Agroecology, best practices

GUIDE

2010 Edition

20 YEARS OF LEARNING IN ANGOLA - BRAZIL - CAMBODIA - GABON
HAITI - INDIA - LAOS - MADAGASCAR - MOROCCO - MAURITANIA
NIGER - DR CONGO - SAO TOME AND PRINCIPE - SENEGAL - SRI LANKA

AGRISUD INTERNATIONAL

Agrisud, enterprising against poverty

As an international solidarity association, Agrisud has been promoting economic development in the South since 1992.

Its purpose: lifting populations out of poverty into economic and social self-reliance by creating sustainable Very Small family farming Enterprises (VSEs), strongly rooted on the local markets.

These VSEs create jobs and generate income. They satisfy local market needs and reduce food imports.

In 2010, Agrisud represents:

- → **an operational presence in 14 countries in Africa, Asia, South America**
- → **165 employees,6 in France, 159 in the field**
- → **29 operational partners in the North and South**
- → **37 development programs underway**
- → **€4.8 million committed to these programs**
- → **2 training sessions for NGOs managing programs focused on VSEs, agro-ecological practices**

Since 1992, Agrisud has also represented:

- → **27,500 VSEs created including 3,350 in 2009**
- → **100,000 sustainable jobs including 12,000 in 2009**
- → **155,000 tons of food produced in 2009**
- → **€32 million net income generated in 2009**
- → **2,300 tons of carbon sequestered in 2009**
- → **90 NGO partnerships formed including 22 in 2009**
- → **250,000 people lifted out of poverty including 31,600 in 2009**

Organizations associated with Agrisud's agroecology promotion scheme:

AADC (Angola), ABIO (Brazil), AGRIDEV (Democratic Republic of the Congo), AGRICAM (Cambodia), AGRIDEL (Niger), AMADESE (Madagascar), AVAPAS (Burkina Faso), CARE Madagascar (Madagascar), CARI (France), CAVTK (Democratic Republic of the Congo), CIRAD (France), Colibri (France), CPAS Diembering (Senegal), CRAFOD (Democratic Republic of the Congo), CTHA (Madagascar), EAN (Niger), France Volontaires (France), HARC (India), JAPPOO Développement (Senegal), Jardins d'Afrique (Senegal), IGAD (Gabon), Intelligence Verte (France), ORMVA Ouarzazate (Marocco), PAFO Luang Prabang (Lao People's Democratic Republic), RAIL (Niger), SYDIP (Democratic Republic of the Congo), Terre et Humanisme Maroc (Marocco), Terre et Humanisme France (France), Vétérimed (Haïti).

All the practices collected in this guide are the result of Agrisud's experience, alongside farmers, on the various sites where it is present.

All illustrative photos have been taken on those sites.

This guide may also be downloaded free of charge in e-book format from the www.agrisud.org web site

Editorial

For nearly 20 years, Agrisud has been committed to combating poverty and ensuring food security for impoverished populations in numerous African, Asian, and South American countries.

Our response is to support these populations creating very small, sustainable Very Small family farming Enterprises, strongly rooted on the local markets. These VSEs generate income, jobs, and local added value while satisfying market needs: local products for local markets.

"Enterprising against poverty," summarizes our scheme responsible for creating 27,500 VSEs, i.e. more than 100,000 jobs, in a dozen countries.

This scheme is based, among other things, on in-depth knowledge of the markets, a professionalization program, and assisting entrepreneurs in their activities. While the goal pursued by Agrisud is primarily social, the scheme is deliberately economic using the market economy's levers. Jacques Baratier, our founder, set forth this basis for Agrisud.

This scheme is also ecological, based on common sense, providing for reconciling development with decreased pressure on the environment and sustainably managing natural resources. We have been learning this path since Agrisud's creation, but it was under the impetus of our chair, Robert Lion, that we have become increasingly attentive to our actions' ecological aspects and the need to limit the negative effects of Man's interactions with his surroundings. Which is why we place our emphasis on agroecology.

