equipment

Hand weeding

You can pull out weeds by hand, or slash them with a machete, sickle, slasher or billhook. You can also use a hoe for weeding, but this disturbs the soil surface. Hand weeding is often the job of women and children.

Here are some advantages of hand weeding:

- Uprooting weeds by hand disturbs the soil less than using most types of equipment. Try not to disturb the soil too much if you use a hoe or other implements.
- Hand tools are cheap and can be bought in most markets.

Hand weeding has several disadvantages:

- It is hard work and takes a long time.
- The weeds may regrow easily.
- The stalks may not be crushed well, making it difficult to plant crops through the residue.

Animal- and tractor-drawn weeders

To use an animal- or tractor-drawn weeder, plant the crops in rows with the same spacing as the cultivator blades.

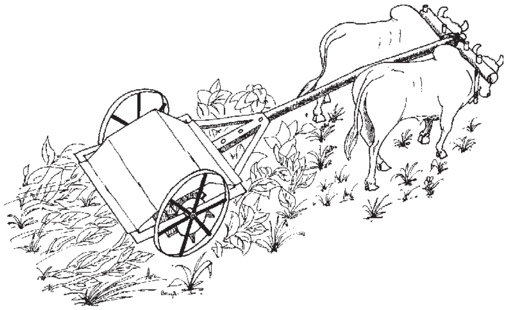
Weeding by draught animal or tractor power is quicker and easier than by hand. Using an animal-drawn weeder can take less than one-fifth of the time needed for hand hoeing.

However, weeders have several disadvantages:

- They can damage crop roots. This may be a problem especially in arid and semi-arid areas.
- They disturb the soil. They bring up weed seeds to the surface and let them germinate more easily. That means more weeding later on.
- They may carry weed seeds from place to place.
- They do not work properly if the field has crop residues or mulch from cover crops.

Knife-rollers

A knife-roller kills the cover crop and weeds by bending them over and crushing them. It is used before planting the main crop. It can be pulled by draught animals or by a tractor. Knife-rollers are fairly simple, and can be designed and made locally.



Animal-drawn knife-roller

Knife-rollers and black oats

Farmers in Brazil plant black oats (*Avena strigosa*) as a cover crop. They use a knife-roller or roller-chopper to kill the oats after flowering but before the seeds have matured. The best time to do this is when the oats have reached the milk stage (squeeze the grains and a white liquid like milk comes out). This has two advantages: when the oats are this old, the dead leaves and stalks stay on the ground as mulch for longer. And the oats do not have a chance to produce seeds, which would be difficult to control.

The knife-roller crushes the cover crop, but does not cut it up. That means the residues are not dragged along by the roller and do not get tangled in equipment.

Herbicides

In some places, there are not enough people to do the weeding. If this is the case, consider using herbicides.

Herbicides are quick and easy to apply, and do not disturb the soil. Some herbicides kill only certain types of weeds.

Not many smallholder farmers use herbicides because they are expensive and hard to find. They also need special equipment, such as sprayers or wipers. It is important to use the right amounts of chemicals, mix them with clean water, and handle them safely. If you are considering using herbicides, get training on how to use them the right way.

Herbicides can be applied in different ways:

- **Weed wiper** (such as a Zamwipe)
- **Knapsack sprayer**
- **Hand-pulled sprayer**
- **Animal-drawn sprayer**
- **Tractor-mounted boom sprayer**.

Weed wipers

A weed wiper looks like a broom with a sponge on its head. A small tank on the handle holds the herbicide, which flows down into the sponge. The best-known type of weed wiper is the "Zamwipe", used in Zambia.

Wipers are ideal for small farms. Use them to apply herbicide on weeds between crop rows, or to kill cover crops before planting the main crop.

A weed wiper looks like a broom with a sponge on one end and a bottle on the handle

Their advantages include:

- They are light and easy to use, and ideal for women farmers.
- They are fairly cheap (about US$ 17) and easy to maintain.
- They have low application rates (only 20–25 litres/ha), so use little water.
- There is no risk of wasting herbicide or damaging the crop because of spray drifting in the wind.

Wipers have some disadvantages:

- They are useful only for small plots of land.
- Farmers need to know how to use the wiper properly.
- Wiping weeds on uneven ground is difficult.

The Zamwipe works best just before planting the main crop. Use it to kill weeds that have started to regrow after they are slashed, when they are 10–12 cm tall. Use it also to deal with individual weeds. It can also be used to control weeds in between rows of maize or sorghum, when the crop is knee-high – i.e., at the same time as when farmers normally weed their fields.

Never use dirty water, and clean the wiper immediately after use.

Knapsack sprayers

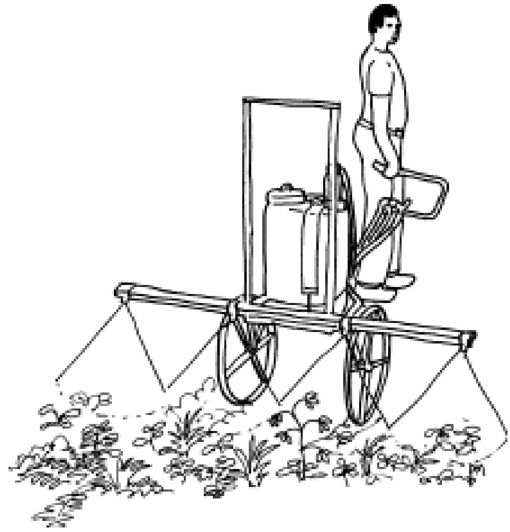
Many small-scale farmers already have a knapsack sprayer. These sprayers may be manual or powered by a petrol engine. They are reasonably cheap and easily available. Mounting a shield prevents the spray from drifting onto crops, so the sprayer can be used after the crop has emerged. Knapsack sprayers are not suitable for large farms.

Knapsack sprayer

Hand-pulled sprayers

Hand-pulled herbicide sprayers are like a knapsack sprayer mounted on wheels. When the wheels turn, they pump the herbicide into a boom with four or six spray nozzles. The height of the boom can be adjusted to deal with plants of different heights.

These sprayers are sometimes called "pedestrian-pulled" sprayers.



Hand-pulled sprayer

They have more nozzles and a larger tank than a knapsack sprayer, so can cover a larger areas more evenly. They are suitable for treating a whole field; they cannot be used to spot-spray individual patches of weeds. Because the spray is behind the operator (unlike with knapsack sprayers), there is much less risk of breathing in the spray or getting it on your skin other clothing.

Animal-pulled sprayers

Animal-powered sprayers may have up to 10 nozzles (spaced about 50 cm apart). They can be pulled by one or two animals. They have a larger capacity than hand sprayers, so are suitable for larger areas.

Tractor-powered sprayers

Tractor-powered sprayers can be very sophisticated. They are suited for large farms. It may be possible to hire someone to spray your farm with a tractor sprayer, rather than investing in one yourself.

When and how to weed

After changing to conservation agriculture

When you first adopt conservation agriculture, weeds may be a big problem. Conservation agriculture improves the soil fertility, so encourages weeds to grow. African couch grass (*Digitaria abyssinica*) and yellow nutsedge (*Cyperus esculentus*) may be a particular problem because they are difficult to uproot.

There are a lot of weed seeds in the soil, and if you let them grow, they will destroy your yield!

Here are some steps in controlling weeds. Adapt them to suit your own situation.

1 It is a good idea to slash weeds immediately after the harvest and during the dry season to prevent them from producing seeds.

2 Before you plant, slash any plants (weeds, cover crop, stalks left over from the previous crop) in the field. (A disadvantage with this is that it may encourage grasses and certain other weeds to grow if it is wet.)

3 Dig planting pits with a hoe, or open planting furrows with a ripper or subsoiler.

4 After the first rains have fallen, allow weeds to regrow or new weeds to emerge. Wait about 2 weeks until they are growing vigorously, then apply a post-emergence herbicide such as glyphosate using a Zamwipe or a sprayer. This will kill all emerged weeds before you plant.

5 Immediately afterwards, plant the main crop.

6 Plant a cover crop between the rows of the main crop.

7 Check for weeds every week and control them by pulling them out by hand, scraping the soil surface with a hoe, using an animal-drawn weeder, or using a selective herbicides.

8 Harvest the main crop and allow the cover crop to grow.

9 Continue checking for weeds and pull them out before they can flower and seed.

10 Harvest the cover crop seeds.

11 Manage (bend over and crush) the mixture of crop residues and cover crops using a sickle, machete, knife-roller or another implement some 3 weeks before you expect the first rains to begin.

In later years

If you control weeds diligently, they should be easier to control in later seasons. It can take 3–5 years for the number of weeds in the soil to be reduced so much that very few new weeds grow.

Leave the soil undisturbed, and keep the soil covered so that weed seeds do not have a chance to germinate. Any weeds that are lucky to germinate have no space or light, so they die.

You should still check for weeds regularly and pull out any you find. You may also need to use herbicides to control weeds. But overall, weed control will be a lot less work.

Challenges in managing weeds

- The switch from conventional farming to conservation agriculture is the most challenging time. Many farmers do not realize the importance of controlling weeds, or they may not know how to do it without disturbing the soil.
- Weeding with hoes or with equipment pulled by animals or tractors is more difficult because of the crop residues or mulch on the ground.
- Farmers may be reluctant to use herbicides because of the expense, or because they do not have the right equipment.
- Some critics of herbicides say they damage the environment or make people ill. (Herbicides are safe as long as they are used and stored properly.)
- Farmers may not know how to use sprayers properly, or how to spray the right amount of herbicide. (See the guidelines below.)

Using the right amount of herbicide

If you use herbicides, it is important to make sure you apply the right amount. If you do not, you risk either using too much (which is wasteful and expensive) or too little (which will not control weeds properly).

Zamwipe

The Zamwipe manufacturer estimates that wiping the weeds or cover crop on one hectare of land will use about 20 litres of liquid. The actual amount used depends on the number of weeds (or cover crop) and how thorough the operator is.

Here's how to make sure you use the right amount of herbicide in a Zamwipe:

1. Fill the Zamwipe container with clean water. Do not put herbicide into the tank.
2. Use the Zamwipe to wipe the weeds in a field until the container is empty.
3. Calculate the area you have wiped:

$$\text{Area wiped with 1 container } (m^2) = \text{Width of area wiped (m)} \times \text{Length of area wiped (m)}$$

4. Calculate the number of containerfuls needed to wipe one hectare:

$$\text{Containers of liquid needed to wipe 1 ha} = \frac{10{,}000\ (m^2)}{\text{Area wiped with 1 tank } (m^2)}$$

5 Check the label of the herbicide you want to use. What is the recommended application rate?

6 Calculate how much herbicide to add to each containerful to get the right application rate:

$$\text{Amount of herbicide per tank (millilitres)} = \frac{\text{Recommended application rate (litres/ha) x 1000}}{\text{Tankfuls of liquid needed to wipe 1 ha}}$$

Example

You do a test-wipe of cover crops in a maize field, with rows 0.75 m apart. You find that you can wipe an area of **0.75 m x 650 m** with one containerful.

- Area wiped with 1 containerful = 0.75 m x 650 m = **488 m²**
- To wipe 1 ha, you will need 10,000 / 488 = about **20 containerfuls of liquid**.

The glyphosate label recommends an application rate of **3 litres** of glyphosate per hectare.

- Amount of glyphosate per container = 3 x 1000 / 20 tanks = **150 ml**
- You will need to put **150 ml** of glyphosate into each Zamwipe container.

Sprayer

You can use the same approach to make sure you use the right amount of herbicide in a sprayer.

1 Fill the sprayer tank with clean water (do not add herbicide).

2 Spray a field until the tank is empty. Walk at the same speed as if you were spraying weeds in a field, moving the nozzle for side to side as you normally do.

3 Calculate the area you have sprayed, the number of tankfuls needed per hectare, and the amount of herbicide to add to each thankful, using the equations above.

Example

In your test-spray, you use a tankful of water to spray an area **20 m x 100 m**. The herbicide label recommends an application rate of **3 litres** per hectare.

- Area sprayed with 1 tankful = 20 m x 100 m = **2000 m²**
- To spray 1 ha, you will need 10,000 / 2000 = **5 tankfuls**
- Amount of herbicide per tank = 3 x 1000 / 5 tanks = **600 ml**
- You should put **600 ml** of the herbicide in each sprayer tank.

Sums with herbicide

For more information on working out how much herbicide to use, see the following websites:

- www.arc.agric.za/institutes/sgi/main/howdo/calibrate.htm
- www.knowledgebank.irri.org/ppfm/cropProtection/WebHelp/Crop11.htm

Hand-pulled or animal-drawn sprayers

You can use a similar method to the one above to work out how much herbicide to apply using a hand-pulled or animal-drawn sprayer.

During your test run, make sure that the sprayer boom is set to the right height so the sprays overlap with no wastage of liquid. Pull the sprayer (or lead the animals) at the same speed as you would when normally spraying.

Using herbicides correctly and safely

Using herbicides correctly

- Check the amount of herbicide the sprayer applies to make sure you are using the right amount (see text above).
- Spray from the right height. This depends on the height of the weeds and the type of nozzle. If you are using a hand-pulled or animal-drawn sprayer, adjust the height of the boom so the spray from the nozzles covers the weeds evenly – not too much overlap, and no gaps.
- Mix the herbicide with clean drinking water.
- Always read the label carefully before using any herbicide.
- Make sure you know how to use the herbicide properly. Get training if you need it. If you are not sure about any herbicide or equipment, ask a specialist for help.
- Some dealers sell fake or outdated herbicides. Buy only from a certified dealer. Check the date on the label to make sure the herbicide you buy is still effective.
- Do not use the same herbicide year after year, because weeds may become resistant to it. Switch herbicides each year or every few years.

Using herbicides safely

- Use protective clothing to protect yourself from harmful effects of the herbicides.

Weed control in Laikipia

Farmers who practise conservation agriculture in Laikipia district, a semi-arid area in Kenya, use herbicide to control weeds.

Immediately after harvest, when the soil is not too hard and dry, they rip their fields using an animal-drawn ripper. This allows dew and the first rains to sink into the soil.

It also allows weeds to grow. So the farmers check which type of weeds have germinated, then buy a herbicide that will kill these weeds. In the short rainy season, broadleaved weeds are normally more common, so the farmers buy 2,4-D herbicide (a very toxic chemical!). In the long rains they buy Roundup (a herbicide that contains glyphosate), which controls grass weeds.

They check on weeds regularly and apply another round of herbicide after the crop has started to grow.

The farmers save on herbicide by spraying early in the season when the weeds are small, and by spraying early in the morning. They need only 400–800 ml per acre.

They have found the number of weeds has fallen since they introduced conservation agriculture in 2000. Farmers who cannot buy herbicide use an animal-drawn cultivator, ridger or plough for the first weeding.

- Wash your hands, face, body and equipment immediately after handling or using any herbicide.
- Rinse and clean spray equipment well away from water sources such as wells, ponds or rivers.
- Always store herbicides in their original containers, well out of reach of children and animals.
- Dispose of containers in a deep pit, or as indicated by the manufacturer.

Care of sprayers

- Ensure that the equipment is in good working condition (no leaks or blockages). Check that the valves and switches are working properly and that the spray nozzles and filters are not worn or clogged. Replace worn-out or defective parts.
- Clean the equipment immediately after use.
- Grease and oil moving parts.
- Tighten loose bolts and nuts.

How a Tanzanian farmer controls weeds

"When I was practising traditional agriculture, I had to hand-hoe intensively twice, and do one lighter weeding. It took three labourers 6 or 7 days to weed one acre under normal conditions, or 10 days if the soil was wet.

When I switched to conservation agriculture, I was able to reduce the workload and save time and money. It took fewer people and less time to do the weeding.

The first season when I started conservation agriculture, I had to spend extra on lablab seed and Roundup herbicide. But in the following seasons and years, the costs went down because I had to weed less. I left half of the residues from the previous crop on the field to cover the soil. So the work was easier: only one person could weed an acre in just 2 days by pulling the weeds.

This has given me more time for other work, such as planting trees, gardening, controlling erosion, and making honey. I have three beehives, which produce enough honey for my family and to sell."

Thomas Loronyo, Ngorbob village, Arusha

Controlling *Striga* with agroforestry

Striga hermonthica is a weed that attaches itself to the roots of maize and sorghum plants. It is a parasite – like a flea or leech. It takes nutrients away from the maize or sorghum plant, and reduces the crop yields. It is especially a problem on infertile soils.

Striga is a serious problem in parts of western Kenya. An ICRAF project in this area promotes crop rotation as part of conservation agriculture. It recommends planting leguminous shrubs in rotation with the main crop. These shrubs include *Crotalaria grahamiana*, *Crotalaria paulina*, *Tephrosia candida*, *Tephrosia vogelii*, and *Sesbania sesban*.

The shrubs encourage *Striga* seeds to germinate, but the *Striga* plants cannot attach themselves to the shrub roots, so they soon die. They can completely remove Striga from a field after only two years of rotations.

The shrubs have other benefits too. Because they are legumes, they improve the soil fertility and raise the yield of the main crop. They also provide soil cover, reduce runoff, and control erosion.

More information: Anja Boye

8

Conserving soil and water

EROSION AND lack of rainfall are problems that many African farmers face. Conservation agriculture can help overcome both by conserving soil and by storing water in the soil. If erosion is severe, you can combine conservation agriculture with other techniques to control erosion. In drier areas, you can combine it with water-harvesting methods to make more water available to the crop.

This chapter describes various erosion control and water management methods that you can combine with conservation agriculture. It does not describe these approaches in detail. You can find this information in many other manuals (see, for example, Critchley et al., 1991 – full details in the *Resource materials* section in Chapter 14)

Measures that control erosion and conserve soil almost always help to conserve water too. And techniques designed to conserve water may help reduce soil erosion. Choose from the techniques below, and combine and adapt them to suit your needs.

Soil conservation techniques

Erosion can be a severe problem in conventional farming, especially on steep slopes. Conservation agriculture helps control erosion in several ways:

- **Protective cover** Cover crops and mulch on the surface protect the soil against heavy rain. They prevent rainsplash from dislodging fine particles and from forming a surface crust.
- **Soil structure** Undisturbed by ploughing, the soil structure stays intact. Organic matter holds the soil particles together, making it harder for water to carry them off, or for wind to blow them away. Roots bind the soil and hold it in place.
- **Less runoff** More water sinks into the soil through cracks and pores, so less runs off and causes erosion. Ripping and planting along the contour helps prevent runoff. So does using planting basins, which collect water and allow it to sink in.

If your field is on a steep slope or is badly eroded, you should not expect conservation agriculture, on its own, to remedy the situation quickly. You will have to take special measures to prevent erosion before starting conservation agriculture. These measures may include:

- **Contour and cutoff ditches**
- **Gully treatment**
- **Grass strips**
- **Stone lines**
- **Level contour bunds**
- ***Fanya juu* terraces**
- **Bench terraces**.

You should start by **stabilizing gullies** and **digging cutoff drains** to prevent runoff from upslope from washing your soil away. Then, beginning at the top of the slope, mark out **contour lines** running across the slope. You can use an A-frame, line-level or water-tube level to do this. Establish **grass strips** (or trash lines, or whatever other form of **bunds** or **terraces** you have chosen) along the contour lines.

Building terraces takes a lot of work and can be expensive. Terraces can be hard to maintain. So it may be better to choose a simpler, cheaper option such as grass strips and stone lines.

If your land already has terraces, bunds or other erosion-control structures, you can practise conservation agriculture on the terraces or the land between the bunds. Plant crops using **no-till methods** (Chapter 3), keep the soil covered with **cover crops** or **crop residues** (Chapter 5), and **rotate crops** from season to season (Chapter 6). Make sure you maintain the terraces, and keep other structures in good repair.

Contour and cutoff ditches

A **contour ditch** is a ditch dug along the contour to stop water from running down the slope and causing erosion. Water stays in the ditch and gradually sinks into the soil. Contour ditches are useful to harvest water in dry areas.

A **cutoff ditch** is like a contour ditch but has a slight slope (about 1%), so water drains slowly away. Cutoff ditches are useful to protect fields from uncontrolled runoff and to divert water away from gullies.

If your field is on an eroded hillside, dig a contour ditch or cutoff ditch at the top end first to protect it. You can then start using conservation agriculture on the field.

Soil and water conservation techniques that are difficult to combine with conservation agriculture

Some commonly used soil and water conservation techniques are difficult to combine with conservation agriculture because they involve disturbing the soil or removing the soil cover. Here are some of them:

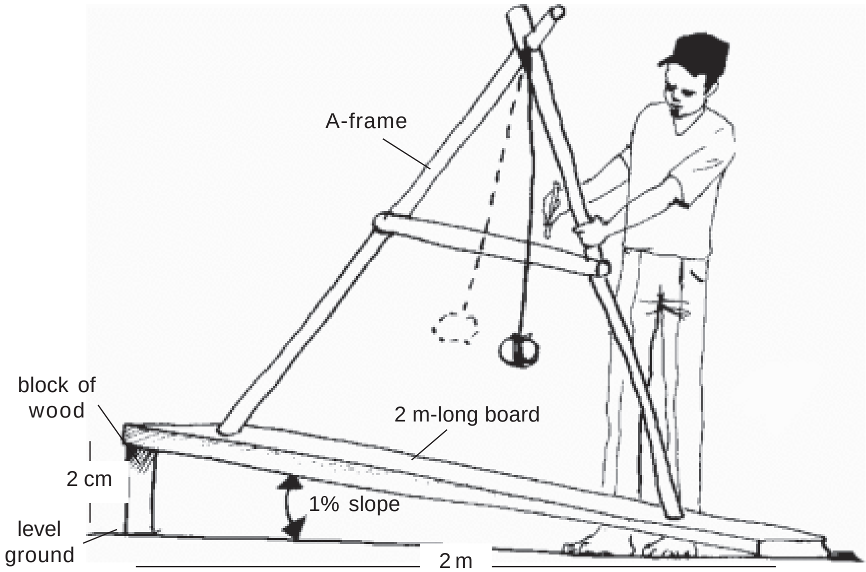
- **Trash lines** (laying stalks and other crop residues in lines along the contour to slow down erosion). This leaves the rest of the soil bare.
- **Contour ploughing** (ploughing along the contour). This aims to reduce runoff – but it means disturbing the soil and removing the soil cover.
- **Tied ridges** and **tied furrows**. These are semipermanent ridges along the contour, with short cross-ties to prevent water from flowing along the furrows between the ridges. In tied ridges, the crops are planted on the ridges; in tied furrows, they are planted in the furrows. These techniques also involve disturbing the soil. The ridges interfere with planters and other conservation agriculture equipment.

How to set your A-frame to measure a slope

You want to dig a cutoff drain with a slope of 1%. How do you know where to dig it?

Simple: use your A-frame. You can mark the A-frame so it shows a slope of 1%. Here's how.

1. Cut a small block of wood 2 cm thick.
2. Put it on a level piece of ground, then put one end of a straight, 2 m long board or pole on top of it, so the other end of the board rests on the ground.
3. Stand the A-frame on the board, and mark where the string touches the crossbar of the A-frame. This mark shows a slope of 1% (2 cm is 1% of 2 m).
4. You can now use the A-frame to mark out a 1% slope in the field. Position the legs of the A-frame so the string touches the mark you have made.



You can also use a line-level or a water-tube level to measure slopes as well as contours.

A-frames for different gradients

If you want the A-frame to mark a different slope, you can use blocks of wood of different thickness:

Slope	Thickness of block	
0% (level)	no block	
0.5%	1 cm	(0.4 inch)
1%	2 cm	(0.8 inch)
2%	4 cm	(1.6 inches)
3%	6 cm	(2.4 inches)
4%	8 cm	(3.2 inches)

The board must be exactly 2 m long for these measurements to work.

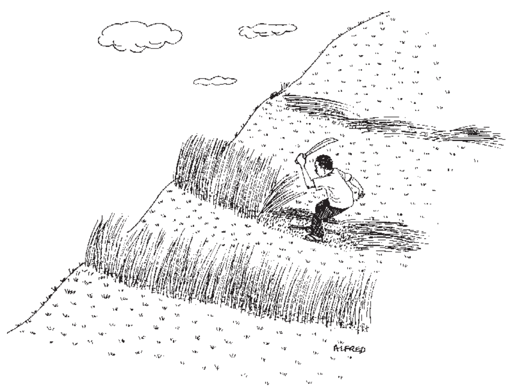
Put cross-ties in contour and cutoff ditches to slow the flow of water and to encourage the water to sink into the ground. Plant grasses to protect the sides of the ditch from erosion and to provide fodder for livestock.

Gully treatment

To control a gully, you must first stop water from flowing into it. Dig a cutoff ditch above the head of the gully to divert water safely away. Then build check-dams from rocks or wooden stakes across the gully floor to slow down any water that still flows down the gully and to encourage sedimentation. Plant trees and grass in the gully and on its sides to stabilize them.

Vegetative strips

A vegetative strip is a strip planted with grass, shrubs or trees that runs across the slope. It slows down water flowing down the slope, and catches sediment that has been eroded uphill. Over time, soil may build up behind the strip, forming a terrace.



Fodder production on vegetative strips

Vegetative strips are cheap and easy to establish. Once they are growing, they are easy to maintain, and they can provide valuable fodder for animals. You can practise conservation agriculture on the land between the strips. You can cut mulch from the strips and use it to cover the land in between.

Mark out contours with an A-frame, line-level or water-tube level. If your field has stones, you can lay these along the contours as an additional barrier. Then plant the strips with grass and (if you want) trees. Here are some options:

- If you need fodder for your livestock, plant grasses such as **Napier grass** (elephant grass, *Pennisetum purpureum*). Do not allow animals to graze the strips; instead, cut grass and carry it to the animals. Caution: Napier grass can compete with the crop growing next to it, so keep it under control.
- **Makarikari grass** (*Panicum coloratum mararikariense*) is a popular grass for barrier strips in East Africa. It is quite drought resistant and can be fed to livestock in the dry season.
- **Vetiver grass** (*Vetiver zizanioides*) forms a dense hedge and grows well even if it is cut for fodder.
- Cash crops such as **pumpkins** and **melons** may also be grown in vegetative strips.

- An alternative to grass is a hedgerow of leguminous trees such as **gliricidia** and **leucaena**. You can feed the leaves to livestock, or prune the trees and spread the branches on the ground as mulch.
- One option is to allow **natural vegetation** to grow in the strips. Make sure that you control weeds in these strips.

One problem with vegetative strips is that they can create alternating bands of fertile and infertile soil. Rich sediment builds up just behind the barrier, so crop yields here are good. Further back from the barrier, though, yields are poorer because the topsoil here has been eroded. These bands may last for some time, until the land between the strips is levelled. Conservation agriculture can help to prevent such bands from developing.