We wish to establish this agroecology as an alternative to classic farming schemes, favouring sustainable family models, attentive to respecting the environment, with high economic performance, promoting human development concerned with food security and public health. Over time, we have become practioners of agroecology. It makes our actions attentive to economic, social, and environmental aspects. This systemic approach provides for preserving the often fragile balances between Man and his environment, while ensuring economic and social continuity for his activities. In so doing, it can effectively contribute to the planet's food issues with regards to both quantity and quality.

We are convinced, as Pierre Rabhi expressed in his preface, that agroecology has its place between traditional production, insufficiently effective, and modern, expensive, and unsustainable practices for developing countries.

Similarly, as Olivier de Schutter says, we are convinced that agroecology and the right to food are destined to converge and, eventually, create a natural alliance to better guarantee food security on the long-term. Like him, we do not accept that, faced with this food challenge, agroecology is not more broadly disseminated and that it is not at the top of countries' agricultural programs as they attempt to boost their agriculture.

This is why, on the strength of our experience in contact with farmers, we have decided that it was time to collect the fruits of our long agroecology learning process in order to share, firstly with all our teams in the field and the farmers they supervise, but also with our partners and with all those who would like to take advantage of this experience to achieve the same goals.

Nearly two years of work have been required to identify and format these best practices. Each country's teams have been asked for feedback about their own in-the-field experience. However, in this experience, the merit falls in particular to a "hard core" composed of Sylvain Berton, Elphège Ghestem, Ivonig Caillaud, and Leïla Berton. Iden studio has provided the graphics. Bravo to this team!

We would like to thank the Caisse des Dépôts, Veolia Environnement, and Club Méditerranée for having actively supported us in this initiative.

We are happy to offer you this "Agroecology, best pratices" guide in the form of a collection of Leaflets. These Leaflets broach the "basics" of agroecology, then describe the primary farming systems and agroecological practices associated with it. These practices are presented from an economic, social, and environmental point of view.

This collection is not exhaustive. By nature, it is open-ended and will be supplemented by new Leaflets on other themes such as livestock, that have only been lightly touched on in this first edition. It will be sourced with contributions from the field and the dialogue it creates.

This guide is freely accessible as an e-book on Agrisud's site www.agrisud.org, along with a discussion forum where readers can comment and enrich our work. This work is also available in French.

In order to facilitate the transfer of this know-how in the field, pedagogical tools have been developed based on this guide's content. They provide for conducting practical training sessions on-site for field technicians, farmers, and partner NGOs.

Through this exercise, Agrisud does not lay claim to an agroecological label for all its field work: we still have much to do and it will take much patience and pedagogy. In the same vein, we make no scientific claims: the only validation comes from farmers with whom we have tested these practices over time.

Enjoy the read and we look forward to seeing you soon on the forums!

Yvonnick Huet
Managing Director
Agrisud International

Olivier De Schutter's Preface

Agroecology consists of farmers seeking to mimic nature in their fields. It involves the complementarities between various plants and animals. It bets on ecosystems' capacity for integration. It recognizes the inherent complexity of natural systems. It rewards intelligence and inventiveness, where industrial agriculture claims to breakdown nature into its component elements and simplify farmers' tasks, even if that means making them monotonouse. It conceives of agriculture not as a process transforming agricultural production inputs (fertilizer and pesticide), but more as a cycle where the waste produced serves as an input, where the animals and plants serve to fertilize the soil, and where even weeds perform useful functions.

And above all, agroecology is a way of meetings this century's challenges. Consider some basic facts. Agriculture accounts for 33% of human-originated greenhouse gas emissions, nearly half of which – 14% – results from unsustainable farming practices, particularly using chemical fertilizer, a source of nitrous oxide, one of the most powerful greenhouse gases. In sixty years, the farming industry's energy efficiency has been divided by twenty: according to the United States Department of Agriculture, in 1940 one calorie of fossil fuel was required to produce 2.3 food calories; in 2000 10 fossil fuel calories were needed to produce one calorie of food. Currently, industrialized agriculture is rapidly destroying the ecosystems on which it depends and it has developed dependence on energy sources destined to become increasingly rare and whose future prices will be both more volatile and higher.

In contrast, agroecology is a source of resilience, both on the regional or national level and for individual households. Africa, where a new "Green Revolution" is being attempted, imports 90% of its chemical fertilizers, and an even higher proportion of the minerals destined to fertilizing soils: this is a fragile basis for claiming to build food security. Like countries, small farmers who depend on costly inputs for their production are not protected from economic shocks that could result in brutal price increases. On the contrary, where biopesticides and organic fertilizers are produced locally – using compost or manure, or plants that can capture nitrogen and fertilize soils – production costs drop and net income increases, sometimes spectacularly.

So, how is it that agroecology is not more broadly disseminated? What is the reason it is not at the top of countries' agricultural programs as they attempt to boost their agriculture? There are several reasons for its slow uptake by governments who have not yet made' it a priority in their action. Some mental blockages, no doubt: the conviction, strongly anchored in a certain conception of what agricultural "modernization" means, that progress necessarily requires more inputs and extensive irrigation and mechanization, on the model of the 1960s Green Revolution. Also there is the resistance of certain circles, in particular among input producers, who see a promising market escaping them with the large-scale deployment of agroecological practices.

Lastly, certain agroecological practices are labour-intensive: they are much easier to implement on small plots where the farmer is connected to the land, where s/he is investing for the long term. Agroecology opposes the idea that progress necessarily implies increasing labour productivity, i.e. producing more with less work and more capital. How can we not see that we urgently need to develop rural employment and that we need to improve the productivity not of men and women but especially of the natural resources that are quickly running out?

Yet, there is still another thing. Agroecology is not only labour-intensive, it is also knowledge-intensive: it supposes knowledge transfer; it is based on dialogue between farmers; it sets them up as experts – instead of best practices coming from laboratories, it is sourced in field experiments. In this, agroecology is a source of emancipation for farmers: instead of receiving advice, they become coactors. The relationship between knowledge-holders and its users are re-balanced, with farmers on both sides of the equation. In countries where the exclusion of farmers from political decision-making constituted, for years, one of the major causes of underinvestment in agriculture and, moreover, agricultural policy choices that sacrificed both social equity and environmental sustainability, agroecology has powerful subversive effects.

For all these reasons, agroecology and the right to food are destined to converge and, eventually, establish a natural alliance: because it can reinforce the most marginal farmers' ability to feed themselves; because it can best guarantee food security on the long term; and because it reinforces the place farmers have in the agriculture production system for which they have too often become simple agents – for all these reasons, agroecology is an instrument serving human rights to adequate food sources, i.e. the right for everyone to adequately feed themselves. I hail the publication of this guide as a major contribution to the struggle in favour of more just and sustainable agriculture and food systems.

Olivier De Schutter
United Nations Special Rapporteur
on the Right to Food

Pierre Rabhi's Preface

Today, citizens in wealthy countries find it impossible to imagine a global food crisis. The over-abundance of food they use and abuse has placed them in a situation of nearly indestructible food security. There is nothing more banal than "grub" – accounting for barely 13% of household budgets in so-called developed countries...

However, this security is illusory since food is subject to ceaseless transportation and transfers. The discontinuation of such transfers would highlight the incapacity of these populations to fulfil, with the resources of their various living spaces, their vital needs autonomously.

Moreover, this food is the result of a production model essentially based on synthetic chemistry, using pesticides harmful to natural environments as well as human and animal health. This has been highlighted by scientists whose ethics transcend the compromises and numerous falsifications engendered by a society that makes finance the supreme good.

As for the so-called developing countries, the volume of food required to maintain their existence continues to diminish as a result, among other factors, of a rationale that motivated them to produce for exportation, based on costly inputs – with their production being subject to arbitrary and implacable international market forces.

For this reason, and many others, modern agriculture subsidized by wealth countries, supposedly to eradicate the planet's food shortages, tragically aggravated them. In the context of a world in political, economic, geopolitical, ecological, energy, and human crisis the food issue cannot, without risking a considerable social disaster, continue to be treated as a subsidiary issue. With the absolute preponderance it represents for each of us without the slightest exception, food constitutes the most decisive issue for the continuation of our history. Compared to the food crisis already present, and constantly increasing, the financial crisis will be remembered as an anecdote.

Currently, it can be said that all the parameters regarding the food issue are negative: soil destroyed by erosion, ill-considered deforestation, agroeconomic practices detrimental to their biological vitality, polluted, unhealthy water, 60% of humanity's seed heritage established over 10,000 years has already been lost to hybrids and the imposition of GMOs, the disappearance and abandon of food-producing land by peasants in favour of unproductive urban concentration generating poverty, using deforested land for fuel production, the disappearance of bees and other insects required for pollination, etc.