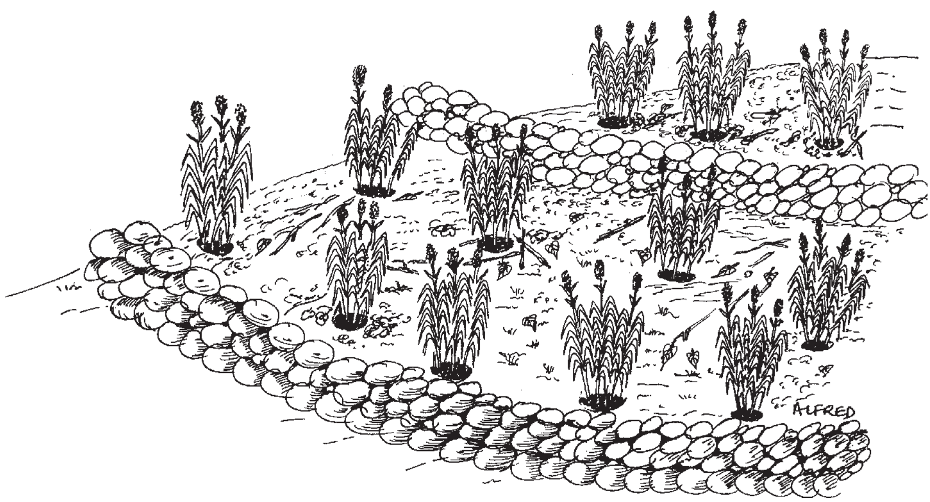
Stone lines

Stone lines are common throughout Africa, in both dry and humid areas. They are used wherever there are loose stones in the field. In the Sahel (especially Burkina Faso and Niger), they are small – at most three stones wide, and one or two high. They slow down runoff, and soil gradually builds up behind them.

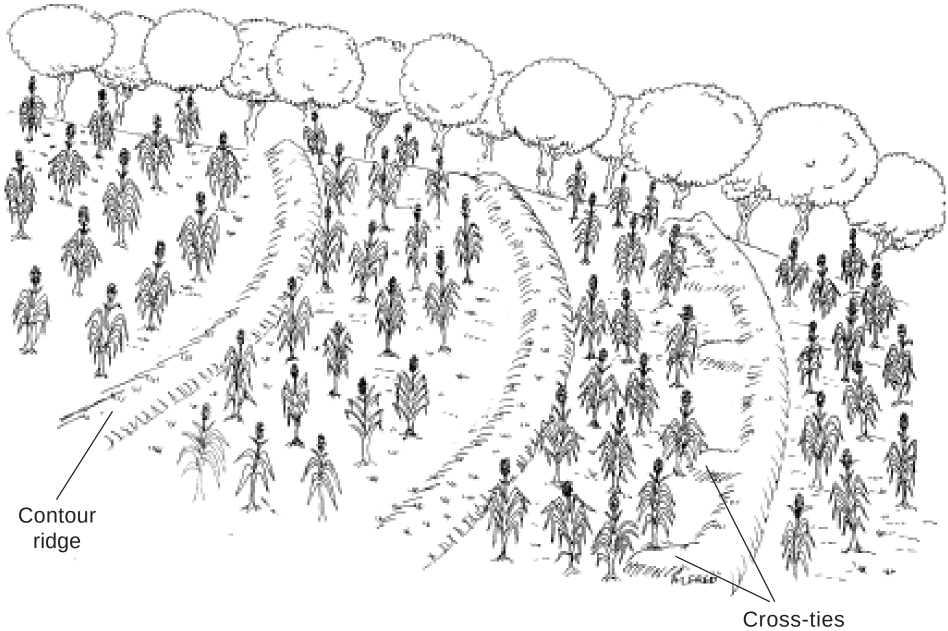
The distance between the lines depends on the slope and how many stones are available. On 2–5% slopes they are often 25–50 m apart.

You can make stone lines from stones in your field, though some farmers bring them in by donkey cart or lorry from up to 10 km away. Line them up along the contour, and plant grass or trees on either side.

Planting pits are often used in combination with stone lines. This is a traditional form of conservation agriculture.



Planting pits in combination with stone lines



Contour ridges

Contour ridges

Contour ridges are ridges of soil that run along the contour. Like other contour barriers, they slow down water flow and catch sediment before it is washed away.

You can make small ridges (called "cross-ties") at right angles to the contour to make the contour ridges more effective at trapping water. These cross-ties prevent the water from flowing along behind the contour ridge and collecting at the lowest point – where it may break through the ridge and start a gully. Space the cross-ties 10 m apart (closer on steeper slopes and in areas with heavy rainfall).

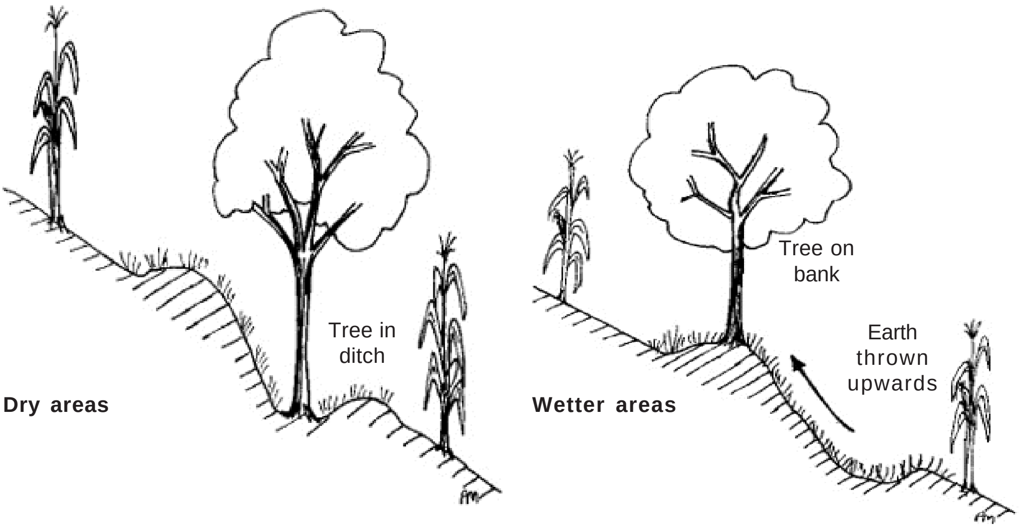
Fanya juu terraces

Fanya juu terraces are made by digging a drainage channel and throwing the soil uphill to make a ridge (*fanya juu* means "throw soil uphill" in Swahili). The channel is usually 50–60 cm deep and may have cross-ties at 10 m intervals.

Grass planted on the ridges helps stabilize the ridges, prevents erosion, and can be used to feed livestock or as mulch.

In drier areas, *fanya juu* terraces may be built along the contour, and trees planted in the ditches.

In high-rainfall areas, it may be better to build them with a slight gradient so the water drains slowly away. Trees can be planted on the banks.



Fanya juu terraces

Fanya juu terraces in Makanya

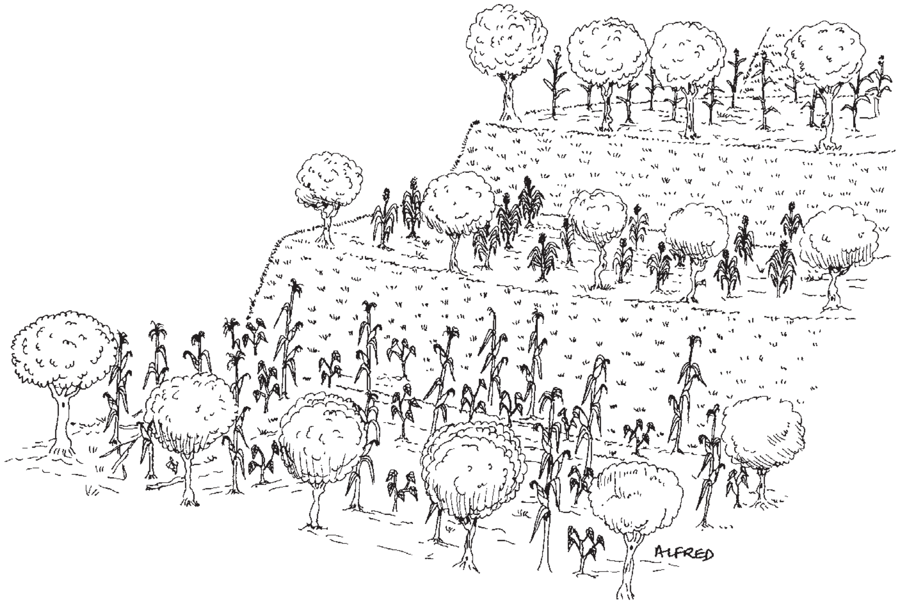
Farmers in Makanya, a dry, hilly area in northeastern Tanzania, use *fanya juu* terraces to conserve water and control erosion. They use a line-level to mark contours in their fields, then dig trenches 50 cm wide and 60 cm along the contours. They pile the earth in ridges upslope of the trenches, and plant fodder grass on the ridges.

They grow maize on the land between the trenches. They used to harvest less than 1.5 t/ha using conventional ploughing. But when they used an animal-drawn Magoye ripper, the yield rose to 2.4 t/ha. Applying manure and planting dolichos as a cover crop raised it still more, to 3.6 t/ha.

Bench terraces

Bench terraces are usually found on medium to steep slopes. They consist of beds which are more or less level, and risers (walls or bunds). It is easy to grow crops on the beds because they are fairly level.

Bench terraces can be made by moving soil from one place to another on the slope. Moving large amounts of soil takes a lot of work: 1500 person days or more to terrace a single hectare on a steep slope. To make this worthwhile, bench terraces must produce much higher yields than before. This is not always the case, so building new bench terraces is going out of fashion. If you do want to build bench terraces in a field, you should do so before starting conservation agriculture.



Bench terraces

Bench terraces may also develop gradually as soil builds up behind a vegetative strip, contour bund or stone line.

To be effective, bench terraces must be well maintained. Keep the risers planted with grass, and repair them if necessary. Use conservation agriculture on the beds to conserve the soil, encourage water to sink in, and maintain fertility.

Water harvesting and conservation

In areas with poor rainfall, there may not be enough water to grow crops reliably. But even in dry years in these areas, more than half the precious rainwater may be lost through evaporation or because it runs off. Conservation agriculture helps conserve water and use it efficiently in at least five ways:

- **More water in the soil** Crop residue or a cover crop protects the soil, prevents crusting on the surface, and slows runoff. Roots, earthworms and other soil life maintain cracks and pores in the soil. Less water runs off, and more sinks into the soil. Ripped furrows and planting basins collect and store water.
- **Less evaporation** Reduced or no tillage means the soil is not turned and does not dry out. The cover protects the soil from wind and direct sun (you can often feel the temperature difference with your hand). Because there is no hardpan, water can sink deeper into the soil.
- **Better use of season's rainfall** Ripping during the dry season allows farmers to plant earlier – right at the start of the rains.

More crop per drop

Over the last two decades, smallholder farmers in Babati District, Tanzania, have adopted conservation agriculture. Instead of disc ploughs, they now use animal- and tractor-drawn rippers and subsoilers. Their yields have more than doubled since the mid-1980s.

That means farmers get more crop for every drop of rain: an extra millimetre of rain now produces as much as 4 kg more grain per hectare. Before, each millimetre produced only 1.5 kg of grain.

It is easy to see – or rather, to feel – the effects of conservation agriculture. Several weeks after the last rains, the soil in ploughed fields is hard and dry. On conservation agriculture fields, however, the soil is still soft and moist. Even after a prolonged dry spell, the crops are still vigorous and do not show signs of water stress.

- **Roots can reach more water** Breaking the hardpan with a subsoiler allows roots to reach water deeper in the soil.
- **Water concentrates in planting lines or pits** Rainwater collects in ripped planting lines or planting basins, where it sinks into the soil – just where the crop needs it.

In wetter areas, conservation agriculture can also help manage water. It can reduce runoff and erosion, make springs run more steadily, and reduce pollution in rivers.

Conservation agriculture helps conserve water, but it may not be enough in dry areas. You can use various other techniques to harvest extra water, either in the field itself, or by bringing water in from outside to where the crops are growing.

Techniques to manage water include:

- **Broad beds and furrows**
- **Planting basins or pitting**
- **Permanent strips**
- **Contour bunds and catchment strips**
- **Bunds and runoff strips**
- **Road catchments**
- **Half-moon microcatchments**

One word of caution: cover crops also use water. In dry areas, you should consider using other types of mulch, such as crop residues or plant remains brought in from outside the field. That will help conserve moisture in the soil where it can be used by the crop.

Broadbeds and furrows

Broadbeds are flat beds about 1–1.2 m wide, separated by furrows. The width of the broadbeds and furrows depends on the crops grown. In areas prone to waterlogging, the furrows drain water away from the beds. In drier areas, they can be used to bring water harvested elsewhere into the field.

Crops such as maize can be grown on the broadbeds, while rice can be planted in the furrows. It is necessary to make the beds only once, before starting conservation agriculture. Afterwards, plant the seeds directly on the beds through the soil cover without tilling, using the techniques described in Chapter 3.

Planting basins or pits

Planting basins (see Chapter 3) collect water and give it time to sink into the soil. Stagger the rows, so basins in one row catch the water that does not fall into basins in the row upslope. Add manure or compost to the basins to improve the soil fertility.

Planting pits (known as *zai* in Burkina Faso and *tassa* in Niger) are a variation on the idea of planting basins. They are hand-dug circular holes which collect water and store it for use by the crop. Each pit is about 20 cm across and 20 cm deep. After planting, the holes are left partly open so they collect water.

Planting pits take a lot of work to dig when the soil is dry. But they produce good yields in areas where otherwise crops might die because of a lack of water.

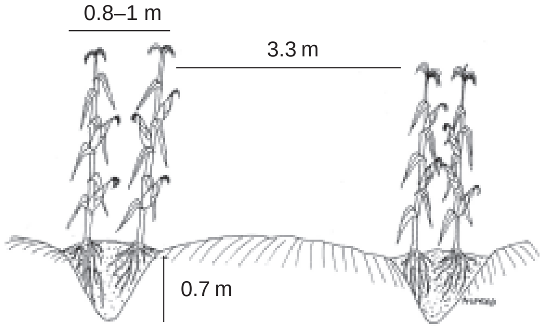
Once made, the pits can be used again, season after season. Leave the soil covered, and add compost or fertilizer to the pits to increase their fertility.

Zai holes with sorghum plants: typical of the Sahel

Permanent strips in Botswana

In very low rainfall areas, it is possible to grow crops by planting them in strips. By sloping the ground in between towards the strips, rainwater will flow towards the strips, close to the crop.

A farmer in Botswana makes his cropped strips 0.8–1 m wide and 3.3 m apart. He subsoils these strips using a tractor-powered subsoiler to a depth of 0.7 m. He shapes the land between the strips so it slopes towards the cropped strips, so rainwater will flow towards the crop. He plants two rows of maize in each strip, and sows a cover crop such as cowpea in between the strips.



Maize in permanent strips

The strips are permanent: they can be used to grow crops season after season. The tractor never drives over them, so there is no risk of compaction or hardpan formation. The soil in the strips gradually improves in fertility as crop residues accumulate there. Rotating maize with a legume crop will improve the soil fertility further. The farmer has been able to grow up to 6 t/ha of maize with less than 400 mm/season of rain.

More information: Gus Nilsson

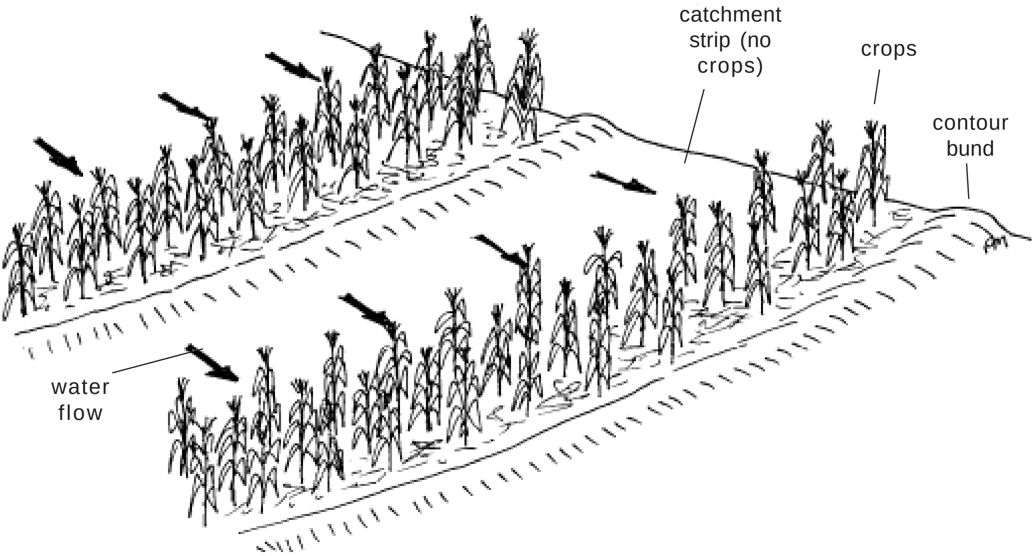
Contour bunds and catchment strips

In areas with low rainfall, there may not be enough water to grow a crop over the whole area. On gentle slopes (less than 3%), one possibility is to use contour bunds and catchment strips. Catchment strips are areas where no crops are planted. When rain falls on this ground, it flows downslope and is trapped by the contour bund. Plant rows of crops behind the bund to use this water. This can produce a good yield even with very little rain.

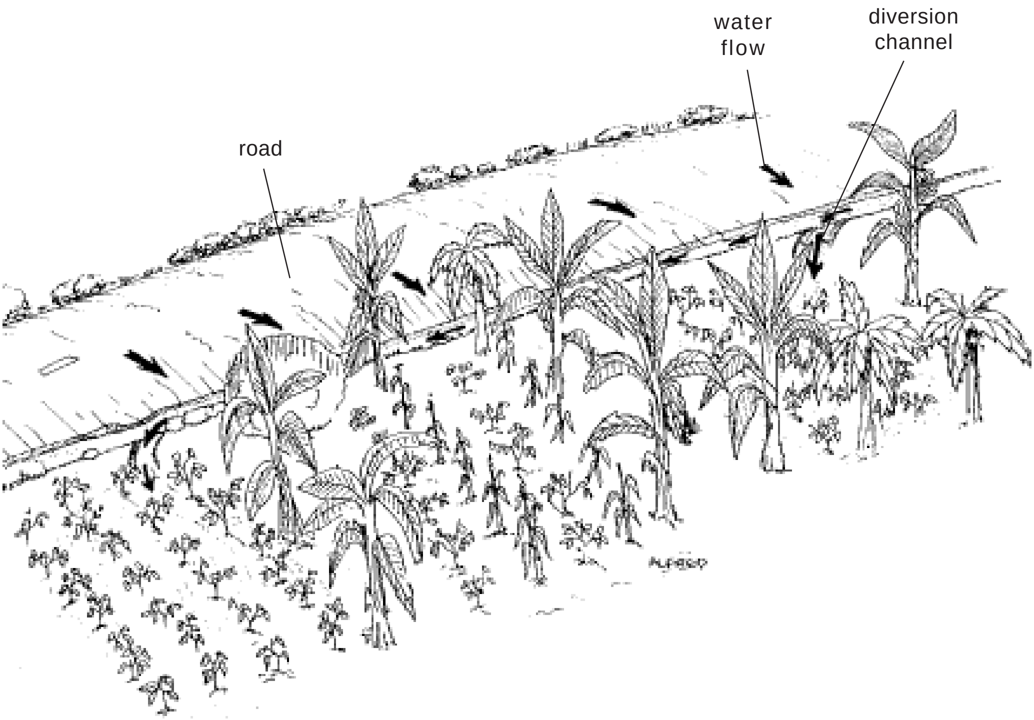
Mulch the cultivated area with crop residues to prevent erosion, help water sink in, and slow evaporation. Plant crops using conservation agriculture practices such as ripping, pitting or direct planting through a soil cover.

Road catchments

Water from roads – and from other unproductive areas such as paths and homestead compounds – can be channelled onto fields. It may be possible to divert water from structures that already exist, such as the ditches below *fanya juu* terraces. Or special bunds can be built around fields close to the road. Another possibility is to direct the water into a pond, which can be used to irrigate crops.



Contour bunds and catchment strips



Rainwater harvesting using a road catchment

Harvesting rainwater in Kordofan

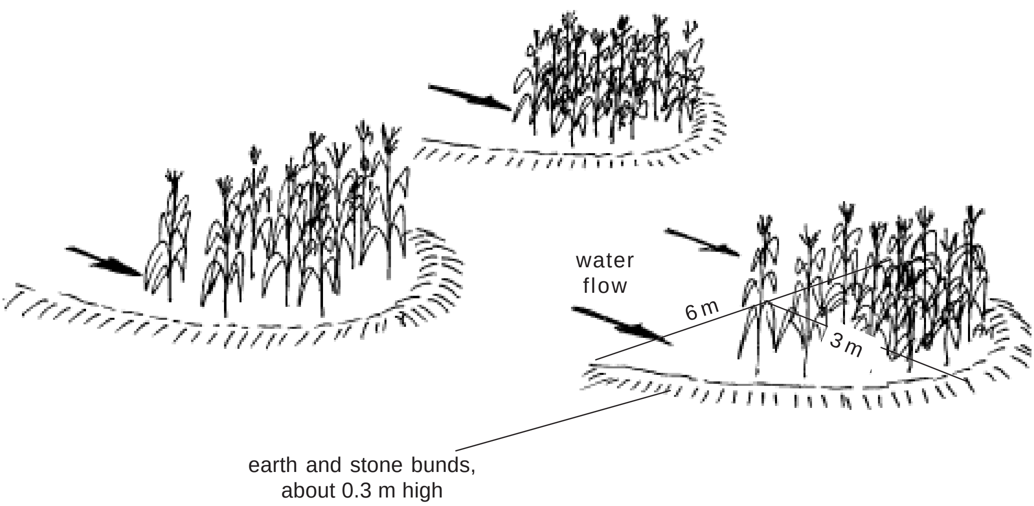
The Agricultural Research and Technology Corporation has tested contour bunds and catchment strips in Kordofan, western Sudan, since 1998. Soils in this area are sandy or sandy clay loams. Slopes are gentle – about 1%. Rainfall is erratic, varying from 140 to 625 mm a year in the period 1998–2002. Prolonged dry spells during the cropping season are frequent. The main crops are sorghum, millet, watermelon and groundnuts. With the first rains the soil surface becomes crusted. The precious water runs off and is lost.

Researchers and farmers have tried using parallel earth bunds, about 40 cm high, spaced 10 m apart. The upper half of the area between the bunds serves as the catchment. Most of the lower half is ripped and planted with sorghum, while cowpea or groundnuts and roselle are planted in the lowest part. This simple technique can triple or quadruple sorghum yields in normal years, and prevent total crop failure in dry years.

More information: Osman Afaldani

Half-moon microcatchments

Half-moon microcatchments are small, semicircular earth bunds. They are quite common on the desert margins of the Sahel, where they are called "demi-lunes". The half-moons catch water flowing down a slope. Crops such as sorghum, millet and cowpeas can be planted in the lower portion of the half-moons, using conservation agriculture techniques. Half-moons are helpful to rehabilitate degraded land.



Half-moon microcatchments

No-till irrigation in western Sudan

Farmers in the Khor Abu-Habil Agricultural Scheme in western Sudan grow crops using irrigation from the Khor Abu-Habil, a seasonal stream.

The fields in this scheme cover 2 ha each. They are surrounded with earth bunds, 1 m high. Water is diverted from the stream into a main canal, and from there through feeder canals and the fields. The fields are flooded to a depth of 80 cm for 15 days – which allows the water to sink 1 metre into the soil. The fields are then ready for sowing.

The farmers do not plough the soil. Instead, they direct-sow cotton, sorghum, sunflower, tomatoes and legumes. They weed the fields by hand.

The farmers of Khor Abu-Habil could improve their production further by introducing other aspects of conservation agriculture: a soil cover (such as cowpeas) and crop rotation or intercropping.

More information: Osman Afaldani

9

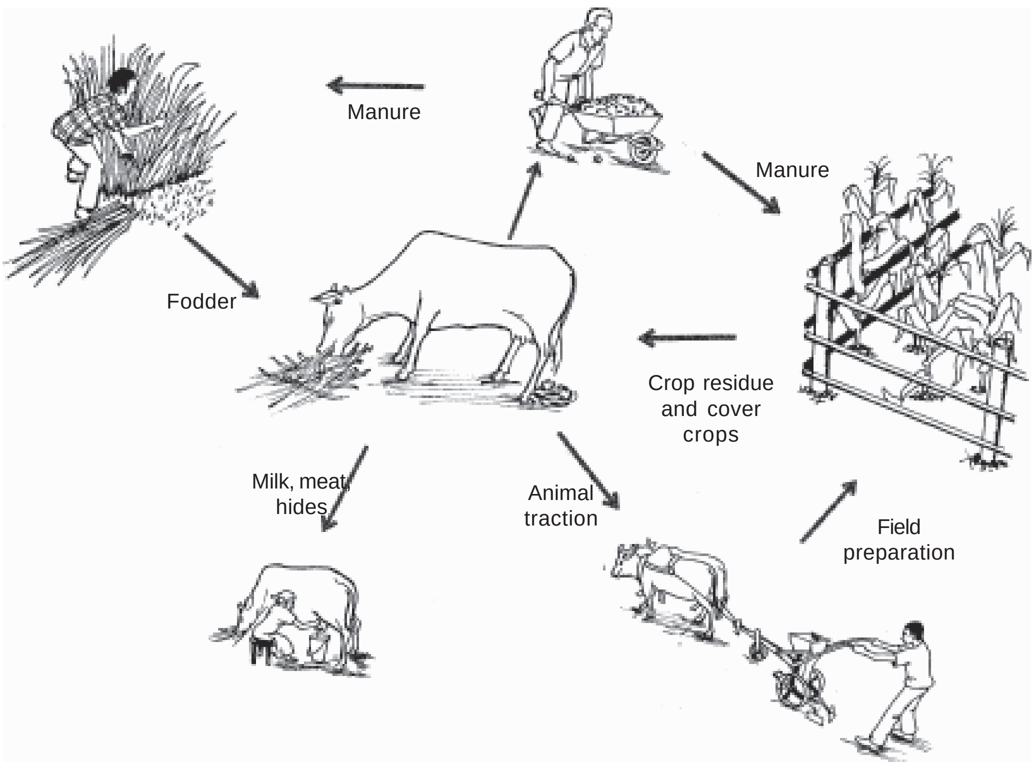
Livestock

Livestock are very important for many farmers. They provide meat, milk, hides, and manure, and they pull farm implements and carts. Farmers often allow their animals to graze on crop residues in fields after the harvest. But this is a problem in conservation agriculture because of the need to keep the soil covered. If the animals eat all the cover crops or stalks from the previous crop, the soil surface will be bare and exposed to heavy rain and to the wind. There will be little organic matter left to enrich and protect the soil. Heavy animals such as cattle also trample the soil and compact it, especially if the soil is wet.

So it is best to keep animals out of the fields even when there is no crop growing. You can fence your fields to keep livestock out, or you can reach agreements with neighbours who own animals about where to graze them.

But if the animals do not graze on the crop residues, what do they eat? You and your neighbours must find other ways to feed them. You can feed them with some of the residues from the main crop and part of the cover crop. If the animals do not trample the cover crop, you can use more of it as feed. You can also grow fodder in special plots.

It is quite possible to produce enough feed so that both crops and livestock benefit from conservation agriculture.