Moreover, this objectively verifiable scenario is part of an increasingly unpredictable climate and meteorological risks, as may be seen throughout the world. In addition there are increasing occurrences of internecine violence with devastating effects on food production.

While the rich countries persist in agriculture that cannot produce without destroying, developing countries are facing a dilemma between insufficiently effective traditional production and modern, costly practices that are unsustainable for them, since, to cite only one example, the production of a ton of fertilizer requires two tons of oil, whose price in indexed to the dollar whose value is, in turn, determined by stock market vagaries. Yet today, oil reserves are running inexorably towards depletion. Basing the future of food on this material opens the way for unprecedented discomfitures and impasses.

The agroecology we have been experimenting with since 1962 on our own farm in the rocky soils of southern France and since 1981 in the semi-arid area of Burkina Faso has demonstrated, after rigorous application, its high-performance and pertinence as a universal alternative validated by the poorest peasants[1].

Until proven otherwise, the agroecology whose operational aspects are presented in this guide is the only possible way for the future of food in general – and the future of developing countries in particular. I am grateful to Agrisud for having integrated in its already consequent solidarity program, this agroecological alternative whose pertinence it has noted and that it is working, with us, to propagate in its numerous operational sites.

However, this alliance would have never come to be without the meeting of minds working with the same determination and conviction to improve the conditions of populations left behind by modernity. The January 2008 meeting between Robert Lion, Yvonnick Huet, Dominique Eraud, and myself was decisive. It was the definitive start to a collaboration which has already borne fruit and will, without a doubt, continue to do so more and more.

Pierre Rabhi
Founder of the Colibris movement
and Terre et Humanisme

Photo credit: © Corine Brisbois

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[1] *On this subject read "L'Offrande au crépuscule" published by Harmattan describing and justifying this positive experience – awarded a prize in 1989 by the French Ministry of Agriculture.*

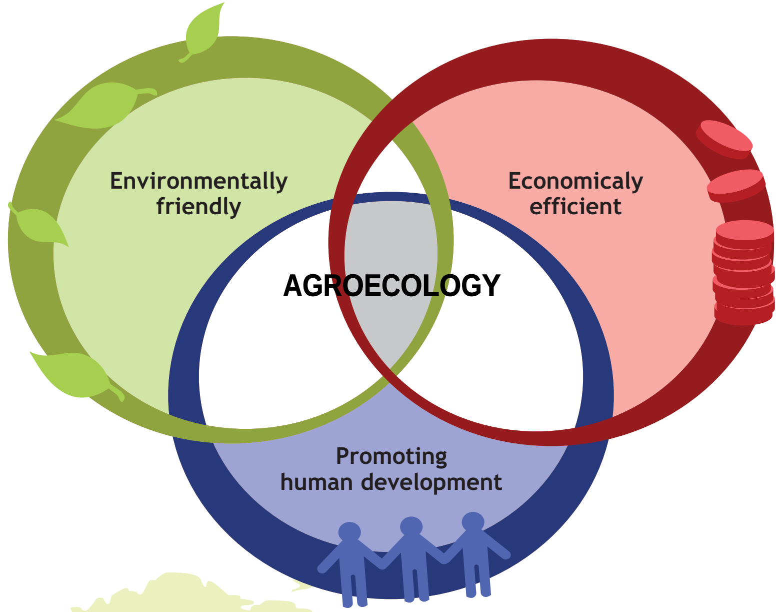
An alternative for sustainable agriculture

Agroecology is the application of ecological principles to the interactions between human beings and their environment, as well as to their consequences, with the goal of minimising the negative effects of certain human activities.

It aims at protecting the environment, ensuring the sustainable renewal of the natural resources (water, soil, biodiversity, etc.) necessary for production, and making sparing use of non-renewable resources. By gradually eliminating the use of chemicals, it strives toward implementing organic farming, thus contributing to improving the health of farmers and consumers alike.

Agroecological practices thus combine technical solutions reconciling productivity, reduced pressure on the environment and the sustainable management of natural resources. All this is a question of ensuring a balance between human beings, farming and nature.

Terms such as 'agroecology', 'conservation farming' and 'ecologically responsible farming' are all used to refer to the promotion of economically viable, environmentally-friendly and sustainable farming, enabling human development and with a particular focus on food security and human health.



Producer, southern Morocco

Vegetables shopkeeper, Sri Lanka

Family, Cambodia

This agroecological approach directs Agrisud's efforts towards farmers in the various countries where it is involved, continuously ensuring that economic, social and environmental aspects are all taken into account.
This systemic approach enables the often fragile balance between people and their environment to be protected.
Agrisud intends to continue along this path to become a a full-fledged ecological actor.

Agroecology: an effective means to combine food security, protecting food systems and economic and social development

Wherever they are and whatever the size of their farm, farmers' foremost concern is to maximise the value of their products' value.

Agroecology is based on a set of farming practices which help to create this value. Farmers generate income to meet their own needs, as well as contributing to food security and better health for their own families and those to whom they supply food. The results can be measured in terms of the nutritional, health and environmental quality of their produce, in addition to how well production potential is preserved.

Agroecology must be implemented in an entire an entire production area: region, lowland, production site, etc. Farmers practising agroecology will have a greater impact on the protection of their farming system provided that their neighbours adopt the same practices.

Even as it maintains balance, agroecology may also aim for a certain degree of intensification In order to effectively contribute to the planet's food challenges.

Summary table of the advantages and drawbacks of agroecological practices

POINT OF VIEW	ADVANTAGES	DRAWBACKS
Environmental	→ Sustainable management of natural resources: soil fertility, water resource and biodiversity → Reduction of the ecological footprint and protection against farming pollution → Fighting against erosion and desertification → Good management of soil types and ecological balance → Reducing pressure on the environment and ecosystems	→ The less immediate effects of certain natural plant protection products compared to artificial chemical products (but advantageous on the medium and long term → Additional space may be required in order to integrate agroecological practices (hedging, cover crops, etc.)
Economic	→ Reducing costs related to the use of artificial chemical inputs and/or certain techniques (soil cultivation, slash and burn, weed control, etc.) → Maximising use of local materials → Possibility of enhancing the value of the products of agroecological practices (better price or purchasing preference) → Durability of the farming production potential and economic activity	→ In some cases, lower yields (offset by lower costs and better long-term fertility management) → Possibly greater labour needs for certain operations → Maximising value of product quality sometimes limited by consumers' purchasing power
Social	→ Improving food safety in terms of quantity and regularity → Improving products' nutritional and taste quality → Better health protection of farmers, their families, and consumers by reducing the use of chemicals → Increased autonomy for producers by reducing dependence on input suppliers → Revenue generated invested in social development (education, health, etc.) → Profitability of know-how and local resources, techniques adaptable to different contexts	→ Necessary changes to traditional or conventional practices requiring willpower and motivation

Guide, user's manual

Guide structure

The guide is established based on farming systems and climate zone, decisive factors in choosing agroecological practices.

Part 1 / Basics: Presentation of the interactions between the various elements (soil, water, plants, animals, and landscape) within a farming system and identifying the major principles regarding managing these elements.

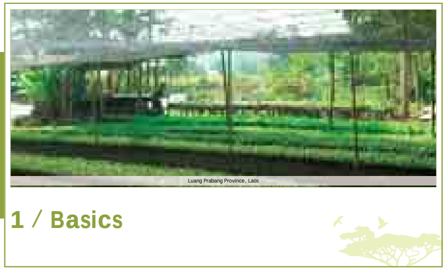
Part 2 / Farming systems: Presentation of the agroecological characteristics of the climate zones and a quick description of the farming systems and production promotion through examples from several countries.

Part 3 / Practices: Description of the principle, implementation methods, and advantages / disadvantages on the technical, economic, and environmental levels for the various practices.

Presented in the form of Leaflets, the guide allows users to adapt their reading to their interests, without necessarily following a linear course.