Animals provide meat and milk to people and pull farm implements. They also produce manure that can be used to fertilize the crop field. They can be fed with crop residues and specially grown fodder.

Feeding animals

Here are some ways to feed livestock within conservation agriculture.

- **Cut-and-carry** Grow fodder in the conservation agriculture field, then cut it and carry it to the animals.
- **Controlled grazing** If you cannot keep animals out of the field, then at least limit the damage they do. Let them eat only part of the forage or residues. Leave the rest to cover the soil.

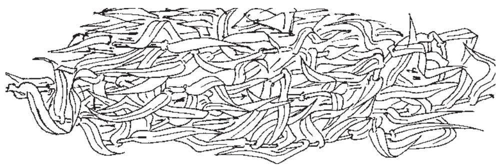
Sources of feed

Cover crops

Many cover crops produce excellent livestock forage. Legumes are rich in protein and help animals grow fast. See Chapter 5 for a list of cover crops.

Crop residues

The leaves, stalks and pods of legume crops such as beans, cowpeas, pigeonpeas and groundnuts are rich in protein. Oilseeds such as cotton, soybean and sunflower can be used to make feed meal. Maize and sorghum leaves provide roughage. It is best to leave the stalks on the field as mulch.



Check the crop and remove any barren plants, then feed them to livestock.

Grasses and legumes

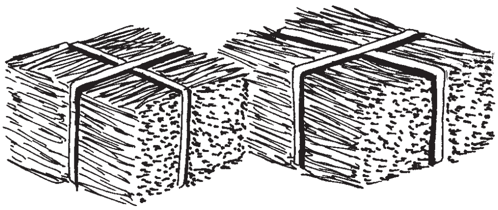
You can grow legumes (such as lucerne) and grasses in special fodder plots or along contour lines, the edges of bench terraces, and around fields. Suitable grasses include elephant grass, *Brachiaria*, Guinea grass, star grass, Rhodes grass and *Setaria*.

You can also cut natural grasses, weeds and other vegetation from field edges and roadsides and use it as feed.

Fodder trees

Leaves and pods of trees such as gliricidia and leucaena make good fodder. They are often planted around the fields or along contour lines to reinforce them. They are also often grown in rotation with maize or sorghum because they fix nitrogen.

Hay



You can make hay to use as feed when fresh fodder is scarce (see the box on the next page). Store hay in a dry place.

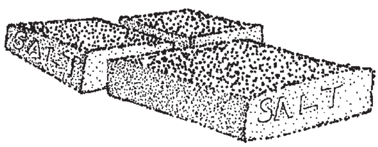
Silage

Silage is a good way of preserving fodder for use when other sources are scarce. See the box on the next page for how to make silage.

Purchased feed

You may be able to buy hay from other farmers or feed from shops.

Mineral blocks



Animals need vitamins and small amounts of minerals such as calcium, iron and phosphorus. Give them these in mineral blocks and licks. You can make mineral blocks yourself (see the box on page 152).

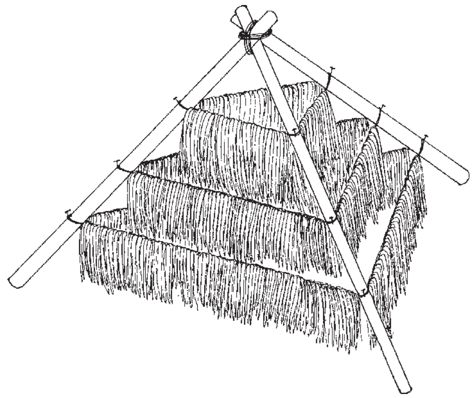
Making hay with a tripod

1 Make a tripod from three stakes and some wire or string. Build it in the open, away from shade.

2 Cut grass or lucerne and hang it over the wires. Leave it to dry.

You can use a tripod even during the rainy season because raindrops simply roll off without wetting the inside.

Air circulates freely, so the hay dries without any mould forming.



Silage

Silage is a good way to preserve livestock feed. You can make silage during the rainy season from **natural grasses**. Cut the grass when it is beginning to flower, about 10 cm above the ground.

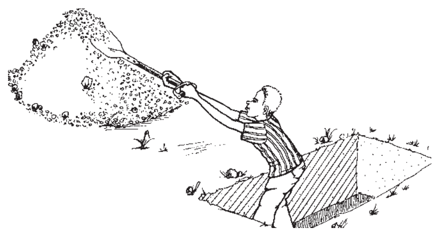
You can also make silage from **cover crops** or **purpose-grown forage** from your conservation agriculture fields.

You can even make silage from your **main crop** of rice, maize, sorghum and millet if it does not produce grain, or if it cannot grow on to maturity (e.g., if the rains stop). Cut the plants when the grain is at the dough stage. Cut them about 15 cm above the ground.

How to make silage

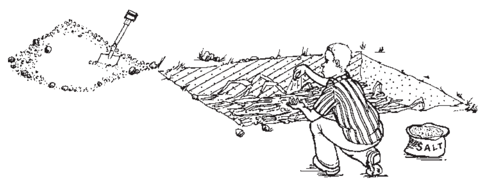
1 Pick a good site, preferably on a slight slope where water cannot collect.

2 Dig a pit about 3 m x 1 m, and 1.2 m deep.



3 Spread a layer of fine sand or kaolin clay, 20 cm thick, on the bottom of the pit.

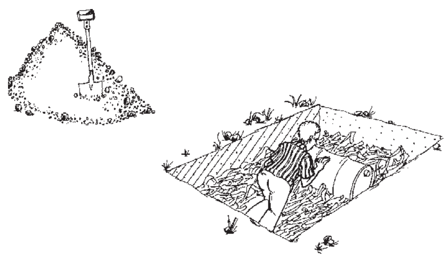
4 Sprinkle 500 g of salt evenly over the bottom of the pit. Use the cheapest salt you can find.



5 The pit is now ready for filling. You will need about 3.5–4 tons of green grass and other vegetation, plus 500 kg of salt.

6 Cut the vegetation and let it wilt for about 20 minutes in the sun.

7 Put a layer of wilted vegetation in the pit, about 10 cm deep. Sprinkle some salt on this layer. Compact the vegetation by rolling it with a big drum filled with water.



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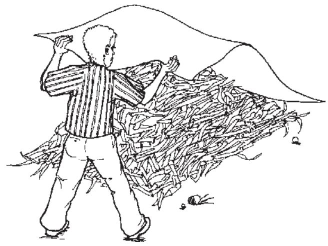
Silage (continued)



8 Add another layer of vegetation and salt, then another and another. Roll each layer as you add it. Sprinkle less salt on the lower layers but gradually add more salt on the upper layers.

9 Continue to add and compact the layers until the pit is completely filled, well above the ground surface and in the shape of a dome.

10 Cover the pile with a sheet of thick plastic 3.5 m x 1.5 m, then put a 10 cm layer of earth on top of the sheet. This earth keeps the pit watertight, airtight, and well compacted.

A group of 25 farmers can complete a silo like this in about 16 hours: 10 people to cut the forage, 5 to carry it, and 10 to fill and compact the forage in the pit.

Inspect the silo regularly. The pile will contract gradually as the vegetation inside ferments. Pile more earth on top to keep the dome shape and prevent rainwater from getting into the pit.

The silage is ready to be fed to animals after about 3 weeks. Take enough out of the pit to feed each day, then cover it with the plastic sheet again. The silage can be stored for 3–4 months.

Making salt licks

When the silo is empty, you can make salt licks from the layer of clay or sand at the bottom.

1 Make a shallow, open box about 40 x 20 x 10 cm.

2 Fill the box with sand or clay from the bottom of the pit. Press it into the box so it is compact.

3 Turn it out onto a flat surface and allow it to dry in the sun.

4 The resulting salt licks will weigh about 2.5 kg. Each silage pit can produce about 20 blocks. Livestock love them!

Protecting your fields

You need to protect your fields and cover crops from grazing animals throughout the year. That means managing animals in a different way.

This is usually a sensitive issue in semi-arid areas. After the harvest, herders often move their animals into the fields to graze on crop residues. The farmers are usually happy about this: the animals convert the stubble into valuable manure.

But conservation agriculture means keeping the soil covered with mulch or a cover crop, and preventing animals from trampling on and compacting the soil.

So herders and farmers who have set aside some of their fields for conservation agriculture may come into conflict.

It may be possible for the communities to agree for the herders to graze their animals on some fields freely, and to keep off the fields used for conservation agriculture.

If the land is communally owned, the whole community needs to be involved in controlling grazing.

Fencing

Fences are one way of keeping animals out of fields. There are three types:

- **Metal fences** Wire netting or barbed wire fences are expensive but quick to erect.
- **Thorn bush fences** If there are dead thorn bushes nearby, you can drag them into place.
- **Living fences** Living fences take longer to establish than thorn bushes or metal fences, but they also produce firewood, act as windbreaks and provide shade. The best living fences are made of species that livestock do not browse on, such as *Balanites*, *Ziziphus* or *Euphorbia*, which are traditionally used for fencing. *Jatropha* seeds contain oil, which farmers can use as fuel or to make soap.

Which species of tree or shrub to use? Check the table on the next page, and consult the local forestry department if necessary. Choose one or more species, collect the seeds, dry them in the sun and treat them with insecticide so you can store them until you need them. Grow the seedlings in a nursery, then transplant them to where you want the fence.

Work animals

Various animals are used to pull farm implements: oxen, donkeys, horses, mules, camels and water buffaloes.

- Pulling equipment is hard work. Animals need to be strong and healthy. Before using them for work, give them extra feed and treat them for worms to build up their strength.
- Prevent animals from eating crops and residues when they are working in the fields. If necessary, put muzzles on them.
- Feed them well the night before they work so they are easier to control.

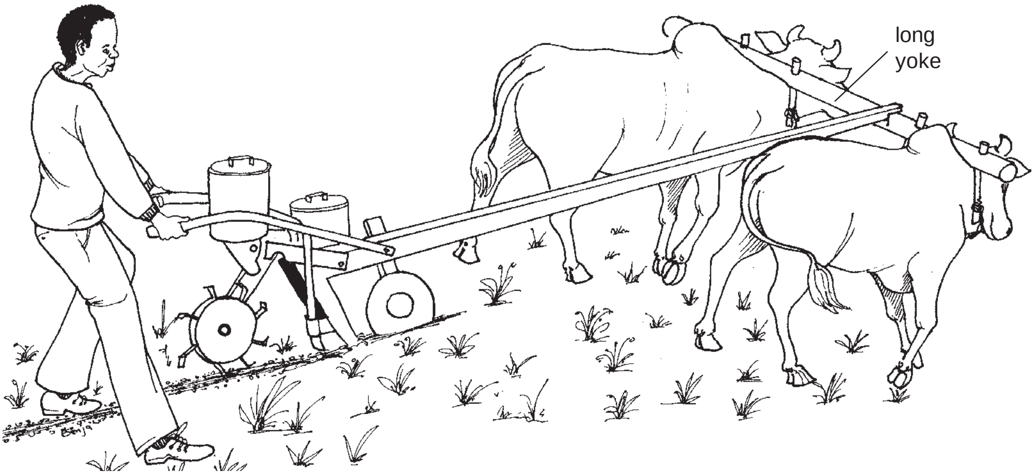
Shrubs for living fences

Common name	Scientific name	Fodder	Firewood	Fencing
Humid areas				
Sunn hemp	*Crotalaria grahamiana*			+
Sunn hemp	*Crotalaria paulina*			+
Tephrosia	*Tephrosia candida*		+	+
Tephrosia	*Tephrosia vogelli*			+
Sesbania	*Sesbania sesban*	+	+	+
Gliricidia	*Gliricidia sepium*	+	+	+
Grevillea	*Grevillea robusta*	+	+	+
Calliandra	*Calliandra*	+	+	+
Leucaena	*Leucaena trichandra*	+		+
Dry areas				
Acacia	*Acacia*	goats	+	+
Desert date	*Balanites aegyptiaca*		+	+
Euphorbia	*Euphorbia*			+
Jujube	Ziziphus	+	+	+
Kei Apple	*Dovyalis caffra*		+	+

Training animals

- Train the animals so they get used to pulling conservation agriculture equipment (subsoilers, rippers, planters, sprayers and knife rollers). Animals are trained to follow the previous furrow line. Conservation agriculture equipment uses a long yoke: a little more than twice the width of the distance between the planting rows (see page 58).

  A normal yoke used for ploughing is only about 75 cm long, so the animals are close together and in bodily contact as they work. Changing to a long yoke means that they no longer have this mutual support. Training them to work with a long yoke takes 2–3 days.
- Both the animals and operators need to get used to the new equipment. For example, subsoilers have no wheels, so are harder to turn at the end of the row.



The long yoke is needed to get the right spacing between the rows in conservation agriculture. Animals take time to get used to being further apart when they work.

10

Harvesting, marketing and input supplies

Adopting conservation agriculture may mean making other changes in how you run your farm:

- Your production should increase, so you will need more labour to harvest and handle the crop, and more room to store the grain.
- The soil will hold more moisture, so you may be able to grow an extra crop in the dry season.
- You may need new types of inputs: cover crop seed, herbicides, special equipment, etc. You may need credit to buy these.

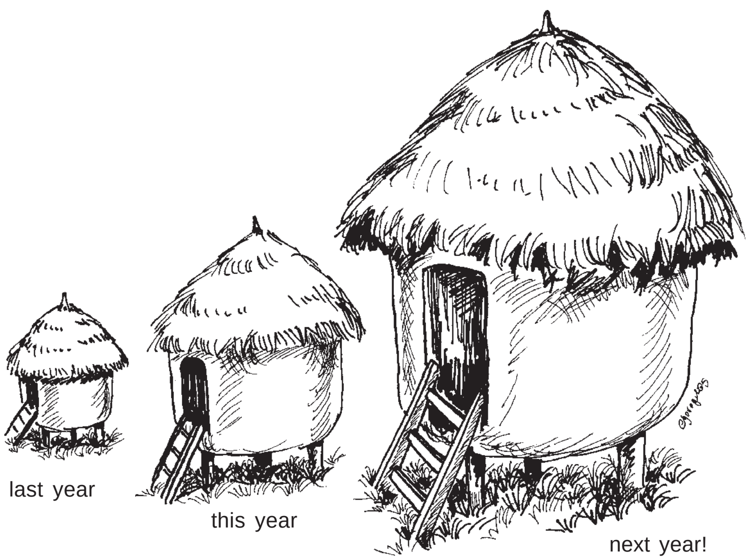
This chapter is aimed not just at farmers, but also at the people who provide them with inputs such as seeds, equipment and fertilizer.

Harvesting

When harvesting, make sure that the crop stalks and leaves are left on the ground as mulch. Use a machete to cut maize and other tall plants such as sunflower at about 20 cm high, leaving the roots in the ground. Old roots in the soil improve the soil texture and structure, and the standing stalks show clearly where to apply herbicide and plant the next crop. Lay the cut materials between the rows, parallel to them. Because the rows run across the slope, the mulch will help prevent erosion.

Alternatively, you can use a combine-harvester with a spreader attachment to distribute the stalks evenly over the ground.

When cleaning or processing the harvest, use the waste to make compost, or put it back on the soil as mulch.

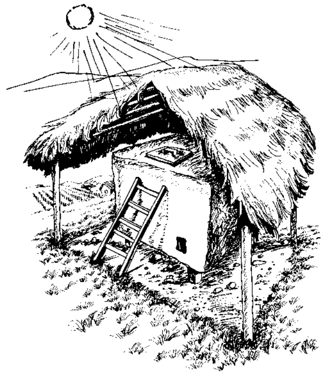


Higher yields from conservation agriculture means you may need a bigger grain store!

Storage

Dry grain thoroughly before storing or processing it. It should have less than 12.5% moisture content. This helps prevent damage by pests and diseases during storage.

If you live in a humid area, you may have to use a drier. Consider having your grain dried by a commercial grain drier. Or it may be worthwhile buying or making a drier yourself, perhaps along with some neighbours.



A well-designed grain store made of bricks or cement

Make sure the grain is clean before storing it.

Grain stores on farm are best made of brick and cement, with few openings so that pests cannot get in. They must be weatherproof: the roof must protect the grain from rain and sun and keep the grain dry and cool. Channel rainwater away from the store to keep it dry.

Use an approved insecticide to protect the grain from insects. You can mix the insecticide into the grain by hand, with an auger or in a cement mixer. Or you can spray it onto the grain and then mix it in. If you use a spray, dry the grain before storing it for a long time.

If you store grain in jute or woven plastic bags, treat it first with an insecticide.

Rats and mice can be a big problem. They eat the grain and damage it with their urine. It is vital to keep them away from the store: put wire mesh over openings, and fix metal cones on the legs of grain cribs to keep them out. Use treated bait in the store. Cats and owls also help control rats and mice.

Processing and marketing

If you grow vegetables or other perishable crops, plan to get them to market quickly so they are fresh and fetch a good price.

Consider forming a marketing cooperative with your neighbours so you can sell a large amount of produce together. That should give you a better price, and will help cut transport costs. Also consider options such as contract growing to guarantee a market for your produce.

Inputs

The main inputs that farmers need for conservation agriculture are:

- **Information**
- **Equipment**
- **Seed**
- **Fertilizers, herbicides and pesticides**
- **Credit.**

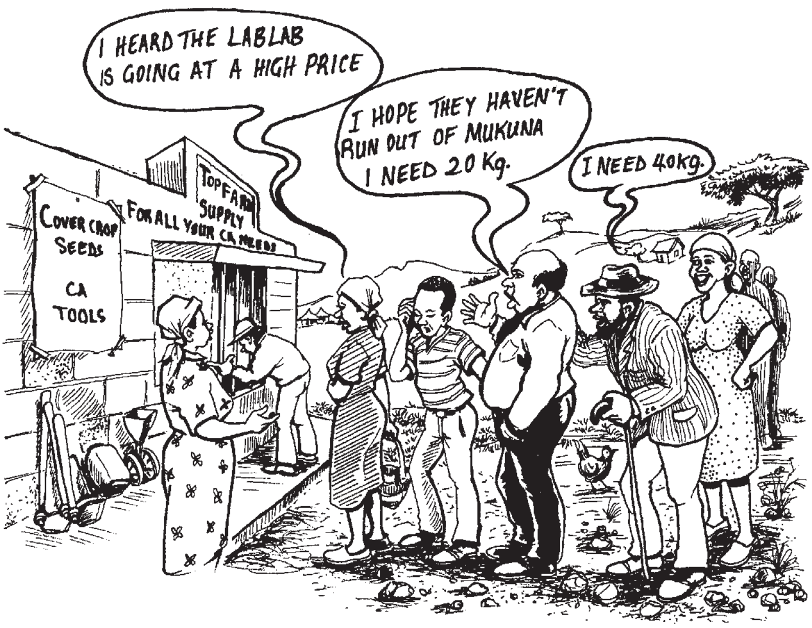
We will discuss each of these in turn.

Information

Farmers (and extension staff) need various types of information:

- **Services** Where to get services, who can provide what?
- **Marketing** Demand for produce, prices. This will influence what crops they grow.
- **Technology** How to grow a particular crop, how to overcome problems in the field.

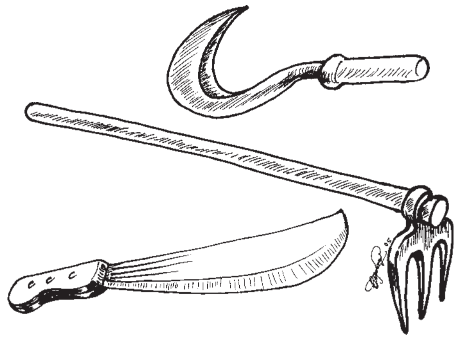
They can get this information from various sources: radio, extension agencies, leaflets, research institutes, successful commercial growers, farmer associations, local dealers, manufacturers and input suppliers. Events such as on-farm field days are crucial to bring together the various groups and enable them to share information. See Chapter 13 for more information.



Equipment

Most small-scale farmers have (or can borrow) hoes, planting and weeding implements, and knapsack sprayers. It may be possible to borrow or hire other equipment rather than buying it yourself. An implement should last for several years, so it may be worth investing in it even though it looks expensive.

The table on the next page summarizes what equipment you may need when. See the other sections in this manual for details on the various types of equipment.



Hand tools used for harvesting

Seed

It is important to plant good-quality seed. This will ensure:

- A high germination rate (more than 90% of the seeds should sprout).
- There are no seeds of weeds or of other crop varieties mixed in.

You can make sure of this by buying only certified seed.

You can also grow your own seed. This is a specialized business, but it can be very profitable. In areas where a lot of farmers are adopting conservation agriculture, there may be a good market for seed of cover crops such as pigeonpea, lablab and mucuna.

You may also be able to get seed from other farmers, seed suppliers, NGOs or research institutions.

Fertilizers, herbicides and pesticides

You can use the same fertilizers, herbicides and pesticides in conservation agriculture as in conventional farming.

Once your conservation agriculture fields are well established, you will probably need to use less inorganic fertilizer and herbicides. This is because the soil will be more fertile, and cover crops will suppress weeds.

Try to use integrated pest management to control pests and diseases. However, you may find you have to use pesticides to control pests in the cover crops and mulch.

Be careful when handling pesticides. Read the label carefully, and make sure you use them safely.

Equipment used in conservation agriculture

When needed	Hand equipment	Animal-drawn	Tractor-mounted
Field preparation	Hoe String	Ripper Subsoiler	Ripper Subsoiler
Planting	Hoe Machete Planting stick Jab-planter	Ripper- planter Direct seeder	Direct seeder
Weeding	Hoe Slasher Machete Push/pull weeder	Knife-roller	Knife-roller
Herbicide application	Weed wiper Knapsack sprayer Hand-pulled sprayer	Sprayer	Sprayer
Harvesting	Machete Slasher Sickle Billhook Rake		Combine harvester

Credit

Small-scale farmers find it difficult to get credit for their farm operations. Few banks have branches in rural areas. And banks require collateral (usually in the form of land title deeds – which few farmers have) in order to extend credit. But there are ways around this.

Farmer associations Groups of farmers have stronger credibility than an individual, and can overcome the problem of collateral to get credit. Banks can extend a loan to the association, which then lends on to its individual members. The burden of recovering loans from individual members lies with the association, and not with the bank. If someone fails to repay a loan, the bank can disqualify the whole association. This puts pressure on other members to make sure the defaulting person pays up.

Village banks Village banks are where farmers group together and pool their savings into a common account. Individual members can then get loans from this account if they want to buy inputs. Group members agree on the conditions for borrowing. The money saved can be invested in small-scale businesses, deposited with a larger bank, or lent to non-members at a higher interest rate.

Collateral or loan security Prices for grain typically fall very low just after harvest time, when many farmers want to sell at the same time. Farmers can get around this problem by delivering their grain to a private warehouse, which issues a receipt. When the grain prices rise, the farmer can sell the grain, or can choose to keep it in storage in the hope of a better price. The farmer can also use this stored grain as collateral for a loan to buy inputs for the next crop.

Contract outgrower schemes Processors of farm produce often sign contracts with farmers to grow produce for them. The processor may provide some or all of the inputs needed, as well as extension advice and services such as spraying and harvesting. The farmer gets a guaranteed price for the produce. Small-scale farmers can join one of these schemes to finance their crop production. Such schemes are popular for commercial crops such as cotton and paprika.

Other sources of credit It may be possible to get credit from various other sources: through the manufacturer or dealer, a government loan scheme or a development project.

If it is possible to pay back the loan over several seasons, farmers or small groups can buy equipment without having to invest too much money at one time.

Microfinance eases access to inputs

After seeing demonstrations and trying out the new techniques, farmers in Kalama Division in Kenya were enthusiastic about conservation agriculture. But they couldn't afford to buy the equipment and inputs they needed. So the Kenya Network for Draught Animal Technology (KENDAT), the NGO promoting conservation agriculture, helped them organize themselves into credit groups and to operate their own village bank.

The credit groups were formed from the clubs which had been involved in trying out conservation agriculture techniques and running on-farm demonstrations. Each group set its own rules, decided on its own constitution and elected its own leaders. Seven such groups were formed. They registered with the government authorities and opened a bank account, with the group representatives as signatories.

The chair and treasurer or secretary of each group attended training in group dynamics and on establishing and managing a revolving fund. Group members deposit a small amount of savings into the account on a regular basis. KENDAT added funds to the account to help the funds grow. The NGO remains a cosignatory for the account.

The group processes applications for loans, and all loan repayments are deposited directly into the account. The members decided on vital details such as interest rates, fines, repayment periods and how to recover unpaid loans. Loan recovery rates are a remarkable 100%. Many farmers are anxious to repay their loans so they can borrow more for the following season.

The original intention was to help farmers borrow money to buy rippers, subsoilers and other conservation agriculture implements. But the farmers wanted to invest in things that would give them quicker returns. For example, they chose to buy fertilizer and hybrid seed rather than a ripper, to start with. Some also used their loans to invest in small businesses, and then to use their profits to buy equipment for conservation agriculture.

More information: Pascal Kaumbutho, KENDAT

The warehouse receipt system in Zambia

Zambian farmers are faced with the problem of marketing of their produce. Poor storage facilities mean they cannot keep their produce until prices are good. So they are forced to sell at very low prices.

Some privately owned warehouses implement a system called “warehouse receipt”. This system is controlled and promoted by the Zambia Agriculture Commodity Agency, which certifies the warehouses and ensures they are properly managed.

Farmers transport their crop to the warehouse, and they are given a receipt.

The warehouse gives the farmer an advance payment based on the total value of the crop at that time. This advance payment is usually about 50–70% of the current value of the crop.

When the market prices go up, the warehouse sells the produce. It deducts the advance and the cost of storage, and pays the balance to the farmer.

This system has several advantages:

- The farmer can choose when to sell the crop, or the warehouse will advise him or her when the price is right.
- The warehouse is responsible for storing the crop and maintaining its quality.
- The farmer can use the receipt as collateral to obtain a bank loan.

In 2003/4, farmers practising conservation agriculture in Choma District in southern Zambia stored about 300 tonnes of grain using this system. Their crop was sold after 7 months, when the prices were high, and in time for farmers to buy inputs for the coming season.

Farmers like this system because they can sell their crop when they want, and can get a loan so they can invest in other businesses. Some have even started earning money by buying produce from other farmers and putting it in the warehouse.

More information: Cholwe Chiposwa

Obtaining inputs

Farmers need to have easy access to seed, fertilizers and other inputs if they are to adopt conservation agriculture. It is a challenge is to get the necessary inputs to remote areas. Businesspeople are reluctant to transport small amounts of inputs long distances over bad roads: it is too expensive and risky. Here are some ways to overcome this problem.

Linking suppliers and farmers

Extension officers should form links between farmers and suppliers. They can help farmers find out what is available, and suppliers know what farmers need. Field days and agricultural shows are good ways to bring farmers and suppliers together so they can learn from each other.

Local dealerships and agents

There are a number of advantages in establishing local dealerships. They reduce the distance farmers have to travel to obtain inputs. A well-stocked local dealer will save the farmer a lot of time and expense by providing a wide range of inputs. The dealer can also extend credit for inputs to farmers. He or she should have a good working knowledge of each product sold, so will be able to provide excellent customer service.