Part 1 / Basics

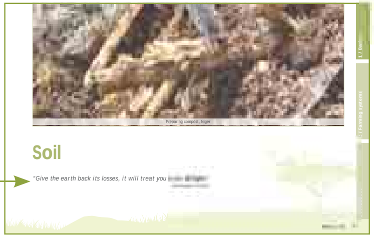
- → 1 Leaflet presenting a general explanatory flowchart of the existing interactions between soil, water, plants, animals, and the landscape within an agro-system;
- → 5 Leaflets each presenting, for one of the 5 elements (soil, water, plants, animals, landscape), the major management principles and associated agriculture practices, the consequences of poor and good agricultural practices and a farmer's testimonial.

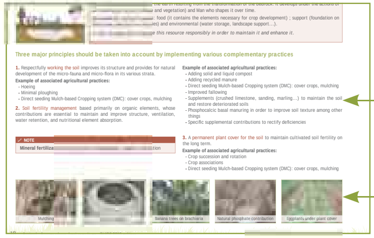

Luang Prabang Province, Laos

1 / Basics

Leaflet detail:

Proverb expressing a key idea related to managing the element

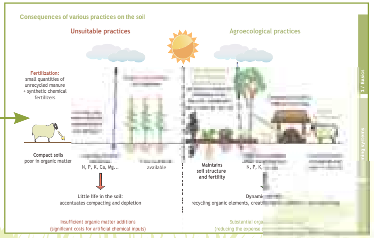


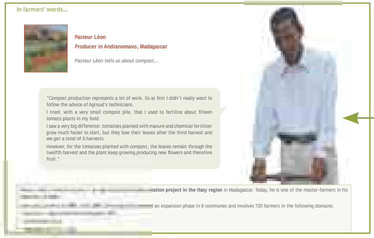


List of the major principles of integrated management of the element

Illustration using agricultural practices

Diagrammatic representation of the consequences of various agricultural practices

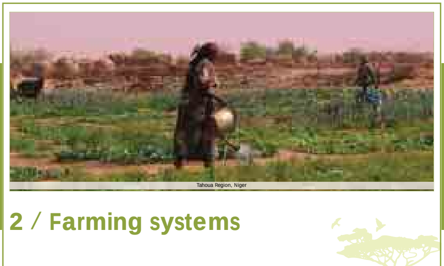




Farmer's Testimonial for a Practice

Part 2 / Farming systems

→ 6 sheets presenting various agroecological contexts and implementing farming activities through country-based examples: Vegetable farming systems in humid areas (Cambodia, Madagascar) and in dry areas (Morocco, Niger); fruit farming systems in humid areas (Cambodia, Sri Lanka) and in dry areas (Morocco, Niger); rainfed food-farming systems (Gabon) and irrigated rice-farming systems (Madagascar); The 6 Leaflets also present the effects of various agroecological practices on the soil, water, plants, and landscape.

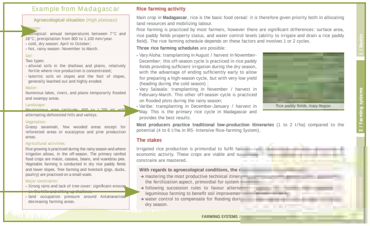


Leaflet detail:

Box presenting the agro-ecological situation

Description of the activity as it is practiced through Agrisud's operations

Identifying the activity's issues according to agro-ecological conditions



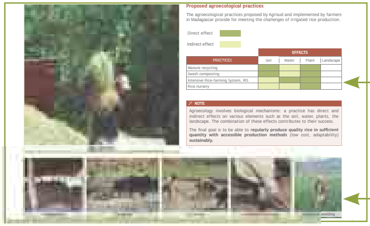


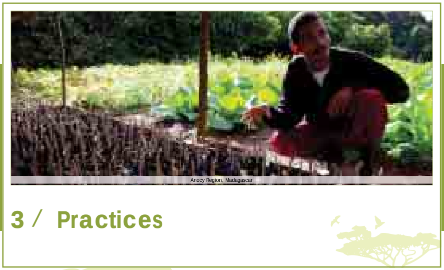
Table of agroecological practices associated with the system in response to identified issues
Presentation of direct and indirect effects of practices on the soil, water, plant, and landscape

Photo illustrations of the practices

Part 3 / Practices

→ 29 Leaflets presenting the principle, implementation methods, and advantages / disadvantages for each practice…

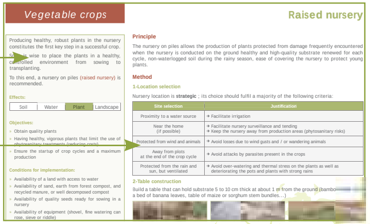
→ … classed under 6 themes: water management (3 sheets); fertilizer production (4 sheets); vegetable farming (10 sheets); fruit farming (3 sheets); food farming (7 sheets) and irrigated rice-farming (2 sheets).