Dealers will have to stock new types of inputs, such as:

- Herbicides and other chemicals.
- Cover crop seeds.
- Hand tools such as jab-planters and weed wipers.
- Animal-drawn equipment such as rippers and subsoilers.
- Spare parts for equipment.

Farmer groups

Farmers groups can buy equipment for their members to share – and to hire out to non-members. As farmers' incomes rise and the area planted to conservation agriculture increases, the group can buy extra equipment. It can also buy seed and fertilizer in bulk, so cutting costs and saving on transport.

Equipment hire services

Individual smallholders cannot afford expensive, sophisticated equipment such as heavy-duty rippers or tractor-drawn spray rigs and planters. But they may be able to hire it – if there is a hire service nearby.

This is a potentially profitable business opportunity for entrepreneurs or groups of people. Projects or extension services might consider helping them set up such a business. In Ghana, for example, young men have formed contract spraying and planting teams. They hire themselves out to farmers to apply pesticide and fertilizer and to do planting. The farmers supply the inputs needed.

Benefit from better-off farmers

If you cannot afford to buy equipment yourself, perhaps a better-off neighbour would be interested in investing in it, then hiring it out?

If large-scale commercial farmers nearby adopt conservation agriculture, inputs may become available for small-scale farmers too. If a few large-scale farms demand certain types of inputs, suppliers may find it profitable to open a local depot. Small-scale farmers can then buy inputs and get information from the same depot.

Local manufacture and repair of implements

Africa must import most of its conservation agriculture equipment, mainly from Brazil. This is expensive, takes time, and restricts the amount and type of equipment that farmers can buy.

Equipment such as rippers, subsoilers and planters can be made more easily available if local artisans and blacksmiths are trained to make it. Farmers can then buy the equipment cheaply, instead of waiting for hard-to-find, expensive imports. Artisans can also repair equipment that is damaged or worn out.

Locally made equipment has to be good quality. It must use the right materials (such as quality steel) and be made with precision. If implements do not work properly, no one will buy them.

Learning how to make rippers and subsoilers

Many farmers would like to use conservation agriculture, but they can't. They don't have the right equipment, and they can't buy it anywhere.

The solution? Teach local artisans to make the equipment.

Farmers in Kalama Division, Machakos District, Kenya, and in Arumeru in Tanzania, learned how to use direct planting and cover crops. But they still had a problem with hardpans. And they couldn't buy or hire subsoilers to break the hardpans.

The Maendeleo Agricultural Technology Fund, a KENDAT project supported by FARM Africa, trained local artisans how to make the equipment. Before the training, artisans attended field days and demonstrations so they were familiar with the equipment, the principles of conservation agriculture and the needs of farmers.

They then attended two training courses. The first was held at Nandra Engineering in Moshi, Tanzania. It covered basic workshop procedures, safety measures, materials selection and costing, basic workshop skills (cutting, bending, measurements, etc.), and the use of jigs and fixtures for accurate, consistent reproduction of tools and parts. Each of the participants made a prototype subsoiler to take home.

The same artisans then attended another course, this time closer to home, at Ekima Engineering in Machakos. It reviewed the production process, and in particular the use of jigs and fixtures. Each participant was given a set of the jigs and fixtures needed to make rippers and subsoilers. The project then placed an order of five subsoilers and five rippers with each of the artisans to get them started. It also arranged for credit so they could buy materials for big orders.

Buying materials remains a problem: some can be found only in Nairobi, some 100 km away. The cost of transport adds to the sale price of the equipment, and makes small orders uneconomical.

Links with farmers are critical. If they are to buy conservation agriculture equipment, farmers have to know where to get it. The same is true if they need it repaired.

More information: Joseph Mutua, KENDAT

Appropriate packaging

Seeds, fertilizers and other agrochemicals often come in large packs, designed for commercial, large-scale growers. But these large packs are not ideal for smaller scale farmers. Retailers can re-bag these inputs into smaller packages better suited for smaller farms. For example, seeds packed in 1 kg, 2.5 kg and 5 kg bags could be sold in local dealer shops, supermarkets and garages in rural areas. The small packs are lighter, affordable, easier to carry and can be planted in a short period. Seed firms in Kenya and Zimbabwe have tried this approach and found it is very successful.

Equipment manufacture in Zimbabwe

A workshop in Zimbabwe highlighted the need for conservation agriculture equipment for smallholder farmers. A representative of a local equipment manufacturer attended the workshop, and the firm started producing ripper-planters soon afterwards.

The firm procured a prototype from South Africa and modified it to suit Zimbabwean conditions. It conducted on-farm trials with the help of NGOs and extension organizations. The planter is now available commercially.

Small packs for small farms

CropLife, an industry association, is encouraging firms to make things easy for small-scale farmers. Among its recommendations:

- Supply inputs in small packs.
- Make packs the right size for specific needs – for example, a 2.5 kg bag of maize seed is enough to plant 1000 m^2; one sachet or bottle of insecticide for a 15 litre knapsack sprayer.
- Print labels in the local language.
- List problem pests, weeds and diseases on the labels, with the local names.
- Provide local-language brochures, pamphlets and video presentations.

Mixing a small pack is easy: no measuring equipment is needed, and some packs have markings on the container. Application is accurate, reducing the misuse of products. A farmer can mix and spray a small pack of herbicide quickly: a single knapsack of insecticide takes 15–20 minutes to spray out. Storing and disposing of small packs is easy.

More information: Jim Findlay

11

Should you adopt conservation agriculture?

So should you adopt conservation agriculture? Is it likely to be profitable? This chapter shows you how to work out whether conservation agriculture will be worthwhile for you.

Some questions to ask:

- How can conservation agriculture **benefit me**?
- How does conservation agriculture **benefit other people**?
- How much **yield** does conservation agriculture produce?
- How much does conservation agriculture **cost**?
- Is conservation agriculture **profitable**?
- Is conservation agriculture **worthwhile**?
- How much **work** is conservation agriculture?
- **When** is work needed for conservation agriculture?

This chapter deals with each of these questions in turn. For many of these questions, it gives a simple way of working out the answers using your own farming experience. Check also Chapter 2, *Converting to conservation agriculture,* for more ideas to help you make the right choice.

How can conservation agriculture benefit me?

Conservation agriculture has many benefits. Here are some of them:

- Your soil will become more fertile. It will be richer in organic matter, and more earthworms and other soil life. That means healthy crops and **higher yields**.
- A more fertile soil also means **money saved on fertilizer**.
- The soil should hold **more water**, so is less likely to dry out quickly. That means better yields in dry years, more reliable springs, and wells that do not dry out.
- The soil cover **reduce erosion**, preserving the soil for the future. This may seem like a long-term benefit, but many farmers see the value of it in terms of higher yields in only a few years.
- A healthier crop should mean **less pesticide** use, meaning a cleaner environment and safer drinking water.
- **Fewer weeds** mean less weeding and money saved on herbicides.
- You should have more **free time** that you can use in other ways. Running a business, for example, trading, keeping animals, or making honey.
- Your fields may produce **new products** that you can use yourself or sell. Examples are cover crop seeds, firewood or forage.

Some of these benefits are reflected in higher yields and lower costs. Others are harder to measure in money terms: how much is clean drinking water worth, for example?

How does conservation agriculture benefit other people?

If you adopt conservation agriculture, you will gain in many ways. So will other people in your community and elsewhere. Everyone benefits from cleaner water and reduced erosion. If many farmers take up conservation agriculture, the benefits can be considerable for society as a whole.

- Less erosion means less soil carried away into rivers. **Cleaner rivers** mean better water quality for people living downstream. Less silt clogs irrigation canals and reservoirs. That means irrigation schemes work better and are cheaper to maintain, and reservoirs have a longer life.
- More organic matter holds carbon in the soil rather letting it disappear into the air as **carbon dioxide**. Large amounts of this gas change the climate – making drought more likely in some places, for example. So conservation agriculture will help make global weather patterns more reliable.
- Farmers buy things like planters, subsoilers and seeds to practise conservation agriculture. That stimulates artisans, seed growers and traders to provide these items. Higher yields also mean farmers have more produce to sell and more money to spend. This in turn stimulates **markets and growth** in the local and national economy.

How much yield does conservation agriculture produce?

The easy way to find out how much extra yield conservation agriculture will bring is to try it out.

1. Get together with a group of neighbours, and set aside a field for conservation agriculture.
2. Decide which conservation agriculture practices you want to use on this field. Decide who is going to do the work.
3. Meet regularly throughout the season to check on the crop and discuss any problems.
4. Keep careful records on the types and amounts of inputs you use, the amount of labour needed, and so on.
5. At harvest, measure the amount of grain or other yield produced. Compare this with your regular practices.

Here are some questions to ask:

- How much grain and other types of **yield** did the field produce?
- How much **work** did it take?
- How much did you have to **spend** for inputs?
- Check the soil. Is there more **organic matter**? How about the number of **earthworms**? Does it feel **hard or soft**? Is there a difference in the amount of **erosion** (rills in the ground, silt in water draining from the field, etc.)?

Remember, you may not begin to see the full benefits of conservation agriculture for several years. If your field produced no more grain in the first year, don't give up! Keep using conservation agriculture on the same field for another year or two, and you should see real differences.

How much does conservation agriculture cost?

If you have done the kind of test above, or if you have already started using conservation agriculture, you can draw on your own experience and records to calculate the costs and benefits. It is easy to do this if you keep records of what you have bought and the money you have spent on your farm (see box on page 174). If necessary, ask an extension worker to help you do this.

If you have not yet started using conservation agriculture, it is hard to decide what your costs would be and how much profit you would make. Where can you find the information you need?

- Think of changes you would need to make, extra equipment you would need, and new types of seeds and agrochemicals you would have to buy.
- Perhaps you belong to a farmers' group that has tried conservation agriculture. Or maybe you can ask other farmers about their experience. Ask how much various items cost, and how much yield they harvested from their conservation agriculture fields compared to their conventional fields.
- If you buy equipment or animals, remember they will last more than one season. You may have to spend a lot of money this year, but none next year. You may be able to get a loan to help cover the cost.
- Remember, you do not have to buy all the equipment at once! If you farm using a hoe, you probably don't need any new equipment. But if you use an animal-drawn plough, you would need to buy (or hire) a subsoiler or ripper if you don't already have one.
- Also remember that labour and other costs may be high in the first year. For example, weeds may be a major problem before your cover crop is established, so you may have to hire labourers to weed for you. You may also need to buy cover crop seed. In the second year, you may be able to use seed you have grown yourself.

Inputs: seeds, fertilizer, herbicides, etc.

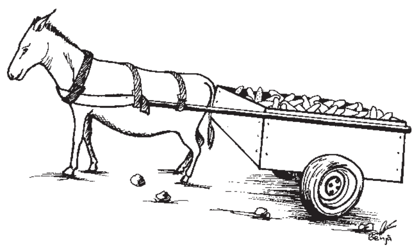
Land clearing

Spraying herbicide

Planting using jab planter

Weeding

Harvesting



Carting

Some of the things to take into account when you are calculating costs

Keeping records

It's a good idea to keep records of your farm, even if you are not considering taking up conservation agriculture.

Why should you take the trouble to do this?

Because it helps you make the right decisions. For example, do you have enough money to invest in a ripper? Is it a good idea, or would you be better off investing in something else? Should you ask the bank for a loan, and if so, can you afford to repay it? Should you apply a herbicide this year, or is it cheaper to slash weeds by hand?

You can answer questions like these only if you have good records.

What type of records should you keep? Here's a summary:

Costs

- The cost and quantity of **equipment** (plough, draft animals, ripper, jab planter, sprayer, etc.).
- The cost and quantity of **inputs** (herbicides, seeds, fertilizer, etc.).
- The cost of **farm operations** (land clearing, planting, spraying, weeding, harvesting, drying, transport, etc.).

Income

- The **quantity** of crop you harvest and the **price** you received when you sell it (or the price you would get if you were to sell it).

Operations

- **For each crop**: the crop variety, seeding rate, dates planted and harvested, dates of key operations (fertilization, weeding, pest control), yield and price.
- **For fertilizers, herbicides and pesticides**: type of chemical used, dates of application, and application rates.

You can calculate the costs of practising conservation agriculture by adding up the costs of **equipment** and draught animals, **inputs** such as fertilizer and herbicides, and **operations** such as field preparation and weeding.

The following sections show how to do this. Fill in the tables on the following pages with your own figures so you can calculate your own costs.

Equipment and draught animal costs

1. List the different items of **equipment** and **draught animals** you bought last year for conservation agriculture (or would have to buy next year). Write down how much each one cost (A, in Table 1 on the next page).
2. Add the amount you spent to **run and maintain** the equipment (for example, the cost of repairing a sprayer) **(B).**
3. **Sum the amounts**. This is your total cost of equipment and animals **(E).**

Input costs

1 List the different types of **inputs** you have used (or plan to use next year): seeds, fertilizer, herbicides and pesticides. Write down how much you paid for each (Table 2).

2 **Sum the amounts**. This is your total cost of inputs (**I**).

Operation costs

1 List all the **field operations**, starting with field preparation and ending with transport and sale of the produce. It's easiest if you write down the dates as well to make sure you don't forget something. Also include any interest payments you have made for credit (Table 3).

2 For each operation, write down how much you paid for it (for example, to hire workers or to pay for transport).

3 **Sum the amounts**. This is your total costs of operations (**K**).

Total cost

Add the costs of equipment, inputs and operations together (Table 4). This is your total cost per year.

Total cost = Equipment cost + Input cost + Operations cost

$$T = E + I + K$$

Note that you will have to buy the equipment only once, so your expenses next year should be lower. If you do not need to buy any more equipment, your costs next year will be:

Total cost = Input cost + Operations cost

$$T = I + K$$

Table 1 Costs of equipment and draught animals for conservation agriculture

Equipment	Purchase cost	Cost of running and maintaining	Total cost
	A	B	C = A + B
Hoes			
Cutlasses, machetes			
Draught animals			
Subsoiler			
Ripper			
Planter			
Sprayer			
Others			
Total cost of equipment			E

Table 2 Costs of inputs for conservation agriculture

Input	Cost
Main crop seeds (e.g., maize)	
Intercrop seeds (e.g., beans)	
Cover crop seeds	
Herbicides	
Fertilizer	
Pesticides	
Others	
Total cost of inputs	**I**

Table 3 Costs of farm operations for conservation agriculture

Date	Operation	Cost
4 Feb	Land preparation	
11 Feb	Herbicide application	
17 Feb	Planting	
etc.	Weeding 1	
	Weeding 2	
	Harvesting	
	Transport to market	
	Payment of interest on credit	
	Others	
Total cost of operations		**K**

Table 4 Total cost

Type of expense	Cost
Cost of equipment	E
Cost of inputs	I
Cost of operations	K
Total cost	**T = E + I + K**

Buying expensive equipment

You don't have to buy a sprayer or subsoiler every year – it should last for several years. So if you want, you can spread the cost over that time (accountants call this "depreciation").

Fill in the table below to take this into account in your calculations.

Extra equipment needed for conservation agriculture – taking depreciation into account

Equipment	Purchase cost	Lifespan (years)	Cost per year	Cost of running and maintaining per year	Total cost per year
	A	B	Y = A / B	R	C = Y + R
Hoes					
Cutlasses, machetes					
Draught animals					
Subsoilers					
... etc.					
Total cost					D

You can now use this figure to calculate your total cost per year:

Total cost = Depreciated equipment cost + Input cost + Operations cost

$$T = D + I + K$$

But you still have to pay for equipment all in one go. Or do you? Here are some ways to get around this:

- Get a loan from a bank or from your farmers' association to buy the equipment. You can repay the loan in several easy stages.
- Band together with a group of other farmers, and buy the equipment as a group. You will have to agree on who can use it when, and who is responsible for repairing and maintaining it.
- Ask the equipment supplier for credit. They may be willing to accept a down-payment now, and wait for the balance until the end of the season.

Using stones to calculate costs

Instead of using a pencil and paper, you can use stones, twigs or grains to calculate your costs. You can also use this method if you are an extension agent working with a group of farmers.

You will need a pile of small stones (or grains or pieces of twig). One stone can represent 100 shillings, or 10 rand, or whatever your currency is.

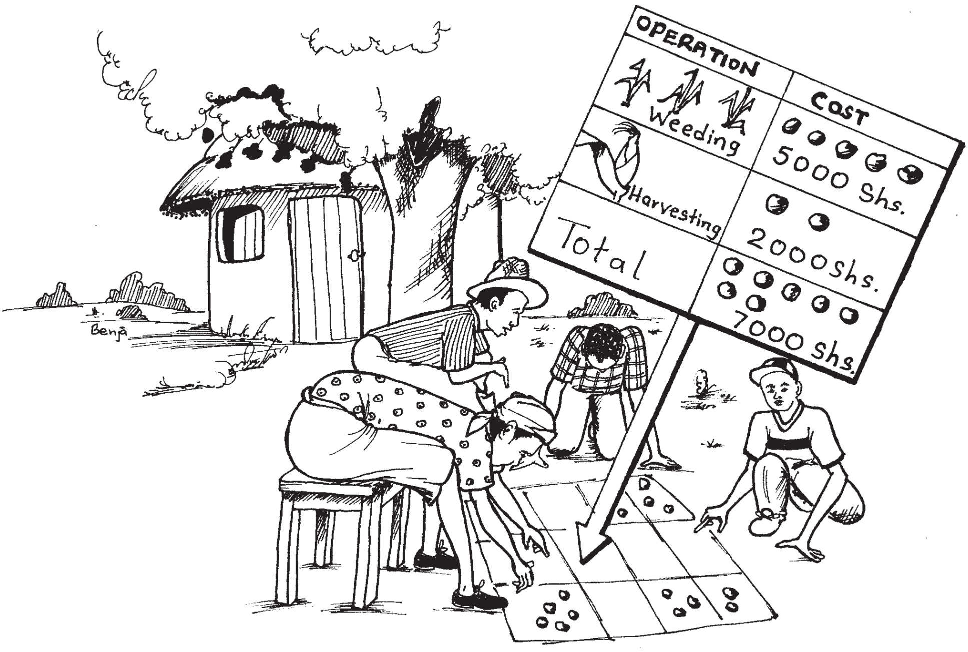
You can draw a table on the ground, or use a big sheet of paper so everyone can see and participate in the discussion.

1 **Equipment costs** List the various types of equipment you have bought. For each piece of equipment, put the right number of stones next to it to show how much it cost.

2 **Input costs** List the various types of inputs used. Next to each input, put the right number of stones to represent how much it cost.

3 **Operation costs** List the various operations done. For each operation, put down the right number of stones to show its cost.

Add up all the stones to get the **total cost**.



Is conservation agriculture profitable?

Profit is your **income** minus your **costs**. Here is how to calculate it.

Income

1 List the **crops** you have produced using conservation agriculture: maize, beans, cover crops, etc. (Table 5).

2 For each crop, write down how **many kilograms or bags** you harvested. (Make sure you count all the various types of yield. For example, your cover crops might produce firewood, fodder you can feed to your animals, as well as seed you can sell to your neighbours.)

3 Write down the **price** you got per kilogram or bag for each crop. (It doesn't matter if you sold only part of the crop and your family ate the rest: treat it as if you had sold all of it. For fodder, work out how much you would have to pay for the same amount of fodder if you had to buy it.)

4 **Multiply** the number of bags or kilograms harvested by the price per bag or kilogram to get your income from each crop.

5 **Sum the amounts** for each crop. This is your **total income (N)**.

Table 5 Total income

Crop	Amount harvested (kg or bags)	Price per kg or bag	Income
	H	J	M = H x J
Maize			
Beans			
Cover crops			
Total income			N

Profit

Subtract your total costs (**T**) from your income (**N**). This is your profit (**P**).

$$P = N - T$$

If the answer is greater than zero, you made a profit. If it's less than zero, you made a loss!

Using stones to calculate profits

You can use stones to calculate profits in a similar way to costs (see previous box).

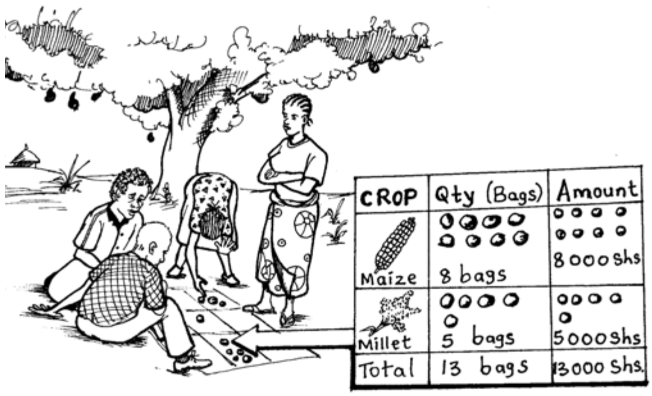
1 **Income** List the various types of yield from your crops. You can use leaves or seeds of each type of crop so you remember which one is which.

2 For each crop you sold, work out how much money you got when you sold it. Put the equivalent number of stones next to that crop.

3 If you did not sell all of a crop (for example, if you and your family ate some of it), work out how much money you would have got if you had sold it. Put the equivalent number of stones next to that crop.

4 Add up all the stones. This represents your income.

5 **Profit** Take total costs you calculated earlier (see previous box) away from the income. This is your profit.



Determining sales value of harvested crops

Is conservation agriculture worthwhile?

To decide whether it is worthwhile to start practising conservation agriculture, you need to know which is more profitable: conservation agriculture or your current practice?

To work this out, simply make **two sets of calculations**:

- One for **conservation agriculture** (outlined in the previous sections)
- Another for your **normal practice**.

You can now compare the results. Which one gives you the best yields? Which one gives you the highest profit?

See the box on the next page for an example of this type of calculation.

Profit from conservation agriculture in Ghana

An experiment in Ghana over six years found that ripping produced more than twice as much maize as slash-and-burn farming: 1200 kg per hectare instead of just 500 kg.

Not only that: the farmers saved labour too. Slashing fallow vegetation is hard work: it took 83 person-days to clear and weed a hectare of land using the conventional approach. Using herbicide, it took only 48 person-days to do the same job.

The result: a profit of 940,000 cedis from conservation agriculture, compared to a loss of 495,000 cedis from slash-and-burn.

The farmers did not get the full benefits in the first year because it took several years to control weeds and they learn how to use the new equipment.

Comparison of conservation agriculture and slash-and-burn in Ghana

	Units	**Unit price** (cedis/ unit)	**Ripping** (conservation agriculture)		**Slash-and-burn** (conventional practice)	
			Quantity	Total value (cedis)	Quantity	Total value (cedis)
	a	**b**	**c**	**d = b x c**	**e**	**f = b x e**
Income						
Maize sales	100 kg	150,000	12	1,800,000	5	750,000
Total income (N)						**750,000**
Costs						
Labour	Person-days	15,000	48	720,000	83	1,245,000
1st herbicide spraying	Litres	60,000	1	60,000	0	0
2nd herbicide spraying	Litres	60,000	1	60,000	0	0
Knapsack sprayer hire	Days	10,000	2	20,000	0	0
Total costs (T)				**860,000**		**1,245,000**
Profit (P = N – T)				**940,000**		**–495,000**

More information: Philip Boahen

How much work is conservation agriculture?

It's easy to account for hired labour: you just add up the money you pay the labourers. But how about the work you and your family do – that you don't get paid for? How to keep track of this? How to tell whether conservation agriculture is more or less work?

1 List all the **activities** you and your family have done for conservation agriculture throughout the year. It's easiest if you write down the dates as well, so you don't forget something (Table 6).

2 For each activity, work out how many **person-days** it took. Count each person separately. So if weeding took two people 3 days, count that as 2 x 3 = 6 person-days.

3 **Sum the number of person-days.** This is your total family labour input (**L**).

You can now compare the amount of work you and your family put in to conservation agriculture with the amount you do for your normal farming practice. Which takes more work? Is the extra work worth it?

When is the work needed?

Conservation agriculture may need work at different times of year from usual. For example, you may need to do less work for land preparation (because you don't have to plough), but more work to control weeds later in the season.

How to account for your family's labour

If you want to include family labour in your calculations of costs and profit (like in the box on the previous page), you have to convert the number of days spent into money terms – even though nobody from the family actually got paid for their work. Doing so gives you a clearer picture of whether it's better to adopt conservation agriculture, stick with your normal farming practices, or look for other work.

You can work out the money value of your family labour like this: think of how much it would have cost to hire someone to do the same amount of work.

For example, maybe it took 6 person-days (2 persons for 3 days) to plant your conservation agriculture field. If it costs $2 to hire a worker for one day in your village, then the equivalent cost of your family labour was: 6 person-days x $2 dollars = $12.

Beware: the costs of hiring workers can vary a lot: they go up if there is a lot of work to be done, if there are few labourers available for hire, or if other costs go up. So try to use the actual wage you would have to pay.

The result will only be an estimate. For example, it will not necessarily reflect things such as the quality of work (family members usually take more care than hired workers), or the fact that you really might not be able to hire anyone. But think about it: giving an approximate value to your family labour may be better than not counting it at all.

Here's how to check this so you can plan your calendar.

1 List all the **activities** you and your family have done for conservation agriculture throughout the year (Table 7).

2 On a calendar, fill in the number of **person-days** for each activity in each month. To make things clearer, you can mark who did each activity (e.g., husband did the land preparation, wife and children did the weeding).

3 Sum the number of **person-days** for each month to get the total family labour input for that month.

4 **Sum the number of person-days** for each activity to get the total for that activity.

Table 6 Calculating how much work your family has done

Date	Operation	Person-days
	Land preparation	
	Herbicide application	
	Planting	
	Weeding 1	
	Weeding 2	
	Harvesting	
	Transport to market	
	Others	
Total input of family labour		**L**

Table 7 Labour use in each month

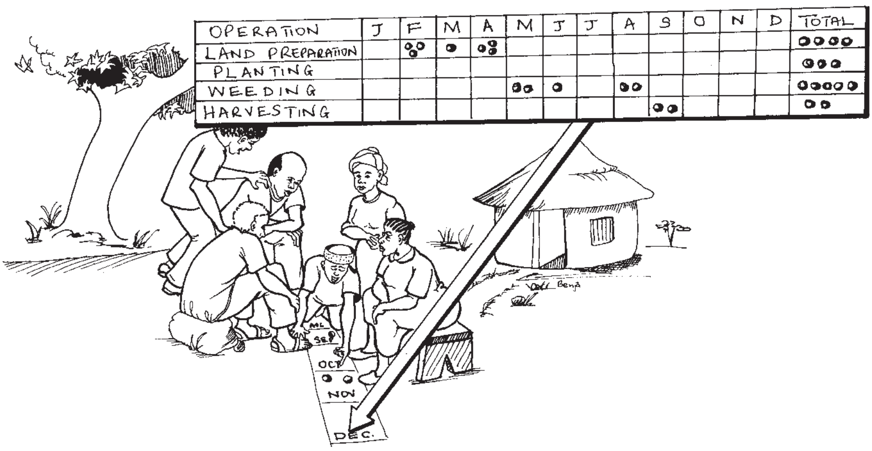
Activity	Number of person-days												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Land preparation													
Planting													
Weeding													
Harvesting													
Total													

Using stones to calculate labour needs

You can use stones to calculate the labour needs for conservation agriculture. You can do this at the same time as you are working out the costs of each operation.

1. **Total amount of work** List all the activities you and your family have done for conservation agriculture throughout the year.
2. Put stones next to each activity: one stone for each week a person worked.
3. Add up the number of stones to get the total family labour input.
4. **Timing of work** Draw 12 columns next to your list of activities. Put the name of a month on each column: January, February, and so on.
5. Using the same stones as above, divide the pile for each activity among the months. So if it took you 2 weeks to weed in January, put 2 stones in the January column.
6. **Sum the stones** for each month to get the total family labour input for that month.

If you want to see who did what, you can use different coloured stones or different types of grain or leaves to represent each person.



Determining labour distribution for various farming operations

More time for beekeeping

Conservation agriculture has freed up so much of Rose Masai's time that she has been able to start a new business – honey production.

Rose farms in Teso, Busia District, in western Kenya. Honey Care, a Kenyan firm, introduced local farmers to honey production. The firm provided hives for a quarterly fee, and would collect honey every 3 months. Akrukranut, a local community-based organization in Busia bought a centrifuge, so now Rose and other farmers produce honey themselves.

Business is good. Rose makes a profit of KSh 20,000 a year from her honey, and she now has seven hives.

More maize for less work in Ghana

Farmers in Brong Ahafo in Ghana have found they can get higher yields with less work. They have started using minimum tillage and to plant leguminous cover crops. The cover crops include mucuna, lablab, *Canavalia* and *Pueraria*. These crops suppress weeds and raise the soil fertility.

Before these new techniques were introduced, farmers would use slash-and-burn to clear land. They had few tools – only hoes, machetes and dibble sticks, so could not farm large areas. The result was declining soil fertility and falling yields.

In 1996, the Sedentary Farming Systems Project (SFSP) introduced conservation agriculture to the region. The project was a joint initiative of the Ministry of Food and Agriculture, GTZ and the German Development Service.

The new methods enable farmers to do 20–40% less work, but get 50% higher yields. Women farmers are especially happy: they now have time to do trading or other outside work, which brings in as much as one-third of their income.

12

Conservation agriculture and people

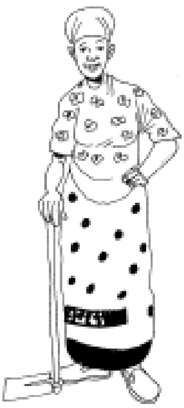
THE SUCCESS of conservation agriculture depends not only on whether it can produce high yields or good profits. It also depends on local customs and culture, the way people think of farming and the unwritten rules they follow. This chapter looks at how conservation agriculture is affected by two issues:

- The different roles and special needs of **women and men**.
- How **cultural beliefs** affect people's willingness to consider conservation agriculture.

This chapter also looks at how conservation agriculture can provide opportunities for special groups of people. It shows how it can:

- Help families cope with the challenge of **HIV/AIDS**.
- Help farmers with **physical disabilities**.
- Provide incentives for **young people** to stay in farming.

Women and men



In many villages and in most families, men and women tend to be responsible for different things. They do different things, know different things, and have different interests, priorities and needs. They have different backgrounds and experiences, and their families, neighbours and society as a whole expect men to fulfil certain roles, and women to perform other roles.

Labour In some places, for example, men may plough the land and sell the produce, leaving the women to do the planting, weeding and harvesting. In other places, women may do the land preparation. Men and women may each tend different fields and grow different crops. Men are often responsible for the crops that can be sold for cash, while women deal with the lower-status crops the family eats every day. It may be culturally unacceptable (or at least unusual) for a woman to handle draught animals or drive a tractor. In general, women do more farm work than men, though this is often not recognized.

Income Husbands and wives do not necessarily share their incomes. Men may keep the money they earn, and give only part of it to their wives to buy food and other essentials. Women may earn their own money by selling produce, making cakes or beer, or trading.

Markets Women tend to sell their produce close to home. Men are more likely to take their produce to distant markets for sale.

Information and knowledge Men are more likely than women to attend extension meetings and be members of farmer groups. They tend to be better educated, go to town more often, and have better access to information from outside. Because of their backgrounds, women and men tend to know about different things: men understand machinery and marketing, women know about nutrition and weed management.

Decision making Men often make the key decisions in the family, while women do more of the farm work. Many men go to the cities in search of work, leaving the womenfolk to look after the farm. The women then either have to wait for the men to decide what to do, or they have to make the decision themselves.

Rights Women tend to have fewer rights than men. Men normally own the land, and in some countries, women cannot even legally own it. Even if it is legal, they are prohibited from doing so by local custom. Wives may find their male relatives deprive them of their land and livelihood when their husband dies. As the formal head of household, a husband may be more likely than his wife to qualify for credit.

Freedoms In many places, women have fewer freedoms than men. Perhaps this is because of traditional views that "the woman's place is in the home". Or it may be that women are afraid to go far from home without protection.

Priorities and needs Because they are responsible for different tasks and have different types of knowledge and experience, men and women tend to have different priorities. A man may want to buy an ox to pull farm equipment, for example, while a woman may prefer to buy a weed wiper to help her control weeds.

Freedom of expression Women may be unwilling or unable to express their views. For example, they may not dare to speak out in public, especially if they have different views from their husbands.

Don't forget the children

Children also contribute to their families. From an early age, they do a surprising amount of work around the farm:

- They plough, plant and weed crops, spread fertilizer and carry loads. They scare birds away from ripening fields of grain.
- They fetch water, collect firewood and help cook.
- They tend animals and keep them off the fields.
- They look after younger brothers and sisters, freeing their parents to do other things.
- Often, they do all these things in addition to their full-time job: going to school!

Children who have lost their parents to AIDS may have to take on the full burden of feeding and caring for their younger brothers and sisters.

Conservation agriculture, women and men

Conservation agriculture may affect men and women in many different ways. That may make them more (or less) willing to adopt it, or may influence the particular techniques they decide to use. Some examples:

- Conservation agriculture may cut the amount of labour needed overall, but it may increase the amount of work that women and children have to do.
- Eliminating ploughing (traditionally men's work) may make it easier for women to adopt conservation agriculture.
- Men who control the family budget may be unwilling to invest in a weed wiper, which would ease the burden of weeding for women.

These distinctions are not always clear-cut. And they differ from place to place and from family to family. Traditional patterns are breaking down anyway as families are forced to cope with the stress of AIDS and migration. A widow may have no choice but to do traditional "men's work" if she is to feed her family. On the other hand, she may find it impossible to do so if she cannot get the support (land, labour, credit, inputs) she needs.

Even though it is difficult to generalize, the differences between men and women are real. And they affect how people may see conservation agriculture and how ready they may be to adopt it.

Ideas for action

If you are an extension agent or development worker, here are some ways to help women and men adopt conservation agriculture, or to help them choose the techniques best suited to them.

Less work for men, but more work for women

Farmers in central Ghana are pleased that conservation agriculture has saved them work. Using minimum tillage and planting cover crops has restored the fertility of their soil and has improved crop yields. And it takes at least 30% less work than the traditional slash-and-burn practices. These techniques were introduced by Sasakawa Global 2000 in collaboration with Monsanto and the Ministry of Agriculture.

But not everyone is happy. Higher yields mean more work harvesting and transporting the grain. Those jobs fall mainly to women and children.

Women say that they now have less time for trading and other types of work, which brings in about one-third of their income. Money from maize sales, on the other hand, goes to their husbands, who decide on how to use it. Often, the men do not share it fairly with their wives.

The women think that the men should help them harvest and transport the grain, and should share the proceeds more fairly.

Understand the roles and views of men and women It may be necessary to do some research into this before you start promoting conservation agriculture. Try to understand men's and women's viewpoints, their roles, cultural beliefs and other things that may affect how they manage their farms. You can do this by observing what people do, discussing with key informants and different interest groups, and participatory rural appraisal (PRA) exercises. Consider holding separate meetings for women (using a woman facilitator) to make sure they have a chance to express their views.

Anticipate problems Check whether conservation agriculture is likely to have any unforeseen effects. For example:

- Replacing ploughing or hoeing with ripping may deprive the people who did the land preparation of an important source of income.
- In the first few seasons, men's workloads may fall (no ploughing), while women's may increase (more weeding).

Encourage flexibility Discuss the changes with men and women, and encourage them to take on new roles. Train women how to handle animal-drawn rippers, and encourage men to do weeding. Men may be more willing to weed if they can use herbicide (spraying is often a man's job).

Ensure that women are not overburdened Talk with families (especially men and elders) about the advantages of conservation agriculture. Point out that there may be more work to do in weeding and harvesting, and facilitate the community to come up with solutions. For example, families might consider using some of their profits to buy a sprayer that cuts the time needed for weeding. Elders may be willing to influence men to help with some of the work that women traditionally do.

Plan extension activities for everyone Recognize you have to talk to the women (and young and old people) as well as the men! Pay special attention to women: plan extension activities and demonstrations especially for them. Hold meetings for a convenient time of day so women can attend.

Involve men and women Ensure that both women and men are involved in planning, designing and implementing conservation agriculture activities. Encourage women to take leadership positions in groups.

Check equipment Check whether there are likely to be any restrictions in women or men using conservation agriculture equipment. A weed wiper may be more appropriate for women than a sprayer, for example. You may have to run separate training courses for women and men on using animal-drawn implements.

Provide information in an appropriate way Find out how men and women in a particular community get information. For example, men may listen to the radio or ask retailers for advice, while women may get information from the local market. Use these channels to spread the message about conservation agriculture. Tailor your message to your audience, and then choose how to get the message to them. For example, you might ask nurses and midwives to tell women how to use conservation agriculture to grow vegetables. Make sure you use the right type of language: use simple words and avoid jargon.

Help people get inputs and credit Assist men and women to access credit, seed supplies, implements, agrochemicals, and services such as hiring of draught animals. Pay special attention to women groups: the group as a whole may be able to buy implements for its members to use.

Assist with marketing Help women to form marketing groups, and put them in touch with traders and transport firms so they can sell surplus produce.

Focus on the family partnership Encourage the family to work as a unit, rather than focusing on the differences between men and women. Dividing up responsibilities is normal, but everyone's main goal should be the family's welfare and livelihood.

Cultural beliefs

People's culture and traditional beliefs may help or hinder efforts to promote conservation agriculture.

Here are some examples of ways that culture can hinder its promotion, along with some suggestions on what to do about it (in *italics*):

Staple foods Throughout southern Africa, people think of maize as their main food. It can be difficult to convince them to rotate their crops. In some areas, people still plant maize even though it is not the ideal crop. For example, parts of Mokhotlong district in Lesotho are above 2500 m and are very cold, but everybody grows maize even though yields are very poor. *(Ask them if they have considered growing something else and selling it, then buying maize to eat.)*

Fire Many farmers like to burn stubble and weeds to clear the land before planting. Livestock owners also use fire to manage pastures. These practices have even been promoted by extension services. *(Burning destroys valuable crop residues and threatens cover crops growing during the dry season. Much better to leave the residue on the surface as mulch.)*

Luo rituals delay farming

The Luo of Nyanza Province in western Kenya have many traditions and beliefs related to farming. They say that if they fail to observe certain rituals, the community will be visited by a calamity. The eldest person in a family must perform these rituals before others can start work on their farms each year. It is taboo for anyone to begin farming before the ceremony has been performed.

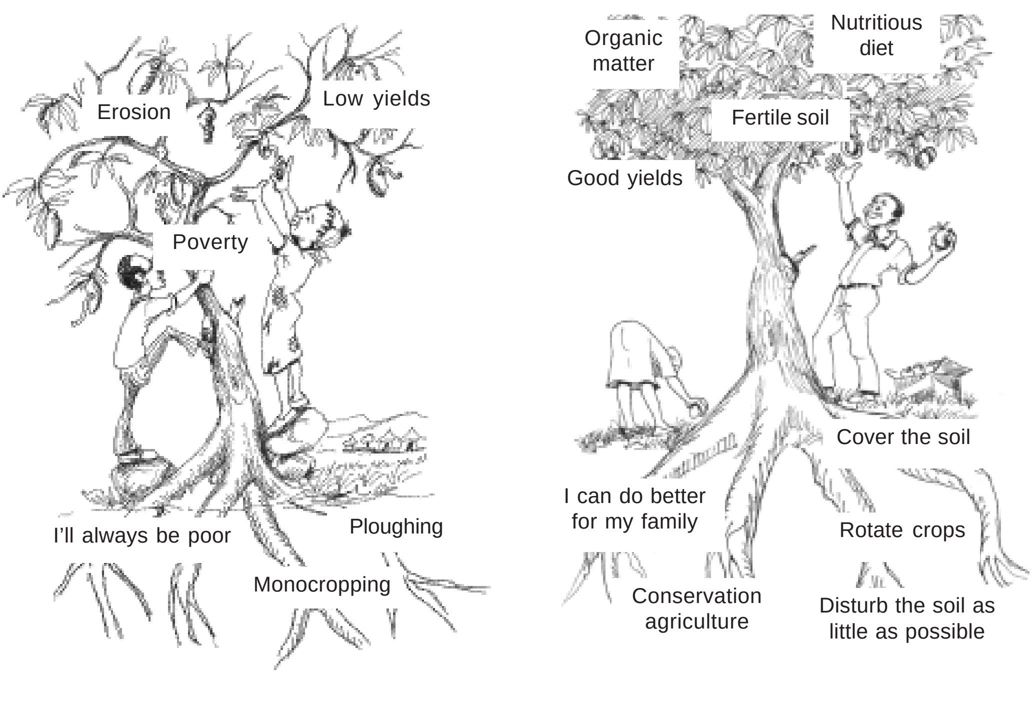
But what if the person who performs the ritual is away working in town? Or has succumbed to AIDS? This can lead to indecision and delay. Vital days or weeks may be lost before the person can return to perform the ritual, or another solution can be found.

Ploughing Ploughing is associated with many mistaken beliefs:

- A "good farmer" is often seen as someone whose field has been ploughed and cleared of everything. A farmer with crop residue is seen as lazy. *(No: a good farmer is one who gets good yields and conserves the soil.)*
- Many farmers think that they must plough to make sure the soil soft so that roots can penetrate easily. *(In fact, the opposite is true: ploughing destroys the soil structure and creates a hardpan.)*
- Farmers believe that they have to plough organic matter under to make compost. *(Not true: organic matter is more valuable if it is left on the surface.)*
- The soil must be ploughed in order for the rain to penetrate and keep moisture in the soil. *(Again, the opposite is true: rain sinks into the soil more easily if the soil is covered with mulch or vegetation.)*

Fatalism Some people believe they are poor and will be poor for the rest of their lives. *(They forget that they can find a way out of poverty; conservation agriculture offers them a way to do this.)*

Land ownership and tenure This is an economic and political issue as well as a cultural and social one. If the land is owned communally (or by the state), individual farmers may have little incentive to improve their soil. Communal



What beliefs are there in your community that hinder development? What beliefs hinder the adoption of conservation agriculture?

No house? No trees

"In western Kenya we found a widow not really participating in the project on fruit trees and planting legumes. We found out later that in that village, a widow was not allowed to plant trees if her husband had not built her a house before he died. We brought this up at a village meeting, and the people decided to abandon this practice. This widow is now one of the resource farmers in the area."

Anja Boye, ICRAF

grazing may mean they cannot keep animals out of their fields. And in many places women cannot own or inherit land. *(Reach agreements in the community to guarantee security of tenure.)*

Ideas for action

It can be very difficult as an outsider to address issues of culture. Many traditions have a practical reason that may not be immediately obvious. Or they are rooted in history. People see their culture as part of their identity, and changing it is very difficult.

On the other hand, mistaken beliefs can seriously harm development. Everyone has a belief system. The question is whether it contains the truth. Here are some ideas on what to do if you are an extension agent or development worker.

Understand and respect the culture Do not automatically condemn beliefs as "wrong" or "bad". Rather, try to understand them and the reasons behind them.

Facilitate discussion Help the community to start to talk about their beliefs. If they recognize a problem, they may be ready to find ways to solve it.

Focus on important issues There is no point in trying to address a particular cultural practice if it is not important.

Build on the culture If you understand the culture and are willing to listen to people, you may be able to identify beliefs and practices that support conservation agriculture. For example, people may already use certain plants as cover crops, or be able to suggest other plants that may be suitable. They may have views about the benefits (or disadvantages) of intercropping. They may be interested in trying out new ideas, or in reviving traditional practices.

Work with respected community members Listen to elders, chiefs and other respected people in the community, and try to get them to support your message.

HIV/AIDS

AIDS and the virus that causes it, HIV, have a devastating effect on farm families in Africa.

- AIDS directly affects the most productive people in the society: adults who would normally support themselves, their children and their elderly relatives. When they fall ill, farming has to be done by weaker, less productive people: the very young and the very old.
- These family members have a double burden: they have to look after their sick relatives, and they have to take over their work. They cultivate smaller plots, and grow a smaller range of less labour-intensive crops. They struggle to keep pace with the seasonal calendar. They plant late and fail to weed on time, so reap smaller yields. Their diet is poorer and they go hungry more often, so they become even less productive and fall ill more often.
- Unable to grow enough to feed themselves, and beset by medical bills and funeral expenses, desperate families are forced to sell what they have. They sell farm implements, draught animals and land to raise money. They have less to invest in their farms.
- Relatives of the deceased may seize the family's property, leaving widows and orphans destitute.
- The survivors – orphans, the elderly, and women – may lack the right skills to use equipment, so it falls into disrepair. They may find it particularly difficult to get credit or extension advice.
- Many communities have traditional ways of supporting less fortunate people. But these customs may be stretched to breaking point by the large numbers of illnesses and deaths.

Junior farmer field schools in Swaziland

AIDS has been a disaster for Shewula, in eastern Swaziland. So many of the adults have died that the community has more than 2000 orphans.

FAO-supported projects have introduced conservation agriculture in the area and are working with the orphans.

The orphans are learning conservation agriculture practices through "Junior Farmer Field Schools". For these children, conservation agriculture has two advantages over conventional farming: it requires less money and takes less work.

One of the things the children learn is how to make compost. They use this instead of expensive artificial fertilizer on their maize and sorghum. They intercrop these cereals with legumes, which improve the soil fertility and provide nutritious beans.

They grow some legumes as a relay crop to cover the soil during the winter, which is the dry season in Swaziland. That increases crop yields during the following season. This practice enables them to harvest two crops from the field in the same year.

Conservation agriculture and AIDS

Conservation agriculture can help overcome some of these problems.

- **No more ploughing** It eliminates ploughing – one of the biggest tasks on a farmer's calendar.
- **Less weeding** Using cover crops, mulch and herbicides controls weeds better than traditional methods – saving time on weeding, another of the most time-consuming tasks in farming.
- **Low-labour implements** Using a jab-planter is faster and less laborious than planting using a hoe. Some jab-planters can plant and apply fertilizer at the same time. Weed wipers are easy to use and effective at controlling weeds.
- **Crop diversity** Growing intercrops and rotating crops allow farmers to diversify their crops and produce a nutritious range of food on the same plot. AIDS patients and their families need nutritious, balanced diets. Many of the intercrops and cover crops used in conservation agriculture are high in protein and vitamins.

Ideas for action

Here are some ways that extension agents and development workers can help people use conservation agriculture to cope with AIDS.

Provide extension support Discuss with local people and community groups how best to work with AIDS patients and their families. Work out how to tell them about conservation agriculture and the benefits of legumes and other crop options.

Identify and support vulnerable households If possible, find out who is affected by AIDS (either as a patient or because someone in their family is infected). Design extension activities especially for them. Help them choose crops and varieties that are nutritious. Provide advice on nutrition, and teach them recipes that use new types of food – for example, how to fortify maize flour with protein-rich legumes or amaranth.

Encourage farmers to plant nutritious crops Examples are cowpeas, pigeonpeas, lablab, climbing beans, ground beans, groundnuts, mungbeans, sweet potatoes, pumpkins, amaranths and other indigenous vegetables. In many areas, farmers can plant traditional vegetables that are easy to grow and suited to the local conditions.

Encourage support groups Groups can help in many ways. Members can pool their labour, contribute money to buy equipment, exchange ideas, and learn new techniques together.

Farmers with disabilities

Physically challenged people have great difficulty in providing for their families. But conservation agriculture has enabled people with serious disabilities to feed themselves and their families, restore their dignity, and change their lives.

People with disabilities may need special help to adapt the technology to their needs. Extension staff and development workers should do their best to provide this assistance.

If a blind man can do conservation agriculture, so can you!

Pahlo is an old man who lives in Ha Monoto village, in the heart of the mountains of Lesotho. Every day, he goes out to tend his fields of maize, sorghum and beans.

Not unusual, you might think. But wait: Pahlo is blind.

The village church had been conducting training on conservation agriculture. Farmers were given strings with marks at regular intervals to show them how far apart to dig planting basins. Each trainee received several strings, so they could teach other farmers. One gave a string to Pahlo, who carefully tied on pieces of plastic so he could feel where to dig the holes.

Every morning, Pahlo's two grandsons take him down the mountain to his fields. They help him to find where he left off the previous day, then they leave for school. Pahlo digs the basins with a spade, then puts seeds and the right amount of fertilizer in the hole with a little cup. He plants the whole day, until his grandchildren come to fetch him.

Conservation agriculture has brought hope to Pahlo. For the first time in his life, he is able to plant his field.

More information: August Basson

Stroke does not stop Lesotho farmer

A farmer in Seforong, Lesotho, suffered a mild stroke a few years ago. He was immobilized so could no longer walk behind his oxen to plough his field. And he cannot afford to pay for a tractor to do the ploughing.

He attended training on conservation agriculture and learned how to make planting basins. He still walks with great difficulty, but is proud that he can now provide for his family despite his disability.

More information: August Basson

Young people

Farming is not an attractive option for many young people. Low yields mean low incomes, and the cities offer opportunities that are absent in the village. Many young people opt to try their luck in town rather than stay on the farm.

But young people are Africa's future, and they are vital if Africa's agriculture is to prosper. Young people have skills, energy and creativity. They are quick to learn and open to new ideas.

Conservation agriculture offers incentives for young people to stay in farming:

- It offers the prospect of higher yields than conventional farming. It requires less work and less investment in expensive equipment such as ploughs.
- It opens opportunities for young people to provide specialized services, such as spraying, field preparation, servicing and repair of implements, vegetable growing and seed production.

A future for delinquent youths

Conservation agriculture can be an important component in efforts to work with delinquent youths.

In 2004, a group of young men in Oliosirkon, close to Ongata Rongai near Nairobi, were making themselves a nuisance. They were either orphans or were from homes that did not provide them with support. Most had little formal education, and they earned money through casual labour when they could get work. They took drugs, and had little hope of improving their lot in life.

Local people were fed up with these lads, so they decided to force them to leave. But one woman asked permission to work with them for four months – before the community took such drastic action.

A committed Christian, she met with them twice a week to worship and study the Bible. Under her guidance, the youths decided to reach out to other young people and to people affected by AIDS. They began to visit the sick, and invited other youths to join them. One asked for help to begin another group for delinquent boys nearby.

One of the major difficulties the lads face is how to earn a living. They tried planting kale, but it withered for lack of water. In 2005, they were introduced to conservation farming. They carefully prepared and planted two plots of land. They received a small amount of financial assistance to buy fertilizer and seed (and fencing, because herders in the area allow their cattle to feed on whatever is growing!).

Other people have heard about conservation agriculture, and the youths have arranged to give a seminar on how to do it. They are now thinking of starting a small business as well.

Conservation agriculture has taken these young people off the streets and has given them a way to make a living.

More information: August Basson

Ideas for action

Here are some ideas to try with young people:

- **Open dialogue** Discuss conservation agriculture with young people in youth clubs, sports clubs, drama groups, etc.
- **Find attractive options** Seek options that may appeal to young people – for example those that can provide quick returns, such as vegetable growing.
- **Work with schools** Find ways to teach conservation agriculture in schools. Establish a school nursery to produce seeds or seedlings.
- **Work with the private sector** Involve private companies in promoting conservation agriculture. Young people are tomorrow's customers!

Company encourages children to teach parents

Reapers, a Zimbabwean firm that produces groundnuts and other crops, normally contracts out its seed production to small-scale farmers.

The firm encourages children to help their parents maintain their farm records. It also gives prizes to the parents who have performed best – it donates seed to their children's schools so they can start school gardens.

13

Encouraging adaptation and adoption

People do not change by just looking. Conservation agriculture will not necessarily spread by itself. Few innovations do.

The techniques have to be adapted to suit local conditions. Conservation agriculture has to be supported and actively promoted by government, extension services, development agencies and the private sector.

Not only that: a drastic mind shift has to take place, not only in the minds of farmers, but also among extension personnel, government officials, researchers, and others involved in agriculture. Conservation agriculture goes against many of the things they have learned and regard as "true": not ploughing, for example, or leaving as much cover on the soil as possible.

Training and extension are important ways to achieve this mind shift, as well as to provide the skills and information necessary. But they are not the only ways. This chapter describes various ways to promote conservation agriculture and adapt it to local needs.

The effort is worth it. Millions of lives could be changed if the message of conservation agriculture gets out to struggling farmers.

This chapter is aimed at extension agents, development workers and trainers who are interested in promoting conservation agriculture.

Adapting conservation agriculture

You have visited a group of farmers in the neighbouring district, and have seen how they practise conservation agriculture. Their crops look healthy, their soil is rich in humus, and they get good yields. You'd like to help farmers in your area take up conservation agriculture. They just need to copy the farmers you have visited.

Right?

Not necessarily. Technologies that work well in one place may not fit conditions in your area. Your area might get less rain. Your soil may be sandier. Farmers in your area may want to grow different crops.

So you may have to adapt the conservation agriculture technologies to suit your area. You might even have to invent new methods. It is not a question of technology transfer, but of adaptation and experimentation.

Conservation agriculture is not one set of techniques. Rather, it is a set of **principles** that can be adapted to suit local conditions. It is important for farmers to experiment and learn, and to share their results with their neighbours. Farmers can do this on their own, but it is much easier if extension agents, development workers and researchers can help them.

Adaptive research is a way of trying conservation agriculture (or any other technology) in an organized, systematic way. There are many ways of doing it. Researchers can test technologies under controlled conditions on the experiment farm. They can conduct trials on farmers' fields. Farmers and extension personnel can take the lead, with researchers providing advice and support. Or farmers can do research by themselves, perhaps with advice or inputs such as seeds from researchers or extension staff.

Remember the three principles of conservation agriculture:

- *Disturb the soil as little as possible.*
- *Keep the soil covered as much as possible.*
- *Mix and rotate crops.*

Adaptive research is best if **farmers are at the centre**. This has various advantages:

- The conditions are realistic, so the technology is tested in real-world conditions.
- Farmers can draw on their own experience, and will choose to test things that they feel they can do and afford.
- People learn best when they are actually doing something and discovering for themselves, rather than merely watching someone else. Farmers can go on to use the same approach to test other innovations.
- Their results carry more weight and will be more credible to other farmers than if researchers were conducting the research.