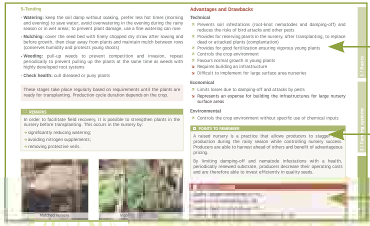


Leaflet detail:

Summary description of the practice, country identification, table of the practice's effects, goals, and implementation conditions

Principle, method (implementation stages illustrated by photos, schematics, tables…)





"Advantages and disadvantages" of the practice on the technical, economic, and environmental levels

"Points to Remember" Summary

"Taking it Further" references to other Leaflets for supplemental information

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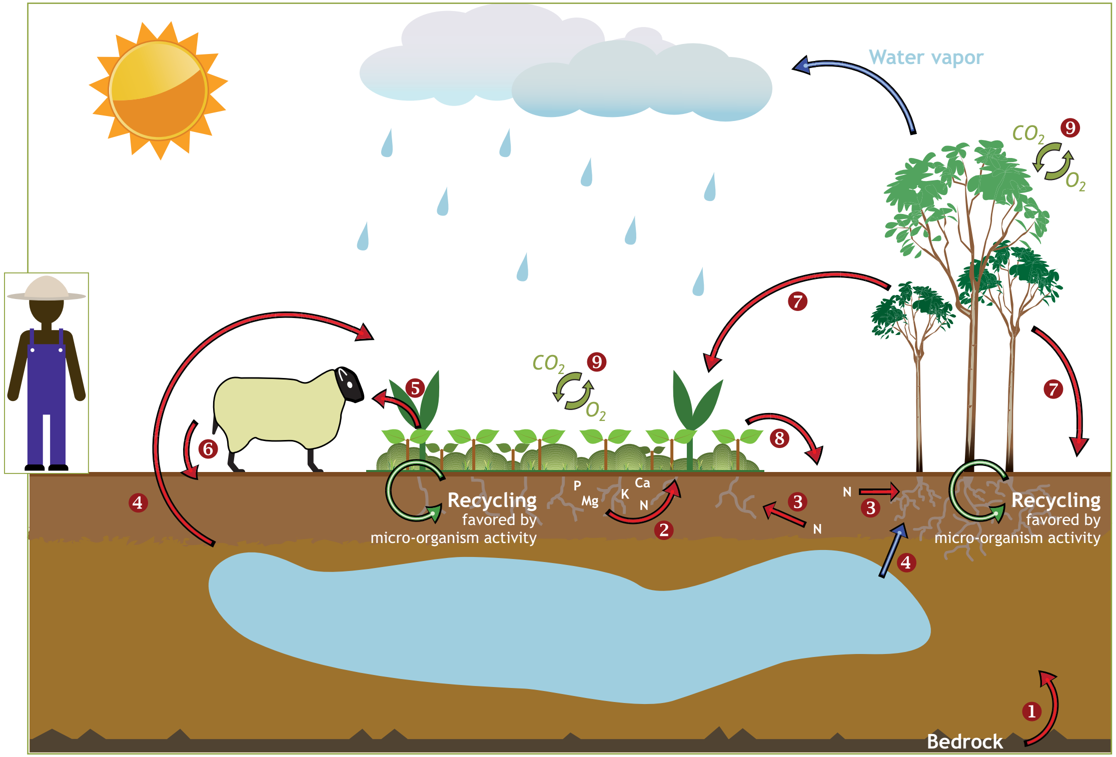
Luang Prabang Province, Laos

1 / Basics

Agricultural system elements and interactions



The Soil, Water, Plants, Animals, and the Landscape are in continuous interaction:

①The soil is the result of altering the bedrock and is fashioned by Man;