Collaboration between researchers, extension staff and farmers combines everyone's knowledge, resources and energies. Farmers who have never tried conservation agriculture will be more confident about embarking on the research, taking calculated risks. Extension workers learn research methods and can help spread them and the technologies tested to other villages. Researchers become better aware of the needs and specific conditions that farmers face. This in turn helps them make their research more relevant to farmers and communities.

Farmer field schools (see below) are a good venue for adaptive research.

An undiscovered gold mine

Conservation agriculture is a gold mine, waiting to be discovered.

- Conservation agriculture unlocks nature's regenerative capacity.
- Farmers can reverse the downward spiral they are in. Once they do so, nature will help them.
- The key is to stop the damage and destruction. Let nature's power become a reality on your farm.

Anyone can practise conservation agriculture – even a blind person (see page 197). You can learn it too!

Demonstrations or adaptive research?

Many extension agents and farmers are familiar with on-farm demonstrations (see below, page 211). Adaptive research is different in two important ways:

- In research, no-one is quite sure what results to expect, because nobody from the community has ever used the technology before.
- Research usually compares several alternatives with each other, to find out which one is best.
- Research usually tries to build and compare a basket of options, rather than assuming one single technology will be best suited for all farmers.

Things to adapt

It is possible to adapt many aspects of conservation agriculture. Here are some ideas.

- **Crops and combinations** Which crops and which varieties grow best in your conditions? When is it best to plant the main crop and the cover crop? Is there enough soil moisture to plant earlier? Is it better to plant closer or further apart? Which crops and cover crops grow best together? How much compost or fertilizer is needed?
- **Soil cover** What is the best way to maintain soil cover? Are there dual-purpose cover crops that provide both food and fodder? Can traditional local cover crops be used instead of exotic types?
- **Equipment** Conservation agriculture equipment can be hard to find, too expensive, or not suited to local conditions. But artisans can adapt existing designs or make their own. Examples of such adaptations include the Zambian Magoye ripper, planter, subsoiler, the Ugandan AEATRI knife-roller and the Maresha modified conservation agriculture implements in Ethiopia.

In some situations, it may not be possible for farmers to use a full conservation agriculture approach. But they can still introduce some of its elements and benefit from improved yields and reduced soil erosion. Some examples:

- **Tillage methods** It may be impossible to introduce zero tillage, especially when tef is the main crop. Alternatives may be strip tillage, minimum tillage or a single ploughing (rather than multiple ploughings). Farmers can still improve the soil structure and fertility by rotating crops. They can control weeds and obtain livestock fodder by planting cover crops.
- **Livestock** It may be impossible to keep livestock off the conservation agriculture fields – especially in semi-arid areas where large numbers of animals are hungry in the dry season. Farmers may have to compromise with livestock owners – for example, to allow the animals into the field for a limited time only, so some cover is still left as mulch. Both farmers and animal owners have to protect cover crops, just like a field of food crops.

A story of on-farm research

Below is a story about how one group of farmers tested a new conservation agriculture technology on their farms. They followed a number of steps, from identifying a problem to assessing the results.

This story is fictitious, but it is realistic. It shows that things do not always go as planned – but that farmers can conduct research and that they can learn a lot from it.

Identify the problem to study

At a meeting, a group of 10 farmers agree that a key problem is to find the best time to plant lablab in their maize field. Only one of them has actually planted lablab, and he got mixed results. Some think they should plant as early as possible; others have heard it is better to wait a little. But nobody, including the extension agent herself, is quite sure!

Identify the alternatives that may help solve the problem

The farmers discuss the issue extensively and get some feedback from a researcher working nearby. They and the extension agent decide to test three planting times: (1) planting the maize and lablab simultaneously; (2) planting lablab 2 weeks after maize; and (3) planting lablab at the first weeding, about 1 month after the maize.

Decide on the details of the experiment

The farmers and extension agent decide that three farmers will do the experiment during the next growing season. Each one will plant two of the three alternatives, as well as a “control” plot without lablab, which is what they are used to. Each farmer will plant a small plot 15 rows wide by 40 m long for each of the two alternatives and the control. They decide to monitor lablab germination and growth, the labour costs, any signs that the maize might be suffering from competition by lablab, as well as maize and lablab yields. Each farmer will need to record the corresponding information. Since two of them do not know how to write, they will need to ask for help from their children.

The group decides to organize three field tours for the group members: 1 month after planting, at maize flowering, and at harvest time. The extension agent and the researcher will attend as well.

Establish the experiments

The extension agent and farmers help the farmers establish the experiments. Things go almost as planned, even though the extension agent showed up 2 hours late. Fortunately, the researcher was there on time. The only worry is that one farmer planted 3 weeks later than the others, because she was not feeling well.

Monitor the experiments and conduct the field tours

The monitoring is not easy. One farmer forgot to record the information about labour and about competition. Another got confused and recorded the information in a rather chaotic manner. But fortunately, the third farmer did what was expected, with the help of her older son. The three field tours are quite a success, even though not everybody came, and not all fields looked great. And the researcher missed the third tour because his car broke down. But the tour took place anyway, and everybody had a lot of fun.

Continued...

A story of on-farm research (continued)

Assess the results and take a decision about how to plant lablab

With all the results available, the group and extension agent meet to look at what happened. The researcher is invited, as well as everyone else in the village. Flipcharts are presented, and there are even a few photographs. Of the three experiments, one did not work well: the farmer who planted late got sick again, and could not control weeds. Her lablab did not produce anything, and her maize yielded little. But the other two experiments worked well: they show clearly that it is better to wait before planting lablab.

Farmers agree indeed that planting lablab at the first weeding is best, because it saves labour. The maize produced more in the plots with lablab than without.

At the end of the meeting, everybody is quite satisfied. Some farmers who are not part of the group ask for some lablab seed. The group itself wants to keep experimenting next season, but on something different. They ask what other cover crop they could plant in their maize fields? They have heard of pigeonpea and mucuna. Some wonder if fodder trees would be better than lablab, because they have trouble feeding their livestock. They ask the researcher to come back with information on all this, and they ask him to get as many different seeds as possible. The researcher promises to do his best.

Ways to promote conservation agriculture

Conservation agriculture may be difficult for people to accept because it goes against many of their cherished beliefs. The biggest obstacle is to get people to understand that ploughing destroys soils and the environment. Once they accept this, they may be willing to try something new.

It is not just farmers who have to change their thinking. Universities, agricultural training institutions, extension providers, researchers and the farming community itself must also change. Training is key to bringing this about.

Ironically, conservation agriculture practices are not totally new in Africa. Many are traditional practices that have been forgotten. It is time to bring them back.

Conservation agriculture can be promoted in many different ways:

- **Training** Training is necessary for various groups, including farmers, implement makers, input suppliers and extension personnel.
- **Extension** The government extension service advises farmers on farming technologies. It provides advice and training, and manages demonstrations and field days. It can be an important promoter of conservation agriculture.
- **Demonstrations** Demonstrations enable farmers to see conservation agriculture in practice before they try it out themselves.
- **Farmer field schools** This is a participatory extension approach in which farmers get together to study farming in their own fields.

- **Farmer champions** Farmer champions are people who have adopted conservation agriculture methods and can demonstrate their success to their friends and neighbours. Because they farm locally, their neighbours are likely to listen to them and copy what they do. The champions can provide advice or seed, and can help organize other farmers into interest groups to further promote conservation agriculture.
- **Farmer-to-farmer extension** Farmer-to-farmer extension involves using farmers as extension agents.
- **Farmer organizations** Farmer organizations can provide vital support to conservation agriculture efforts, especially when it is still new in the area.
- **Schools and churches** Schools and churches can play a key role in promoting conservation agriculture.
- **Other ways to share experiences** include field days, exchange visits, videos, and even radio programmes.
- **Farming as a business** Conservation agriculture offers an opportunity to encourage farmers to see their farms as a business, rather than merely a way to feed their families. Changing these attitudes can also promote conservation agriculture itself.
- **Multiple stakeholder partnerships** Partnerships between extension, NGOs, various levels of government and the private sector are needed to promote conservation agriculture.
- **Entrepreneurs** Conservation agriculture may require some new types of equipment (rippers, planters) and agrochemicals (especially herbicide). People who make this equipment and who sell the inputs needed are vital if farmers are to have what they need to use this approach.
- **Policy support** Governments can promote conservation agriculture, or it can hinder it. Experience in other countries has shown the importance of appropriate policies for the success of conservation agriculture.

The rest of this chapter discusses each of these approaches in turn.

Training

When planning a training course on conservation agriculture, think of the participants' particular needs.

- **Farmers** need practical skills in preparing the field, planting, controlling weeds, and so on.
- **Group organizers and extension agents** may need training on how to organize farmer field schools or use other extension methods.
- **Equipment manufacturers** need to know how to make and use different types of equipment.
- **Extension workers and researchers** need training in technical aspects of conservation agriculture – on the principles as well as on how to do it.

The entry point and coverage of training courses will also depend on what the participants already know. Build on their existing skills and knowledge. The training should give them information they can use directly in their own work. It should be as practical as possible. Training is best done not in the classroom, but on the ground – in farmers' fields, with farmers.

Planning a course on conservation agriculture for farmers?

Here are some of the most important topics to cover when teaching conservation agriculture to farmers. The appropriate sections of this manual are in *italics* in the list below. Choose the topics you need for your particular group of participants.

- **What is conservation agriculture?** *(Chapter 1)*
- **Addressing the problem** Soil fertility and erosion, destructive role of ploughs *(Chapter 4)*
- **Change of mindset** *(Chapter 12)*
- **Field preparation and planting** Direct planting, permanent planting stations (making and using strings, making holes, seeding rate in holes), ripping, subsoiling (training animals, correct spacing, correct seeding rate in lines) *(Chapter 3).*
- **Conversation tillage tools and implements** Operation principles, adjusting and maintenance *(Chapter 3).*
- **Training work animals and users** (See the next box)
- **Soil cover** Use of cover crops, dry vegetation and crop residues as mulch *(Chapter 5)*
- **Crop rotation,** choosing crops and crop combinations, seeds, integrated pest and disease management, agroforestry *(Chapter 6)*
- **Improving soil fertility** Manure, compost, inorganic fertilizer, making compost *(Chapter 4)*
- **Weed management in conservation agriculture** Mechanical, herbicides *(Chapter 7)*
- **Rainwater harvesting, soil and water conservation** *(Chapter 8)*
- **Integrating livestock** into conservation agriculture *(Chapter 9)*
- **Weed management** *(Chapter 7)*
- **Conservation agriculture as a business** Planning a business, record keeping *(Chapter 11)*
- **Promoting conservation agriculture** Working with groups, management of farmer field schools *(Chapter 13)*
- **Social and cultural issues** Gender, HIV/AIDS, food and nutrition, schoolchildren, youths, physically and mentally challenged farmers *(Chapter 12)*

Training on draught animal power

It is necessary to train both the draught animals and their handlers on conservation agriculture. Here are some topics to cover.

- Selecting and caring for draught animals.
- Making yokes and harnesses.
- Harnessing draught animals.
- Roping, yoking, walking in pairs and in pegged rows, pulling light weights and progressively increasing the load.
- Using equipment safely.
- Health of work animals.
- Feeding work animals, including supplementary feeding.
- Challenges in integrating animals in conservation agriculture operations, including cover crops.
- Using and transporting conservation agriculture equipment (direct planters, knife-roller, ripper, sprayer, subsoiler).
- Using equipment for managing crops, planting, ripping, spraying and transportation.
- Setting implements, calibration, and handling during field operations.
- Stripping and reassembling manual and animal-drawn tools and implements.
- Maintaining and replacing worn-out implement parts.

Training for blacksmiths and artisans

Implements such as rippers and subsoilers are still hard to find in many areas. With suitable training, blacksmiths and artisans can make them. Here are some topics to cover in a course.

- Blacksmithing problems that participants face in their workplace.
- Essential blacksmithing equipment and tools for conservation agriculture.
- Safety and organization in the workplace.
- Lighting the forge, managing the fire, and heating metal to the correct temperature.
- Blacksmithing operations and their application to conservation agriculture tools and spare parts. Provide designs for each implement showing how to make them from locally available materials.
- Importance of quality and standards, and interchanging implement parts.
- Making and using jigs and fixtures.
- Finding and identifying useful scrap materials.
- Setting up a rural blacksmith workshop.
- Pricing and marketing of products.
- Bankable smithing technology ideas.

Training for input dealers

Local shopkeepers and dealers may need training so they can sell the right item to farmers, and so they can advise their customers on how to use them. Some topics they may need training in:

- Using equipment (so they can demonstrate to their customers).
- Adjusting planters and sprayers so they deliver the right amount of seed, fertilizer or herbicide.
- Using herbicides correctly and safely.
- Maintaining and repairing equipment.
- Characteristics of crop varieties (so they can advise farmers on what crop and variety to buy).
- Storing and planting seeds.
- Storing fertilizers and other agrochemicals safely.

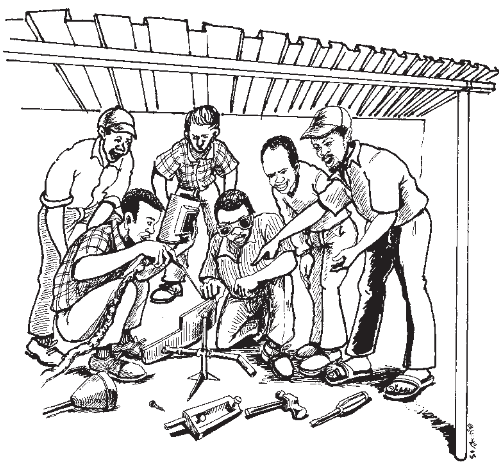
Training for extension staff

Here are some topics to consider including in training courses for extension personnel – in addition to the topics in the box on page 208.

- **Situation analysis** Analysis of local conditions for conservation agriculture, e.g., identifying problems, socioeconomic issues, SWOT (strengths–weaknesses–opportunities–threats) analysis.
- **Participatory approaches** such as participatory rural appraisal.
- **Organizational capacity building** Training on leadership skills, participatory planning skills and participatory monitoring and evaluation.

Because conservation agriculture involves a change in attitudes, it is important that participants come to "own" the approach. This is best done by enabling them to test technologies themselves, empowering them to decide what to try out, and through networking: providing them with ways to get more information.

Joint training, with extension staff and farmers learning together, is a good way to spread the message of conservation agriculture. The farmers hear and understand certain issues, and the extension officers others. During discussions, the two groups remember dif-



Practical training is vital if blacksmiths are to learn how to make conservation agriculture equipment ferent issues, and they complement each other. The result is generally considerably better than if the extension staff or farmers are trained separately. It is quicker to pinpoint mistakes and correct them when working together.

Training on conservation agriculture is also needed in schools and universities. This means revising the curriculum and designing new courses for schoolchildren, agriculture students and trainee extension agents.

Extension

The government extension system provides essential advice to farmers on a wide range of topics. Extension staff should understand and appreciate conservation agriculture, so they can support and promote it where appropriate. This understanding is also important so they do not discourage farmers or contradict the efforts of people promoting conservation agriculture. So extension agents should learn about conservation agriculture as part of their regular training.

Agents should promote conservation agriculture in their normal extension work with farmers. They can do this in many ways. As with all types of extension work, practical demonstrations in farmers' fields are better than "chalk-and-talk" in the classroom or village meeting room. The agents can help organize farmer field schools – which are ideal opportunity for the agents themselves to learn about the potential and intricacies of conservation agriculture. They can also organize visits by farmer groups to farmers who are already practising conservation agriculture, arrange for demonstrations of equipment such as rippers and weed wipers, and facilitate supplies of seeds, herbicides and other inputs that farmers may need.

Participatory extension approaches are important to reach farmers effectively. These approaches enable everyone involved to work together: farmers, extension agents, local leaders, etc. These people can analyse their needs, problems and opportunities. They can decide on their priorities, and explore possible solutions to the problems. They can draw on their own knowledge and skills, and add new ideas from outside. This strengthens their ability to solve other problems they may face.

Demonstrations

Demonstrations are a valuable way for farmers to see a new technology for themselves before they are ready to take the risk of trying it. Demonstrations are best done on farmers' fields, rather than on land owned by the extension agency or research institute. It is important to select the right farmer cooperators to demonstrate the technologies. They should be progressive and well-respected in the community. Try to find someone who is already using many of the components of conservation agriculture – for example, certified seed, fertilizer and herbicides. This farmer will not have to make too many changes to introduce other components of conservation agriculture, so may be more willing to try them, and the demonstration is more likely to be a success. Avoid absentee farmers or weekend farmers, as they will not have the efficient day-to-day management skills on the farm to ensure success.

To start a demonstration programme in a village, select a few farmer cooperators to work with. They should farm near each other so they can visit each others' fields easily – perhaps every 2 weeks. Since they live in the same village, they can discuss the ins and outs of conservation agriculture easily, and can reassure and learn from one another. A group of 5–8 farmers attracts more attention from others than if only one or two farmers are testing the technology. The extension agent can focus effort in this village, rather than trying to cover too wide an area. If the agent has only one demonstration a season, he or she may take several years to learn from the mistakes made.

The members of a farmer field school (see below) may welcome the opportunity of hosting demonstrations.

When first introducing conservation agriculture, choose villages that are easily accessible. This makes supervision easier, allows more people to come to see the demonstrations, and makes it easy for input suppliers to deliver what the farmers need on time. Once the community has adopted the approach on a wide scale, the agent can move on to neighbouring areas – inviting farmers there to visit successful conservation agriculture fields in the initial village.

Farmer field schools

A farmer field school is a partnership between farmers and extension personnel, and perhaps the private sector and researchers. It consists of a group of up to 25 farmers who have identified a problem and agree to meet with a facilitator to discover solutions to it. The farmers meet regularly – perhaps every one or two weeks – throughout the cropping season, in their own fields. They learn by doing: they observe what is happening in the fields, analyse and prioritize problems, discuss and implement possible solutions, and evaluate the results.

People remember 20% of what they hear, 40% of what they see, and 80% of what they discover themselves

Farmer field schools in western Kenya

The first delicate lilac blossoms of water hyacinth spelled disaster for the fisherfolk of Kusa in western Kenya. The aquatic weed had invaded the Nyando District shore of Lake Victoria, choking their fishing grounds. The fishers were forced to start farming to earn a living.

But their problems did not end there. The rain is unreliable, and erosion is severe. AIDS has taken a heavy toll on the younger generation, causing a shortage of labour.

In search of solutions, RELMA (the Regional Land Management Unit, now part of ICRAF) sponsored 20 farmers to go on a study tour in a neighbouring district. There, they learned about conservation agriculture, and they decided to form a group to use these methods on their own land. The farmer field school approach offered an attractive, affordable way for them to learn and test the new practices.

In 2003, the first year, an agronomist from the Kenya Agricultural Research Institute (KARI) branch in Kisii guided ten field-school groups. Each group had about 20 members. Each group selected a "model farmer" to host the main demonstrations and to take responsibility for guiding the other farmers. The model farmers learned how to use the Magoye ripper and tested two cover crops, lablab and mucuna, on small plots.

They tested five different conservation agriculture practices and adapted them to the local conditions. They liked using planting basins for growing fodder crops such as Napier and bana grass.

Training in the general principles of farmer field schools put the Kusa farmers at the centre of the learning process. This essential step was followed with on-farm trials to test intercropping or relay planting of the new cover crops with maize, residue management, and minimum tillage.

The farmer groups also worked with Ministry of Agriculture extension staff to test new varieties of maize and beans. The field schools made the extension officers' work easier because it allowed them to try the new varieties in a structured setting.

The farmer field schools cost outside agencies fairly little. Their main inputs were transport for the senior trainer from KARI, seed for cover crops, and four Magoye ripper/subsoilers imported from Zambia.

There was not enough cover crop seed in the first year. One model farmer, Mr Owalla, harvested enough lablab seed to sell (at KSh 50 per kg) at least two kilograms of seed to each of the other members of his group. Farmers have now planted at least 50 acres to lablab, so there is plenty of seed to go round.

There are still challenges with promoting this approach. There is no source of Magoye rippers in Kenya. Local welders in Kusa tried to make them, but could not find the high quality steel needed.

A strong local organization is needed to organize such field schools. In this case, the Kusa Community Development Society performed this role, but such organizations do not exist everywhere.

But perhaps the main challenge to scaling up the use of conservation agriculture in places like Kusa is the lack of skilled, experienced facilitators like the one from KARI. His ability to motivate and train farmers is based on several years of work with the farmer field school approach, coupled with a strong knowledge of conservation agriculture practices.

More information: John Odingo

The emphasis is on farmers discovering answers rather than listening to lectures by an extensionist or researcher. The farmers learn by themselves and from each other.

Farmer field schools are an ideal venue to introduce a new approach such as conservation agriculture. The farmers can see and test a new technology before adopting it. The field schools can draw on the skills and knowledge of outsiders, such as researchers and technical advisers. These can advise on how to solve specific problems. The field schools are also ideal for doing research to adapt conservation agriculture techniques to suit local conditions.

The field schools can be combined with other approaches to extension. For example, the facilitator may arrange for the field school members to visit a research institute or farmers in a neighbouring district, and to host their own groups of visitors. The group's experimental plots make ideal locations for demonstrations.

Farmer champions

It is usually possible to find several farmers in an area who have tested and developed some sort of conservation agriculture on their own, however incomplete. Other farmers may be eager to try conservation agriculture: they like to keep improving their farm, and they have heard about conservation agriculture somehow.

From drug dealer to champion and trainer

By the time he reached his 30s, Molahlei was a dubious character. He would grow marijuana on his farm in Lesotho, and sell it over the border in South Africa. But in 2003 he was introduced to conservation agriculture. He saw its dramatic potential to increase his yield and income. He soon became a farmer champion in his area. His harvests rose by an amazing 1000%.

Molahlei is now an executive member of his community's conservation agriculture committee. He cannot give you a long CV of academic qualifications… but when he works with a group of farmers, you realize this is one of the best farmers you will ever meet. He is proud of being a farmer.

Molahlei and other farmers have put a series of comic skits together to convey the ideas of conservation agriculture. The skits are hilarious: the audience rolls on the floor with laughter. When they have loosened up the audience in this way, Molahlei and his friends start to teach them practical things.

This is one example of a farmer who became a champion, and who is training people far more effectively than his own teacher did.

More information: August Basson

These farmers are a precious resource for conservation agriculture programmes. They are highly motivated, and may have already adapted conservation agriculture principles to local conditions. They can be excellent partners for extension agents and researchers to develop further options. Many farmers are happy to share their experiences with fellow farmers.

These farmers can become champions of conservation agriculture in their communities. They can become magnificent trainers and motivators, through their enthusiasm and success. They also have the unique ability to convince politicians and policy makers about the value of this approach.

Extension agencies and conservation agriculture programmes should help these farmer champions develop links with other farmer champions, and with farmer organizations and service organizations. They may need help to experiment further – for example, to obtain inputs or to cover the risk of an experiment failing. They may also need assistance in documenting and sharing their findings with other farmers.

Farmer-to-farmer extension

Extension agents are few and generally overworked. They have to serve large numbers of farmers, cover large areas, and deal with a vast range of topics. Plus, many have only limited direct experience in farming, so farmers naturally view them with some scepticism.

Farmers themselves can make excellent extension workers. They have practical experience and credibility, and with a little support, can train their fellow farmers in conservation agriculture, organize farmer groups, arrange activities such as field visits, facilitate farmer field schools, and so on. Farmer facilitators should not be seen as an alternative to the regular extension service; rather, they complement and reinforce the work of extension staff. Well-motivated farmer champions can make excellent facilitators.

Farmers' organizations

To succeed with conservation agriculture, farmers need to work together. Getting training or credit, buying equipment or seeds, setting up small trials of new techniques, learning – these are all easier in a group. Some things are possible only if people collaborate – banning burning of crop residues, for example, or establishing rules on grazing.

Local institutions such as community organizations or farmer groups may be able to support the introduction of conservation agriculture. Such groups may already exist, even though they may not focus on farming. For example, a community organization may enable credit, health or schooling. But such an institution may be able to add a conservation agriculture focus – perhaps by creating a special committee among interested members. Otherwise, it may be necessary for farmers to create a new organization. Extension agents and development workers can assist them to do this.

Whether old or new, local organizations may need outside help so they can support their members adopt conservation agriculture. They may be able to benefit from technical training, participation in field days and exchange visits, linkages with other groups or institutions, and leadership development.

Schools and churches

Schools and churches can play a key role in promoting conservation agriculture.

Teachers can teach conservation agriculture as part of the regular curriculum, both in the classroom and on the school farm. They can organize agriculture clubs to involve children in growing food for the school.

Churches are also important promoters. An active priest or pastor can inspire an entire congregation to try out conservation agriculture as a way of lifting

Farming God's Way

One church in Lesotho teaches conservation agriculture as "Farming God's Way" – farming alongside nature, and not against it.

The pastor uses questions and answers like these to challenge people to start to think differently about agriculture:

- Who is the best farmer in the whole world? (*Answer:* God.) (*Genesis 2:8*)
- We are made in God's image, therefore we are co-creators with God. (*Genesis 1:27*)
- Would you like to become one of the best farmers in the world?
- If God is the best farmer in the world, we have to learn from Him.
- Have you ever seen God's angels, tractors or animals coming from heaven to plough up the soil?

The pastor invites his congregation to look for the lessons they see in nature, and bring the same principles to their farms:

- Nature does not turn over the soil, so you should not have to either.
- Nature produces a thick blanket of mulch on the ground. Your soil needs such a blanket (cover crop, mulch).
- Nature has a diversity of plants. So rotate crops on your farm.

"Learn from the best farmer in the world", the pastor urges, "and you have the potential to become one of the best farmers in the world."

More information: August Basson

School children promote conservation agriculture

A few banana plants and one teacher's determination have had big results in a school in central Kenya.

Mr Githiomi, an agriculture teacher at Gathunguru primary school, aimed to introduce pupils to intensive farming using the school's 2.5 acre garden. At first he tried several crops using conventional farming methods, but yields declined each year.

Then in 2001, he attended a field day on conservation agriculture organized by Makuyu Divisional Agricultural Office. Mr Githiomi was impressed. He explained conservation agriculture to members of the school's 4K Club (part of a national youth organization). The school's head teacher helped him buy 50 tissue-culture banana suckers from Jomo Kenyatta University of Agriculture and Technology. The club planted them in the school garden, using cover crops and other conservation agriculture principles.

The fruit yield was excellent. Many more children and several teachers joined the club.

The improved soil fertility stimulated the growth of many new banana suckers. Mr Githiomi and the club members gave some suckers to the children to plant in their parent's gardens back home. Some of the teachers and members of the Parent-Teachers Association were also given suckers to plant.

That year, the club added kidney beans, French beans, cowpeas, lablab, green gram and sweet potatoes as cover crops to the banana garden.

The club later decided that parents could take banana suckers but should donate maize grain to the school in return. This maize is milled and used to make school meals. For the first time, the school is able to provide lunches for its pupils.

The head teacher also decided to invite the local extension agent to teach new banana management skills to the teachers and children.

The Gathunguru school is not unique. Similar initiatives in four primary schools in Uganda through a Sida-funded programme called "Farm-level Applied Research Methods Research" also had a tremendous multiplier effect.

themselves out of poverty. Many Africans are very religious. They easily make the link between God, nature and good farming practices. Churches are ideal venues for promoting conservation agriculture. They are closely involved in the community, and have strong networks throughout the country. It is their responsibility to address poverty.

Pastors can draw on various passages of the Bible to support their points. For example, Genesis (*Gen 1:*26) says that God has set us as stewards of creation, and not to destroy it.

Other ways to share experiences

Because conservation agriculture has so many aspects, sharing experiences is important so farmers can continue to learn from one another. But sharing does not happen by itself. It has to be facilitated.

Farmers' organizations in Uganda

Farmers' organizations in Bisheshe sub-county, in Mbarara District, are promoting conservation agriculture. The organizations are organized in a hierarchy, from community level up to parish, to the sub-county, to the district and national levels.

Unlike most hierarchies, this one works from the bottom up. Groups of farmers in each village with the same problems and interests come together as "**common interest groups**". They pool their efforts to find ways of solving their problems. These groups each focus on one of range of topics: trees, livestock, horticulture, and soil and water conservation. Conservation agriculture is one of these topics.

The chairs of the various common interest groups are members of **coordination committees** at the parish and sub-county levels. Other committee members include civic leaders, opinion leaders and extension staff. The committee coordinates activities of the various common interest groups, and links them with service providers, extension agencies, NGOs and community organizations.

The common interest groups inform the parish coordination committee of their production problems and training needs. The committee then develops a parish **action plan** to respond to the various groups' needs. It identifies **community facilitators** (interest-group members who have been trained in the appropriate skills) to provide training. If the facilitators lack the right skills, the committee asks the sub-county committee to find an appropriate service provider.

The interest groups are members of a parish-level **inter-group association**. This association helps mobilize resources for savings-and-credit schemes and marketing. The associations took over the training and supervision of the common interest groups in December 2004, when ULAMP, a donor-funded project supporting them, ended.

More information: Anthony Nyakuni

Here are some ways to encourage and enable people to share:

- **Field days** and **visits to fields** where conservation agriculture is being used or tested.
- **Fairs, shows and competitions** are good ways to attract a lot of attention to conservation agriculture.
- **Exchange visits** and **exposure tours** among distant farmers' groups. These may last several days; the visitors may stay overnight in the host village or nearby.
- **Yearly meetings** of farmer-innovators, community leaders and extension officers. These meetings can present (as posters or orally) experiences and the results of experiments. Inputs such as seeds, products or implements can also be displayed.
- **Videos** can include interviews with farmers, and show various parts of the cropping cycle and farming operations that visitors cannot see during a single visit.
- **Drama** and **songs**, like the comedy skits used by Molahlei and his friends in Lesotho.

- **Question-and-answer sessions** with researchers, extension specialists or farmer champions.
- **Open meetings** (meaning everybody is invited!). These are a good opportunity for farmers, extension agents, researchers and others to share their experiences and motivate local people and technicians about conservation agriculture.
- **Radio and television programmes** can raise awareness about conservation agriculture among farmers, extension agents, development workers and decision makers throughout the country. Local community radio can help spread the news about conservation agriculture and enable farmers to share experiences with other people in the area.

With all these activities, it is important to follow them with concrete activities to make sure the momentum created does not evaporate.

Farming as a business

Conservation agriculture offers farmers an opportunity to see their farms in a new way: as a business. Extension agents and development workers should encourage them to do this.

Conservation agriculture offers this opportunity because it allows farmers to increase their yields, produce more than they need for subsistence, and grow new crops they can sell. It can offer a market and trading orientation, and enables farmers to find a pathway out of poverty.

To be successful, many farmers will need to change not only their attitudes. They will also need new skills – in choosing crops to grow for the market, in sorting, grading and marketing their produce, in post-harvest processing, and so on.

Growing tomatoes as a business

Hopolang is a young farmer in Tebellong, in the mountains of Lesotho. He farms an acre of land that his father gave him. He, his wife and small child live in a small house, measuring only about 4 x 5 m. He has little chance of finding work nearby, and he does not want to leave his family to look for work in the city.

Hopolang does not have much. But he is willing to work. He was introduced to conservation agriculture, and someone gave him some pipes so he could water his land.

He has taken the principles of conservation agriculture a step further than he was taught. He figured that if you can grow maize this way, you can also grow tomatoes. So he planted about 3000 tomato plants, along with other vegetables such as cabbage. In one season alone, he was able to sell $1000 worth of tomatoes.

This young farmer has changed his single acre into a living example that conservation agriculture works, and that it can be a profitable business.

More information: August Basson

They will also need to develop links with traders, transport providers, input suppliers, and so on. They may need to organize themselves into groups to enable them to obtain supplies and services they need at an acceptable price, and to sell their crops in sufficient bulk to get a good price in turn.

Here are some ideas for how farmers can treat their farms as a business:

- **Choose the right crops** Farmers should consider growing high-value crops such as leguminous fodders and vegetables. They might grow a variety of crops to overcome oversupplied seasonal markets.
- **Organize** A group of farmers can organize to buy inputs such as seed and fertilizers in bulk, and save on the purchase price and on transport costs. As a group, they can negotiate for loans with a bank or credit institution. They can store produce and sell it more easily than as individuals – perhaps at a more distant market where prices are better.
- **Get information** Farmers often do not know how much their produce is worth. As a group, it is easier to find and share information about what crops are in demand, where to sell them, and at what price. Groups can also get information about new varieties and new techniques more easily.
- **Add value** Farmers should consider how to add value to their produce. This may mean something as simple as sorting and grading. It may also mean planting at a different time (to avoid the peak harvest time when prices are low), storing the produce until prices recover, arranging packing and transport so perishable produce arrives at the market quickly and in good condition, or processing produce to improve its storability or increase its value.
- **Keep records** Few small-scale farmers keep records of their crops or what they buy and sell. Good records are vital if farmers are to treat their farms as a business. Without records, they cannot tell how much profit they are making, or whether they would make more money by switching crops or adopting a new technology. See Chapter 11 for more.

Multiple stakeholder partnerships

Conservation agriculture is not "business as usual". It requires a number of radical changes in the way farming is done. Farmers must make some of these changes themselves. Others are needed at the community level (for example, organizing groups). Others involve input retailers (to sell herbicides, seeds and equipment), NGOs (to provide training, help with organizational issues, study tours, etc.), credit institutions, government agencies such as extension and research services, etc. And some may even require linking with institutions abroad – for example, to import no-till equipment.

This means the success of conservation agriculture will depend on many different people and organizations. It is important to form partnerships to promote conservation agriculture. Farmers, farmers' organizations and community organizations should, of course, be key actors in these partnerships. They are, after all, the ultimate beneficiaries of efforts to promote conservation agriculture. But they need to make sure that promotional activities respond clearly to their needs, and take into account their situation, knowledge and beliefs.

Extension staff and development workers are also key. They should be involved in almost every conservation agriculture-related activity.

Other stakeholders should work alongside them, depending on the nature of the activity.

Roles of stakeholders

Here are two examples of stakeholder partnerships, highlighting the roles played by each member.

Example 1: Conservation agriculture equipment

- **Farmers** and **extension staff** test the equipment.
- **Researchers** help design the equipment tests, and advise the equipment manufacturers.
- **Manufacturers** and **distributors** attend field days to see how farmers are doing. They discuss the equipment with them, how to use it properly, and check any potential improvements to the design.
- **Credit institutions** provide loans so farmers can buy the equipment.
- **Government services** may need to provide subsidies to enable farmers to buy the equipment.

Example 2: Field days

- **Conservation agriculture farmers** host the field days, describe their experiences and answer questions.
- **Other farmers** who have not yet tried conservation agriculture listen and ask questions.
- **Extension staff** help the hosts get ready for the field day – e.g., by helping them make flip charts. They also help prepare the logistics: transportation, refreshments, taking notes, etc.
- **Researchers** come to learn about conservation agriculture, listen to farmers' experiences, and provide technical information.
- **Community leaders, project personnel** and staff of supporting institutions help mobilize farmers and give a formal character to the field day.
- **Private input retailers** may be invited if products they sell have been used in the fields visited. They may cover expenses such as for signs, stationery and refreshments.
- **Politicians** may be invited to learn about conservation agriculture and the type of support needed from government.

Small-scale entrepreneurs and private business

The success of conservation agriculture depends on the availability of the right equipment (subsoilers, weed wipers, etc.) and inputs (such as herbicides and cover crop seeds). This offers opportunities to manufacturers and input suppliers to make these supplies available.

But there is a "chicken-and-egg" situation: manufacturers and dealers are unwilling to produce or stock equipment and inputs unless they are sure there is a demand for them. At the same time, farmers cannot buy these items if they are not on sale.

Development organizations can help by demonstrating the new techniques to farmers, liaising with manufacturers and dealers, extending credit to suppliers so they can invest in equipment or stocks, and guaranteeing initial orders for equipment (or subsidizing their price) until the demand has been established.

See Chapter 10 for more on input supplies and equipment manufacture.

Policy support

Agricultural policies can do much to promote conservation agriculture. In countries such as Brazil where conservation agriculture has been widely adopted, such policy support was vital.

Agricultural policies should focus on improving access to market, credit and input supplies, and rural infrastructure. They should support the development of farmers' groups. Incentives should encourage diversification and conservation agriculture practices, especially during the transition phase from conventional farming to conservation practices.

Appropriate product pricing can raise productivity per unit land and reduce pressure on marginal regions.

Inadequate policies and subsidies that support conventional practices might discourage farmers from adopting conservation agriculture. Land use and customary rights must also be taken

Secure tenure is important if people are to invest in their land into account. They may have to be adapted to favour conservation agriculture.

Subsidies and other incentives can also support the spread of conservation agriculture. Subsidies may be justified because the government wishes to ensure national food security and prevent erosion and pollution.

Policies must guarantee farmers long-term rights to the land they farm. If they do not have secure tenure, they will not be willing to invest in improvements to the land through conservation agriculture.

Governments must also ensure that extension services and other agencies support and promote conservation agriculture. This may involve:

- Promoting **research** on conservation agriculture.
- Changing the **curricula** in extension training institutes and universities.
- Building conservation agriculture into the **extension programme**.
- Ensuring that the extension service becomes more **farmer-centred** – for example, to encourage collaboration with NGOs and facilitate farmer field schools.

14

Resources

Contributors' profiles

Contributors who attended the writeshop

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Joseph holds a PhD in agricultural engineering from Silsoe College, Cranfield University, UK. He has worked as a researcher in tillage and the adaptation of tools and equipment for over 18 years. He currently promotes conservation agriculture through farm-based research and extension, business, marketing and rural transport.

Joseph Mwalley

Agromechanization Officer, Soil Conservation and Agroforestry Programme (SCAPA), Arusha Regional Coordination Unit

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Mwalley specializes in conservation tillage and agriculture extension. He is currently conservation agriculture coordinator with SCAPA for the Arusha region. He has been involved in conservation agriculture since 1998 in collaboration with RELMA.

Charles Mwanda

Assistant Project Coordinator, Conservation Agriculture for Sustainable Agriculture in Rural Development (CA-SARD), Ministry of Agriculture

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Mwanda holds an MA in business and administration, and a BSc in agricultural engineering. He has worked on development issues for over 25 years, five of them on conservation agriculture. He is experienced on the use of various participatory methodologies in agricultural extension.

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Benson is a freelance publication and web designer. He has been involved in several writeshops with IIRR and its various partners since 2000. He has interests in database design, development and management.

Hottensiah Mwangi

Agronomist and Researcher, Crop Protection Programme, Kenya Agricultural Research Institute/National Agricultural Research Laboratories

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Hottensiah holds an MSc in crop protection from the University of Bristol, UK, and a BSc in agriculture from the University of Nairobi. She has worked for 18 years in KARI as a weed scientist, and for 8 years with the Kenya Conservation Tillage Initiative and farming communities in arid and semi-arid areas. She has extensive experience on conservation agriculture in East, Central and South Africa, as well as in Brazil. She is vice-chair and founder member of Professional Association Women in Agriculture and Environment (KEPAWAE).

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Paul holds a certificate in conservation agriculture from ACT, and a diploma in information technology from Strathmore College, Nairobi. He has 4 years of experience in conservation agriculture and community development work.

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Hamisi holds an MSc in natural resource management from Cranfield University, UK, and a BSc in general agriculture at Sokoine University of Agriculture. He worked as an agricultural extension officer for the Anglican Church of Tanzania for 4 years. His current work with FAO involves coordinating farmer field school programmes in Kenya. He is involved in farmer training and provision of extension services to smallholder farmers, as well as project planning and support.

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Originally from Sweden, Gus has a PhD in plant pathology and has worked as a horticulturist in various countries since 1944. He specializes in nursery crops and dryland farming.

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Elijah trained as a graphic designer and has worked as a development artist with several organizations, including the Intermediate Technology Development Group, ActionAid, ABANTU, KHRC, and the International Institute of Rural Reconstruction. He has also worked with the schoolbook publishers Macmillan and Kenya Literature Bureau.

Rahab Njoroge

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Rahab has 15 years of facilitation, training and management experience in business and development. She has been Principal of SATTC College in Mahe, Seychelles, and coordinator of the ActionAid-Kenya Inter-Development Centre in Kisumu. She holds a BSc in business management from Florida International University, a diploma in sales and marketing, and an advanced certificate in adult learning.

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Anne holds a bachelor's degree in chemical engineering and an MSc in industrial engineering from the State University of New York, Buffalo. She has worked for 15 years in food research and development in a government/ private-sector institute. For the past 5 years she has been working with the National Community Development and Land Tenure Programme.

Qureish Noordin

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Noordin has an MPhil in tropical forest soils. He has 12 years of experience in community-based extension services and participatory approaches. He is currently working with ICRAF as a development facilitator specializing in partnerships and scaling up.

Anthony Nyakuni

Extension Advisor, National Agricultural Advisory Services (NAADS) Secretariat

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Nyakuni holds a bachelor's in agriculture and has extensive field experience in soil and water management, agroforestry, sustainable land management and participatory extension approaches. Since 2003 he has facilitated the integration of land management issues into NAADS. He has written books on extension approaches and land resources.

Paul Nyende

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Paul holds an MSc in soil science and a BSc in agriculture. He has previously worked with the International Centre for Tropical Agriculture as a research associate in Uganda and as a programme coordinator with the Africa 2000 Network. He is now a consultant on land management for a project piloting conservation agriculture in Uganda.

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Odhiambo holds a BSc in agricultural economics from Egerton University. He worked as a volunteer team leader for the Kenya Youth Foundation in charge of agriculture, food security and sustainable natural resource management, then joined the Kenya Freedom from Hunger Council as development officer for food security, water and sanitation. In February 2005 he became executive director of the National School Feeding Council of Kenya.

Okech John Odingo

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Okech is a retired education officer. He has worked with many development projects and is a member of various voluntary organizations. He takes a keen interest in farming initiatives.

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Odogola holds an MSc in agricultural engineering from the Agricultural Mechanization and Electrification University, Rousse, Bulgaria. He has 30 years of experience as a lecturer and researcher on agricultural engineering with the National Agricultural Research Organisation (NARO) of Uganda. He has worked with projects funded by the Ugandan government, the World Bank, SIDA, DFID and other donors. Besides specializing in farm power and mechanization, he has 8 years of experience in post-harvest and rural energy systems, and in water for agricultural production. He has been involved in conservation agriculture since 2000.

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Alex holds as MSc in water and environmental resources engineering from the UNESCO-IHE Institute of Water Education in Delft, Netherlands. As a research technologist with the Swedish Agency for Research Co-operation with Developing Countries (SAREC), he was in charge of the Steepland Research Station and the Soil and Water Laboratories of the Department of Agricultural Engineering, University of Nairobi between 1990 and 1998. He also served as a soil and water conservation officer with the Ministry of Agriculture, Machakos District, Kenya, from 1984 to 1990.

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Aileen holds an MA in communication. Before joining the World Agroforestry Centre, she worked as a public relations officer and as a communications specialist with IIRR.

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Artist

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Alfred is a freelance artist. He has worked for EPZ (Ancheneyer), and has developed story books for Ribena and Panadol. He is currently working with Cover Concept Ltd. as an illustrator, as well as with IIRR. He does fine art, paintings, murals, portraits, book illustrations and comics.

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Kennedy has been promoting conservation agriculture in western Kenya since 1995. He learned farmer field school and conservation agriculture methods with FAO and FITCA(K). He has promoted conservation agriculture as a volunteer and has worked with various community organizations on food security and the environment. He is currently studying indigenous practices and cover crops.

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Marietha works with SARI on on-farm socio-economics and agronomy research. She is also assistant national facilitator on conservation agriculture for sustainable development with an FAO-supported project covering 30 farmer field schools in Tanzania.

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Motipi studied theology at the Morija Seminary of the Lesotho Evangelical Church. He has been pastoring at Tsoelike Lesotho Evangelical Church for the last 7 years. He has been practising conservation agriculture for 3 years with support from FAO.

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Cecilia has an MSc in urban planning from Columbia University, New York, and a Fil kand in cultural geography and political science from Stockholm University. She has been involved in international environment research and development cooperation since 1971. Her work with the Stockholm Environmental Institute focuses on policy development for sustainability, and especially on ecological sanitation.

Brian Sims

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Brian has 30 years of experience of smallholder farm mechanization development, especially in Latin America. He has focused on needs assessment, participatory technology development, on-farm testing and evaluation, and communal manufacture and distribution. He is now using his experience to enhance conservation agriculture technology in sub-Saharan Africa.

Kurt Steiner

Independent Consultant in Land Management

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Kurt has worked on agricultural research in Africa since 1970, first in plant pathology and then plant breeding. Since 1980, he has worked on smallholder farming systems, promoting intercropping in West and East Africa. He has introduced on-farm experimentation in research and development projects in various countries. He has promoted sustainable soil management and conservation tillage throughout the continent. He is co-founder of the African Conservation Tillage Network.

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Gelson holds a PhD in agricultural economics and statistics from Oklahoma State University and a bachelor of agricultural sciences from the University of Zambia. He has worked for the Dutch-funded Farming Systems Research Team-Western Province project, and as an agricultural economist for the Zambian government. He has conducted research on economics in Zambia and the USA, and has been involved in various regional and international missions, including for the United Nations, NEPAD, FAO and the African Conservation Tillage Network. He is currently part of a team of designing a collaborative masters programme in agricultural and applied economics, involving 16 African universities.

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Bernard is an agronomist with 20 years' experience in farming and cropping systems research. During the past 15 years he has been combining his interest in participatory approaches with sustainable agriculture, conservation agriculture and cover crops, with direct field experience in Latin America, and more recently in Africa.

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Bob earned his MSc in dryland natural resource management with the Institute for Desert Research, University of Beersheba, Israel. As regional coordinator for the Arid Lands Information Network (1993 to 1999), he produced the well-known *Baobab* magazine. Since then, he has worked as a freelance writer and editor for several international organizations, with a focus on documenting sustainable natural resource management projects and practices.

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Resource organizations and websites

Africa-wide

Africa Conservation Tillage (ACT) Network

Zimbabwe office: No. 9 Balmoral Road, Borrowdale, Harare, Zimbabwe. Tel. +263 4 882107, fax +263 4 885596, email actnetwork@africaonline.co.zw, internet www.act.org.zw. Contact: Martin Bwalya, Coordinator

Kenya office: PO Box 14733 00800, Westlands, Nairobi, Kenya. Email actnairobi@wananchi.com

Promotes and facilitates sharing of information and experiences on conservation farming principles and practices in Africa.

Animal Traction Network for Eastern and Southern Africa (ATNESA)

www.atnesa.org

Access to over 700 documents, many of relevance to conservation agriculture.

CropLife Africa Middle East

www.croplifeafrica.org

Represents manufacturers and distributors of crop protection products (pesticides), seeds and biotechnology products in Africa and the Middle East.

Ecoport

http://ecoport.org

An important database for conservation agriculture practitioners and others.

Green Water Harvesting Network

Contact: Maimbo Malesu, m.malesu@cgiar.org

Eastern and Southern Africa and South Asia.

Regional Land Management Unit (RELMA in ICRAF)

World Agroforestry Centre, ICRAF House, UN Avenue, PO Box 30677, Nairobi 00100, Kenya. Tel. +254 20 524400, 524418, fax +254 20 524401, 524001, email relma@cgiar.org, internet www.relma.org

Supports small-scale farm production management (including conservation agriculture), capacity building, information and documentation, gender, environmental concerns, poverty reduction and efforts to combat HIV/AIDS.

Winrock International

ONFARM, BP E 457, Bamako, Mali. Tel. +223 293880, fax +223 292281, email nhanssens@winrock-mali.org, internet www.winrock.org. Contact: Neils Hanssens, West Africa Coordinator

Conservation Tillage Project (Senegal, Mali and Cote d'Ivoire); On-Farm Agriculture Resources Management (ONFARM) Program

Burkina Faso

Institut de l'environnement et de recherches agricoles (INERA)

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Cameroon

Bimbia Bonadikombo Natural Resource Management Council (BBNRMC)

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Cotton Development Company (SODECOTON)

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Soil conservation and water harvesting project monitored by Sodecoton and implementing field activities, training on soil conservation, water harvesting and implementation of conservation agriculture.

Institute of Agricultural Research for Development (IRAD)

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National research institute which works on conservation agriculture.

Chad

Institut Tchadien de Recherche Agronomique pour le Développement (ITRAD)

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Mekelle University

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Adaptation of maresha ploughs.

Ghana

Ministry of Food and Agriculture, Crop Services Directorate

PO Box M 37, Accra, Ghana. Tel. +233 21 665066, email cropserv@ghana.com Contact: J.K. Poku

Conservation agriculture included in work programme.

Guinea

Centre de Recherches Agronomique de Bordo (CRAB)

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Kenya

Consortium for Scaling up Options for Increased Farm Productivity in Western Kenya (COSOFAP)

PO Box 25199, Kisumu, Kenya. Tel. +254 057 351163/64, fax +254 057 2021234, email icrafksm@cgiar.org, internet www.ugunja.org/cosofap/

Training and provision of starter seeds for cover crops and fertilizer trees.

International Maize and Wheat Improvement Centre (CIMMYT)

PO Box 1041-00621, Village Market, Nairobi Kenya. Tel. +254 20 7224600/05, fax +254 20 7224601, internet www.cimmyt.org. Contact: Fred Kanampiu, fkanampiu@cgiar.org

The project "Conservation agriculture promotion in smallholder agriculture" is implemented in Zimbabwe, Zambia, Malawi and Tanzania. It promotes farmer-to-farmer adoption of proven conservation agriculture technologies and practices.

Kenya Agriculture Research Institute (KARI)

PO Box 57811, Nairobi, Kenya. Tel. +254 2 583301–20, email jwwamuongo@kari.org. Contact: Jane Wamuongo or Joseph Mutua

Operating within the Kenya Conservation Tillage Initiative (KCTI) in Kenya's subtropical and semi-arid environments.

Kenya Network for Draught Animal Technology (KENDAT)

PO Box 2859, 00200, City Square, Nairobi, Kenya. Tel./fax+254 20 6766939, email kendat@africaonline.co.ke, internet www.atnesa.org/kendat/ Contact: Pascal Kaumbutho

Partner (with the Ministry of Agriculture, RELMA, KARI, and the University of Nairobi) in the Kenya Conservation Tillage Initiative. Pilot trials of conservation agriculture, training of farmers and animals, training in handling equipment, field-days, key-stakeholder exposure and media campaigns, and manufacture and marketing of conservation tillage equipment.

Kenya Youth Foundation

PO Box 1894,00200 Nairobi, Kenya. Tel. +254 20 550278, email kyf3@hotmail.com, kenya@youthlink.org. Contact: Bernard Luta

Rural Youth Livelihood Programme in Nyando District, Nyanza Province, involves training of youths on sustainable agriculture, income generation, and support services to the agricultural sector in Nyando.

National School Feeding Council of Kenya

PO Box 49772 00100, Nairobi, Kenya. Tel. +254 20 608960, email nsfck@yahoo.com

Community-based school feeding programme involves training and facilitating schools and communities around them to produce food towards school feeding, implemented in Maragwa, Bondo and Thika districts. Conservation agriculture components introduced in Maragwa District.

Triple W Engineering Ltd.

PO Box 176, Naro Moru 10105, Kenya. Tel. +254 62 62255, fax +254 62 62272. Contact: T.B. Muckle, muckle@africaonline.co.ke

Design and development of hand/animal-drawn conservation agriculture equipment for oxen, donkeys and camels. All equipment can be made by artisans with simple facilities using locally available raw materials. Training of artisans, production of manuals, and design of light equipment suitable for women and young people.

Madagascar

Groupement Semis Direct Madagascar

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South Africa

Agricultural Resource Consultants

PO Box 3474, Parklands 2121, South Africa. Tel. +27 486 2254, +27 486 2274, email agrecon@pixie.co.za. Contact: Jim Findlay

Expertise in conservation agriculture throughout Africa, and in registration and legislation of crop protection products.

Department of Agriculture, Western Cape

Tel. +27 21 808 5340, fax +27 21 808 5370, email andrer@elsenburg.com. Contact: Andre Roux

Agricultural research, advisory services and planter modification, especially for farmers who grow wheat and vegetables using conservation agriculture in Western Cape.

Grain Crops Institute

Agricultural Research Council of South Africa (ARC-GCI), Private Bag X 9029, Pietermaritzburg 3200, South Africa. Tel. +27 33 3559410, fax +27 33 3559518, email rmfowler@iafrica.com. Contact: Richard Fowler

Promotion and advice on adoption of conservation agriculture in southern Africa.

Institute for Soil, Climate & Water

Agricultural Research Council of South Africa (ARC-ISCW), Pretoria, Gauteng Province, South Africa. Tel. +27 12 310 2500, fax +27 12 323 1157, email DjBeukes@arc.agric.za or Hjsmith@arc.agric.za. Contact: Danie Beukes or Hendrik Smith

Research and advice on principles and practices of conservation agriculture and the establishment of action research-based conservation agriculture projects, especially among small-scale and emerging farmers.

Small Grains Institute

Agricultural Research Council of South Africa (ARC-SGI), Bethlehem, Free State Province, South Africa. Tel. +27 58 307 3400, fax +27 58 307 3519, email KilianW@arc.agric.za or TolmayJ@arc.agric.za. Contact: Willem Killian or John Tolmay

Research and advice on practice of conservation agriculture, especially by dryland wheat farmers.

No-Till Club of KwaZulu-Natal

PO Box 1052, Howick 3290, South Africa. Tel. +27 33 239 1807, fax +27 33 330 6981, email robin.d@absamail.co.za. Contact: Robin Denny

Farmers in eastern South Africa who meet regularly with one another, universities, researchers, advisers and manufacturers to promote conservation agriculture.

Tanzania

Agricultural Research Institute Uyole

PO Box 400, Mbeya, Tanzania. Tel. +255 25 2510062, 2510363, fax +255 25 2510065, email uyole@ud.co.tz, internet www.drd.mafs.go.tz. Contact: Saidi Mkomwa, Team Leader

Seed supply and advisory services (pests, diseases and management) of cover crops. Training services on conservation agriculture equipment and practices.

Ministry of Agriculture and Food Security

PO Box 4192, Dar-es-Salaam, Tanzania. Tel. +255 22 2862003, +255 744 373395, fax +255 22 2862077, 2862003. Contact: R.M. Shetto, Assistant Director, mshetto@yahoo.co.uk

Technical training services for farmers, farmer-farmer trainers and extension agents in mechanization, including conservation agriculture. Facilitation of mechanization input supply through policy adjustments, credit guarantees for farmers, stockists and manufacturers. Networking of stakeholders and dissemination of information on conservation agriculture and general agricultural mechanization.

Selian Agricultural Research Institute (SARI)

PO Box 6024, Arusha, Tanzania. Tel. +255 27250 3883, fax +255 27 250 3971, mobile +255 748 403921, email wlmariki@sari.co.tz, wlmariki@yahoo.com, internet www.drd.mafs.go.tz/northern.htm. Contact: Ali Bwana or Wilfred Mariki (CA-SARD Facilitator)

Cover crop seed supply and advisory services (pests diseases and management) of cover crops. Training and advice on conservation agriculture equipment and practices; advice on extension methodologies such as farmer field schools and farmer-to-farmer exchange visits.

Uganda

Agricultural Engineering and Applied Technology Research Institute

PO Box 7144, Kampala, Uganda. Tel. +256 41 566161, +256 77 220010, email aeatri@starcom.co.ug

Research and adaptation of conservation agriculture, with focus on conservation agriculture equipment. Training on conservation agriculture for farmers, extensionists and rural artisans. Links with private sector manufacturers and academia.

National Agricultural Advisory Services (NAADS)

NAADS Secretariat, Plot 39A, Lumumba Avenue, PO Box 25235, Kampala, Uganda. Tel. +256 41 345065, +256 77874126, fax +256 41 347843

National Agricultural Research Organization (NARO)

PO Box 295, Entebbe, Uganda. Tel. +256 041 320512

Coordination of research on conservation agriculture, including cover crops, tools and implements, soil and water management and fertility issues.

Zambia

Agriculture Support Programme (ASP)

PO Box 510091, Chipata, Zambia. Tel. +260 62 21284, 21379, email scafe@zamnet.zm, scafeast@zamnet.zm. Contact: R.K. Shula

Conservation Farming Unit, Zambia National Farmers Union

PO Box 30395, Lusaka, Zambia. Tel. +260 1 210112, 264781, 265455, fax +260 1 264781, Contact: Dutch Gibson, email gibcoll@zamnet.zm

The conservation farming unit has been developing and promoting the adoption of the conservation tillage and conservation agriculture technologies with small scale farmers through training; publication of materials to be used, trials and field days.

Golden Valley Agriculture Research Trust

PO Box 50834, Lusaka, Zambia. Tel. +260 1 265455, fax +260 1 264781, email paagaard@zamnet.zm. Contact: Peter Aagaard,

Research trials on conservation farming and conservation agriculture.

Zimbabwe

Agricultural Research and Extension Services (AREX)

PO Box 8117, Causeway, Harare, Zimbabwe. Tel. +263 4 707311/794601, fax. +263 4 730525

Research and extension services on a national scale. Previously known as AGRITEX.

University of Zimbabwe

Dept. of Soil Science, PO Box MP 167, Mount Pleasant, Harare, Zimbabwe. Tel. +263 4 339191, email chuma@africaonline.co.zw, Contact: Edward Chuma

Outside Africa

Alternative Farming Systems Information Center

www.nal.usda.gov/afsic/

Provides access to information on alternative cropping systems, including conservation agriculture.

Confederation of American Associations for the Production of Sustainable Agriculture (CAAPAS)

Email sdrob@idi.com.ar, internet www.caapas.org. Contact: Roberto A. Peiretti, President

Center for Cover Crops Information and Seed Exchange in Africa (CIEPCA)

http://ppathw3.cals.cornell.edu/mba_project/CIEPCA/home.html

Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

TA 74/09, Avenue Agropolis, 34398 Montpellier Cedex 5, France. Email agroeco@cirad.fr, internet http://agroecologie.cirad.fr (French), http://agroecologie.cirad.fr/index.php?rubrique=accueil&langue=en (English). Contact: Christine Casino

For Eastern and Southern Africa: c/o ICRAF, UN Avenue, Gigiri, PO Box 30677-00100, Nairobi, Kenya. Tel. +254 20 722 46 52. Contact: Denis Depommier, denis.depommier@cgiar.org

For West Africa: 5, Av. Kennedy, 01 BP 596, Ouagadougou, Burkina Faso. Tel. +226 50 30 70 70. Contact: Jacques Pages, Jacques.pages@cirad.fr

Development of conservation agriculture-based cropping systems and rotations. Environmental and socioeconomic impact of conservation agriculture systems. Participatory innovation development. Case studies on conservation agriculture adaptation and adoption. Training of researchers and extension officers. Partnerships with donors, national institutions and private sector to develop and implement pilot conservation agriculture projects and programmes.

Cornell University-CIIFAD

http://mulch.mannlib.cornell.edu/CAwebsite/

Useful information and resources related to conservation agriculture.

Cover Crops International Clearinghouse (CIDICCO)

http://cidicco.hn/newcidiccoenglish/

CropLife International

143 Avenue Louise, B-1050 Brussels, Belgium. Tel. +32 2 542 04 10, fax +32 2 542 04 19, email croplife@croplife.org, internet www.croplife.org

Global federation representing the plant science industry. It represents a network of regional and national associations in over 90 countries and is led by companies such as BASF, Bayer CropScience, Dow AgroSciences, DuPont, FMC, Monsanto, Sumitomo and Syngenta.

European Conservation Agriculture Federation (ECAF)

CIFA Alameda del Obispo, Avda Menéndez Pidal, s/n, Apdo 3092, 14080 Córdoba, Spain. Tel./fax +34 957 760797, email conservation.agriculture@ecaf.org, internet www.ecaf.org

Federação Brasileira de Plantio Direto na Palha

Rua 7 de Setembro, 800 - sala – 201, CEP 84.010-350, Ponta Grossa, Paraná, Brazil. Tel./fax +55 42 223 9107, email febrapdp@uol.com.br, internet www.febrapdp.org.br

Food and Agriculture Organization of the United Nations (FAO)

Farm Power and Equipment Group, Conservation Agriculture, Viale Delle Terme di Caracalla, Rome 00100, Italy. Tel. +39 06 57053334, 57052612, email agst-mail@fao.org, internet www.fao.org/ag/ags/subjects/en/farmpower, www.fao.org/ag/ags/AGSE/Main.htm.

Intensifying crop production with conservation agriculture, www.fao.org/ag/ags/AGSE/agse_e/general/CONT1.htm

Land and water development division, www.fao.org/ag/agl/agll/prtcons.stm

Supports and promotes conservation agriculture worldwide. FAO's "Telefood programme" provides small grants to farmers groups that could be used for cover crop seeds or implements for conservation agriculture. For more information, contact your FAO country office.

German Agency for Technical Cooperation (GTZ)

PO Box 5180, 65726 Eschborn, Germany. Tel. +49 6196 790, internet, www.gtz.de/conservation-tillage

Agriculture sector support and food security programmes.

Land Resources Management, World Bank

http://lnweb18.worldbank.org/ESSD/ardext.nsf/11ByDocName/TopicsLandResourcesManagement

LEISA

PO Box 64, 3830 AB Leusden, Netherlands. Email ileia@ileia.nl, website www.leisa.info

Magazine on low external input and sustainable agriculture

LEXSYS: Legume Expert SYStem

www.iita.org/research/lexsys.htm.

Cover crop database has information on legumes, agroecological zones, plant characteristics, etc.

World Congress on Conservation Agriculture

First World Congress (Madrid, 2001): www.ecaf.org/Congress/Latest_news.htm

Second World Congress (Iguaçu, Brazil, 2003): www.febrapdp.org.br/event.htm

Third World Congress (Nairobi, 2005): www.act.org.zw/congress/index.htm

Major international conference on conservation agriculture, held every 2 years. Papers available online.

World Overview of Conservation Approaches and Technologies (WOCAT)

www.wocat.net, email wocat@giub.unibe.ch

Database on soil and water conservation, including examples of conservation agriculture.

Equipment manufacturers

Many of these manufacturers also provide training and advice on conservation agriculture equipment

Brazil

See also www.fao.org/ag/AGS/agse/planters.htm

Fitarelli Máquinas Agrícolas Ltda.

Rua Etelvino Pes. 30, Bairro Industrial, Aratiba, RS, CEP 9970-000, Brazil. Tel./fax +55 54 376 1198, email fitarelli@fitarelli.com.br, internet www.fitarelli.com.br

IADEL Máquinas e Implementos Ltda

Rua Dona Ana 883, Centro Dona Emma, Santa Catarina, CEP 89155-000, Brazil. Fax +55 47 364 042

Indústria Knapik

Rua Pref. Alfredo Metzler, 480, Bairro Santa Rosa CEP 89400-000, Brazil. Tel. +55 42 522 1819, fax 42 522 2789, email knapik@knapik.com.br, internet www.knapik.com.br

Jahnel Indústria e Comércio de Implementos Agrícolas Ltda.

Rua Benjamin Constant 636, Cuna Porã, Santa Catarina, CEP 89890-000, Brazil. Tel. +55 49 646 0587, email jahnel@cpnet.com.br

Máquinas Agrícolas Jacto SA

Rua Dr. Luiz Miranda 1650, PO Box 35, 17580-000 Pompéia, SP, Brazil. Tel. +55 14 3405 2100, fax + 55 14 3452 1306, email jacto@jacto.com.br, internet www.jacto.com.br

Knapsack sprayers adapted to hand-pulled machines.

Triton Máquinas Agrícolas Ltda

Rua Dois Irmãos 263, Centro, Caixa Postal 31, CEP 89.609-000, Luzerna, Santa Catarina, Brazil. Tel./fax +55 49 523 1144, email triton@tritonmaquinas.com.br, internet www.tritonmaquinas.com.br

Kenya

Lolli

PO Box 63514-00619, Outer Ring Road, next to Hardi, Nairobi, Kenya. Tel +254 20 860782, 802060, fax +254 20 860260

Sametract

Bambur Road, Industrial Area, Nairobi. Tel. +254 20 533081, 533446, 537019, fax +254 20 551475

Techno Plast

Nairobi. Tel. +254 20 551771

Triple W Engineering Ltd

PO Box 176, Naro Moru 10105, Kenya. Tel. +254 62 62255, fax +254 62 62272. Contact: T.B. Muckle, muckle@africaonline.co.ke

See description under *Resource organizations and websites*

South Africa

Afritrac Ltd

South Africa. Tel. +27 11 918 5983 fax +27 11 918 0310, email mike@afritrac.co.za, internet www.afritrac.co.za. Contact: Mike McMaster

Manufacturers and distributors of "Mealie Brand" animal and tractor-drawn planters and other equipment suited for use by small scale conservation agriculture farmers.

Northmec/CSE

PO Box 851, Isando 1600, South Africa. Tel. +27 11 974 2501, 82 896 5236, fax +27 11 392 2889, email stefs@northmec.co.za, internet www.cse.co.za. Contact: Steph Strydom

South African representatives of Case, Baldan, Fitarelli, Jacto and other locally manufactured and imported agricultural machinery for conservation agriculture farmers, large and small.

Tanzania

Nandra Engineering Works

Nguvu Kazi Area, Sukari Road, PO Box 304, Moshi, Tanzania. Tel. +255 27 51542, fax +255 27 50575, email nandra@eoltz.com. Contact: Frank Alfred Lesiriam (Managing Director)

Animal-drawn rippers and subsoilers, spare parts for rippers and tractors, piloting the manufacture of hand jab-planters and no-tillage equipment. Also maize mills, hullers, grain storage tanks, cookers, water tanks.

SEAZ Agricultural Equipment Ltd

PO Box 2607, Mbeya, Tanzania. Tel. +255 744 399599, fax +255 25 2502121, email seaz@yahoo.co.uk. ontact: Vasimbile Sinde

Uganda

Soroti Agricultural Implements and Machinery Manufacturing Company (SAIMMCO)

Cementry Road, Soroti, Uganda. Tel. +256 45 61361, fax +256 45 61361, email saimmco.soroti@alam-group.com, internet www.alam-group.com/saimmco.html

Manufactures tools and implements for agricultural production and processing. Particularly strong in the manufacture of draft animal power implements. Participated in the field introduction of conservation agriculture in Uganda, and makes implements such as including rippers, subsoilers, no-till planter and manually operated sprayers.

Zambia

Zamwipe

c/o Fedex, Nangwenya Road, Rhodes Park, Lusaka, Zambia, or PO Box 44, Fringilla, Lusaka, Zambia. Tel. +260 1 264281, +260 1 230112, email zamwipe@zamnet.zm, gibcoll@zamnet.zm. Contact: Dutch Gibson

Zimbabwe

Mealie Brand

39 Steelworks Road, Steeldale, PO Box 1059, Bulawayo, Zimbabwe. Tel. +263 9 887989, 880667 or 71363/4/5, fax 71365. General information: mdsec@zimplow.co.zw, sales: sales@zimplow.co.zw, internet www.zimplow.co.zw

Hastt

PO Box 2356, Harare, Zimbabwe. Tel. +263 4 620321–7, fax +263 4 620371. Enquiries: enquiries@hastt.co.zw, sales: sales@hastt.co.zw, internet www.hastt.co.zw

Equipment development, manufacture and supply for conservation agriculture. Manufactures and supplies rippers and planters for minimum and zero tillage. Product range covers tractor-mounted, animal-drawn and hand-operated equipment.

Resource materials

The following websites have a wide range of information and downloadable documents on conservation agriculture. See the *Organizations and websites* section above for more information:

ACT, www.act.org.zw

ATNESA, www.atnesa.org

CIRAD, http://agroecologie.cirad.fr

FAO, www.fao.org/ag/ags/AGSE/Main.htm

GTZ, www.gtz.de/conservation-tillage

Relma in ICRAF, www.relma.org

CD-ROMs

CropLife International. 2004. *Conservation technologies for sustainable agriculture.* CD-ROM. CropLife International, Brussels. Obtainable from Keith Jones, keith@croplife.org

Presentations from a workshop at the 2004 International Weed Science Congress in South Africa. Presentations from FAO, the World Bank, the Kenya Agricultural Research Institute, the International Crops Research Institute for the Semi-Arid Tropics; Sasakawa Global 2000, as well as Bayer CropScience, Monsanto, Dow AgroSciences, and several others.

FAO. 2004. *Conservation of natural resources for sustainable agriculture: training modules.* Land and Water Digital Media Series no. 27, FAO, Rome.

CD-ROM with training materials. Introduction to conservation agriculture; modules on soil, agronomy, mechanization, pest control, economics, etc.). Useful for training.

Publications

African Conservation Tillage Network. *Information series.* www.act.org.zw/infoseries.html

Series covers various aspects of conservation agriculture.

Ashburner, J., T. Friedrich and J. Benites. 2002. Opportunities and constraints for conservation agriculture in Africa. *LEISA* 18(3):13–14.

Bishop-Sambrook, C., J. Kienzle, W. Mariki, M. Owenya and F. Ribeiro. 2004. *Conservation agriculture as a labour saving practice for vulnerable households.* Study report. IFAD and FAO, Rome, Italy. 80 pp. www.fao.org/ag/ags/programmes/en/enhance/FAO_IFAD_CA_Tanzania.pdf

Study of reduced tillage practices and cover crops for households under labour stress in Babati and Karatu Districts in Northern Tanzania.

Buckles, D. , A. Etèka, O. Osiname, M. Galiba and N. Galiano (eds). 1998. *Cover crops in West Africa: Contributing to sustainable agriculture/Plantes de couverture en Afrique de l'Ouest: Une contribution à l'agriculture durable.* International Development Research Centre, International Institute of Tropical Agriculture and Sasakawa Global 2000. http://web.idrc.ca/en/ev-9393-201-1-DO_TOPIC.html

Calegari, A., J. Ashburner, and R. Fowler. 2005. *Conservation agriculture in Africa.* ISBN 9988-627-04-1. FAO, Rome, Italy. 98p. (in press)

CIDICCO, IITA, and Judson College. 2002. *Food and feed from mucuna: Current uses and the way forward. Proceedings of an international workshop.* CIDICCO (International Cover Crops Clearinghouse), CIEPCA (Center for Information and Seed Exchange in Africa)-IITA (International Institute of Tropical Agriculture), and World Hunger Research

Center, Judson College. www.cidicco.hn/newcidiccoenglish/food_and_feed_from_mucuna.htm

Conservation Farming Unit. 1997. *Conservation farming handbook for small holders in Regions I & II*. Conservation Farming Unit, FAO, Lusaka. www.fao.org/ag/AGS/AGSE/agse_e/3ero/cases1c.htm

Critchley, W., K. Siegert and C. Chapman. 1991. *Water harvesting techniques: A manual for the design and construction of water harvesting schemes for plant production*. FAO, Rome. www.fao.org/docrep/U3160E/u3160e07.htm

CropLife International. 2005 (forthcoming). *Conservation technologies and the plant science industry: Managing natural resources sustainably*. CropLife International, Brussels.

Case studies from around the world showing how the plant science industry is increasing its emphasis on conservation technologies. Draft at www.croplife.org/conservationtech

Dobson, H., G. Matthews, T. Wiles, and P. Baleguel Nkot. 2004. *Pesticide safety and application equipment, sprayer operator pocket book*. FAO, Rome.

Training and reference pocket book, available in English, French and Spanish.

Dobson, H., G. Matthews, T. Wiles, and P. Baleguel Nkot. 2004. *Hints on pesticide use, Hints on spraying, calibration of LK sprayers*. Set of three posters. Yaounde Inititative, FAO, Rome.

Posters with pictograms and simple text to assist in sprayer training. Useful for sprayer training and as a reminder for participants.

Ekboir, J., K. Boa, and A.A. Dankyi. 2002. Impact of no-till technologies in Ghana. *Economic Program Paper* 02-01, CIMMYT, Mexico DF.

Case study of conservation agriculture in Ghana.

Erenstein, O. 2003. Smallholder conservation farming in the tropics and sub-tropics: A guide to the development and dissemination of mulching with crop residues and cover crops. *Agriculture, Ecosystems and Environment* 100:17–37.

Good academic synthesis of conservation agriculture.

FAO. 2000. Manual on integrated soil management and conservation practices. *FAO Land and Water Bulletin* 8, FAO, Rome.

FAO. 2001. Conservation agriculture: Case studies in Latin America and Africa. *FAO Soils Bulletin* 78. ISBN 92-5-104625-5. FAO, Rome. 69p.

FAO. 2004. *Pesticide safety and application equipment: Sprayer operator pocket book*. Agricultural and Food Engineering Technology Service, FAO, Rome.

Groupement Semis Direct Madagascar. Undated. *Le semis direct sur couverture végétale permanente: Enjeux et potential pour une agriculture durable à Madagascar*. Groupement Semis Direct Madagascar, Antananarivo.

Haggblade, S. and G.. Tembo. 2003. Conservation farming in Zambia. IFPRI and MSU, *EPTD discussion paper* 108, Washington DC.

Case study of conservation agriculture in Zambia.

Hercilio de Freitas, V. 2000. Soil management and conservation for small farms: Strategies and methods of introduction, technologies and equipment. Experiences from the State of Santa Catarina, Brazil. *FAO Soils Bulletin* 77, FAO, Rome.

Jonsson, L.-O., E. Mawenya and J. Rockström. Conservation tillage I: Management practices for animal-drawn systems in Tanzania, *Working Paper* 16. RELMA, 2003.

Jonsson, L-O. Conservation tillage II: Handling and care of drought animals under Tanzanian conditions, *Working Paper* 17. RELMA, 2003.

Landers, J. 2001. Zero tillage development in tropical Brazil: The story of a successful NGO activity. *FAO Agricultural Services Bulletin* 147. ISBN 92-5-104672-7. FAO, Rome. 144p.

Liniger, H.P., and W. Critchley (forthcoming 2005). Local responses to global land degradation: Exchange of knowledge for Sustainable Land Management Centre for

Development and Environment (CDE), United Nations Environment Programme (UNEP).

Global overview book with over 30 case studies.

Ministry of Agriculture and Cooperatives. 2000. *Tanzania soil fertility initiative*. Ministry of Agriculture and Cooperatives, Tanzania.

Discussion on soil fertility and related policy issues.

Mutunga, K., and W. Critchley. 2001. *Farmers' initiatives in land husbandry*. Regional Land Management Unit (RELMA), Nairobi.

Farmers' innovations in sustainable agriculture.

Naudin, K., and B. Oumarou. 2002–04. *Raports de synthese campagne*. ESA/ SODECOTON, Garoua Cameroun. Annual report of activities.

Pieri, C., G. Evers, J. Landers, P. O'Connell, and E. Terry. 2002. No-till farming for sustainable rural development. *Agriculture & Rural Development Paper*, IBRD, Washington, DC. 65p.

Pieri, C., G. Evers, J. Landers, P. O'Connell, and E. Terry. 2002. A road map from conventional to no-till farming. *Agriculture & Rural Development Paper*, IBRD, Washington, DC. 20p.

Seguy, L., S. Bouzinac, and A.C. Maronezzi. 2001. *Systèmes de culture et dynamique de la matière organique*. CIRAD-CA, Agronorte Pesquisas, Groupe Maeda, ONG TAFA/ FOFIFA/ANAE. http://agroecologie.cirad.fr/pdf/dosscv.pdf

Shaxson, F. 1999. New concepts and approaches to land management in the tropics with emphasis on steeplands. *FAO Soils Bulletin* 75. ISBN 92-5-104318-1. FAO, Rome. 125p.

Shaxson, F. and R. Barber. 2003. Optimizing soil moisture for plant production: The significance of soil porosity. *FAO Soils Bulletin* 79, FAO, Rome.

Thomas, D. 1997. *Soil and water conservation manual for Kenya*. Ministry of Agriculture, Nairobi.

Technical manual on soil and water conservation.

Van der Merwe, G.M.E., R.O. Barnard, and D.J. Pretorius. 2004. *Overview of conservation approaches and technologies in South Africa*. Department of Agriculture and Agricultural Research Council, Pretoria.

ZNFU. 2003. *Conservation farming in Zambia*. ISBN 9982-52-005-9. ZNFU, Lusaka, Zambia. 46p.

ZNFU CFU. 2002. *Defeating weeds with the Zamwipe*. Zambia National Farmers' Union, Conservation Farming Unit, Lusaka.

How to use the Zamwipe weed wiper to control weeds.

Videos

Critchley, W. 1991. *Looking after our land*. International Institute for Environment and Development, Oxford and London. Book and video comparing soil and water conservation in West and East Africa.

Monsanto Central Africa Inc. *Growing together: Conservation tillage in Africa*. Video on how partnerships are providing solutions needed to empower small-scale farmer.

Photographs

Planting basins (Chapter 3)

1 *Farmer with newly dug planting basins*
August Basson

2 *Digging planting basins using hoes and strings*
August Basson

3 *A former drug-dealer and his field of maize – grown with conservation agriculture*
August Basson

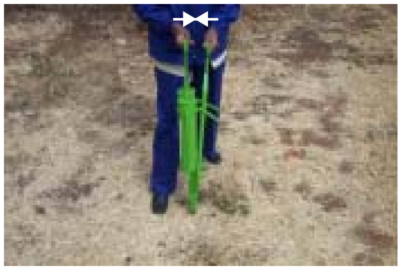
Jab planters (Chapter 3)

4 *A jab-planter with two containers: for seed and for fertilizer*
HASTT, Zimbabwe

5 *Farmers testing jab-planters to plant through mulch*
John Ashburner

6a *Spread handles to feed the seed*

6b *Jab downwards to make a hole*



6c *Squeeze handles to release the seed*

6d *Lift planter so soil falls onto the seed and covers it*

6 *How to use a jab planter*
HASTT, Zimbabwe

Rippers and planters (Chapter 3)

7 Simple ripper-planter pulled by two donkeys. Design by Triple W Engineering.
Barney Muckle

8 Oxen-pulled ripper-planter. Design by Triple W Engineering/ KARI.
Barney Muckle

9 The back wheels on this Hastt ripper–planter control how much seed and fertilizer are applied. The strakes on the wheels prevent the wheels from skidding.
Hastt, Zimbabwe

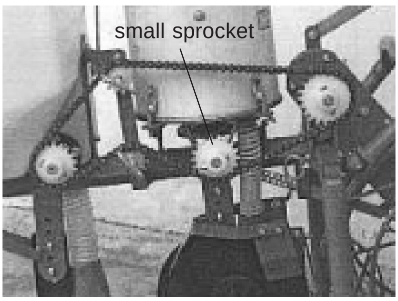
10 A 1.5 m yoke for ripping and planting, giving a row spacing of 75 cm
Brian Sims

11 Testing a Fitarelli No. 12 direct planter and fertilizer distributor
Josef Kienzle

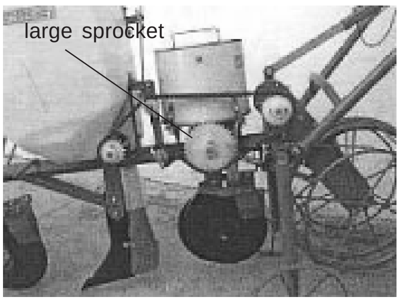
__12__ Fitarelli (Brazil) 3-row tractor-mounted direct planter
Brian Sims

__13__ Triton direct planter
Brian Sims

__14__ Knapik direct planter
Brian Sims



__15__ Knapik planter as supplied by the factory, with a small sprocket. This will give a higher seed rate.
Knapik



__16__ Knapik planter with a large sprocket. This will give a low seed rate.
Knapik

Keeping the soil healthy (Chapter 4)

17 *A South African farmer holds two pieces of soil. The soil on the left is sick because of the way it has been managed. On the right is the same soil, but managed under conservation agriculture.*
Telmo Almado

18 *The taproot of this plant could not push through the hardpan, so it bent sideways instead. Bent taproots like this are a sign of a hardpan.*
Gye Evers

19 *A heavy storm carrying away yet more of Lesotho's precious topsoil, carving a gully as it does so*
August Basson

Soil cover (Chapter 5)

20 Ugandan farmer mulching bananas
William Critchley

21 Canavalia ensiformis, Madagascar
Oumarou Balarabe

22 Tephrosia candida (12 months)
Anja Boye

23 Brachiaria planted after sorghum
Oumarou Balarabe

24 Crotalaria grahamiana flowers
Anja Boye

25 Crotalaria grahamiana, western Kenya (4 months)
Anja Boye

26 Maize intercropped with lablab in Tanzania
Josef Kienzle

27 Lablab, western Kenya
Anja Boye

Controlling weeds (Chapter 7)

28 Using a billhook (nyengo) to control weeds in Tanzania

29 Tractor-drawn knife roller for crushing weeds, crop residues and cover crops before planting
Josef Kienzle

30 An animal-drawn knife-roller, turned upside-down so it can be transported
Brian Sims

31 *Zamwipe herbicide applicator*
Brian Sims

32 *Jahnel hand-pulled 4-nozzle sprayer*
Brian Sims

33 *Knapik hand-pulled 6-nozzle sprayer*
Brian Sims

34 *Triton draught animal-pulled sprayer with an 80 litre tank and a 5 m boom*
Brian Sims