②The soil contains nutritional elements required for plant development which assimilates them using water (role of the root system);

③Plants in the leguminous family fix nitrogen in the soil;

④The water in the subsoil provides for irrigating the plants and resources to deep-rooted plants;

⑤Plants feed animals;

⑥Animals provide organic matter (manure): it nourishes the soil which in turn nourishes plants = recycling;

⑦The landscape protects the plant (windbreak) and nourishes the soil (providing biomass) which nourishes plants = recycling;

⑧Plants protect the soil from solar radiation, wind, and strong rain;

⑨Plants, through photosynthesis, absorb carbon dioxide, sequester carbon, and release oxygen into the atmosphere.

Soil that is protected and enriched with organic matter has better water-retention capacity and better capacity for fixing nutritive elements (②)...

An ecosystem is a defined environment in which living beings (animals and plants) **interact** with inert materials in an interdependent relationship to form an ecological unit. When an ecosystem's entire equilibrium is maintained, fauna and flora (micro-, meso-, and macro-fauna and flora) develop complementarily providing for continued system equilibrium (virtuous circle).

An agro-system is a specific ecosystem in which Man intervenes by implementing agricultural production techniques, such as preparing soils for crops (working the soils, adding organic matters), planting and maintaining crops, performing livestock activities, and correct fertilization to compensate for what is taken out of the soil. **Man's intervention must be balanced** and take into account natural mechanisms in order to preserve the balances required to sustainably develop agricultural activity.

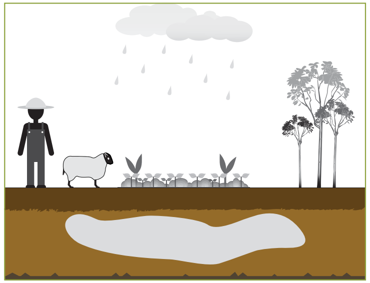
ecology combines technical responses allowing Man to reconcile productivity with low pressure on the environment and sustainable management of natural resources. It takes into account interactions between the soil, water, plants, animals, and the landscape with the goal of integrating the activity into its environment and is based on a certain number of management principles for those elements (see Soil, Water, Plants, Animals, and Landscape Leaflets).

Preparing compost, Niger

Soil

"Give the earth back its losses, it will treat you to its delights"

\- Moroccan Proverb -



Soil, both support and product of life.

Soil represents the top layer of the earth resulting from the transformation of the bedrock. It develops under the actions of environmental factors (climate and vegetation) and Man who shapes it over time.

Soil performs various functions: food (it contains the elements necessary for crop development) ; support (foundation on which Man develops his activities) and environmental (water storage, landscape support…).

→ *So it is essential to manage this resource responsibly in order to maintain it and enhance it.*

Three major principles should be taken into account by implementing various complementary practices

1. Respectfully working the soil improves its structure and provides for natural development of the micro-fauna and micro-flora in its various strata.

Example of associated agricultural practices:

- Hoeing
- Minimal ploughing
- Direct seeding Mulch-based Cropping system (DMC): cover crops, mulching

2. Soil fertility management based primarily on organic elements, whose contributions are essential to maintain and improve structure, ventilation, water retention, and nutritional element absorption.

NOTE

Mineral fertilization may be used to supplement organic fertilization

Example of associated agricultural practices:

- Adding solid and liquid compost
- Adding recycled manure
- Direct seeding Mulch-based Cropping system (DMC): cover crops, mulching
- Improved fallowing
- Supplements (crushed limestone, sanding, marling…) to maintain the soil and restore deteriorated soils
- Phosphocalcic basal manuring in order to improve soil texture among other things
- Specific supplemental contributions to rectify deficiencies

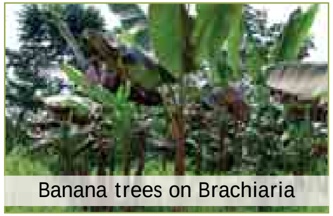
3. A permanent plant cover for the soil to maintain cultivated soil fertility on the long term.

Example of associated agricultural practices:

- Crop succession and rotation
- Crop associations
- Direct seeding Mulch-based Cropping system (DMC): cover crops, mulching

Mulching

Liquid compost

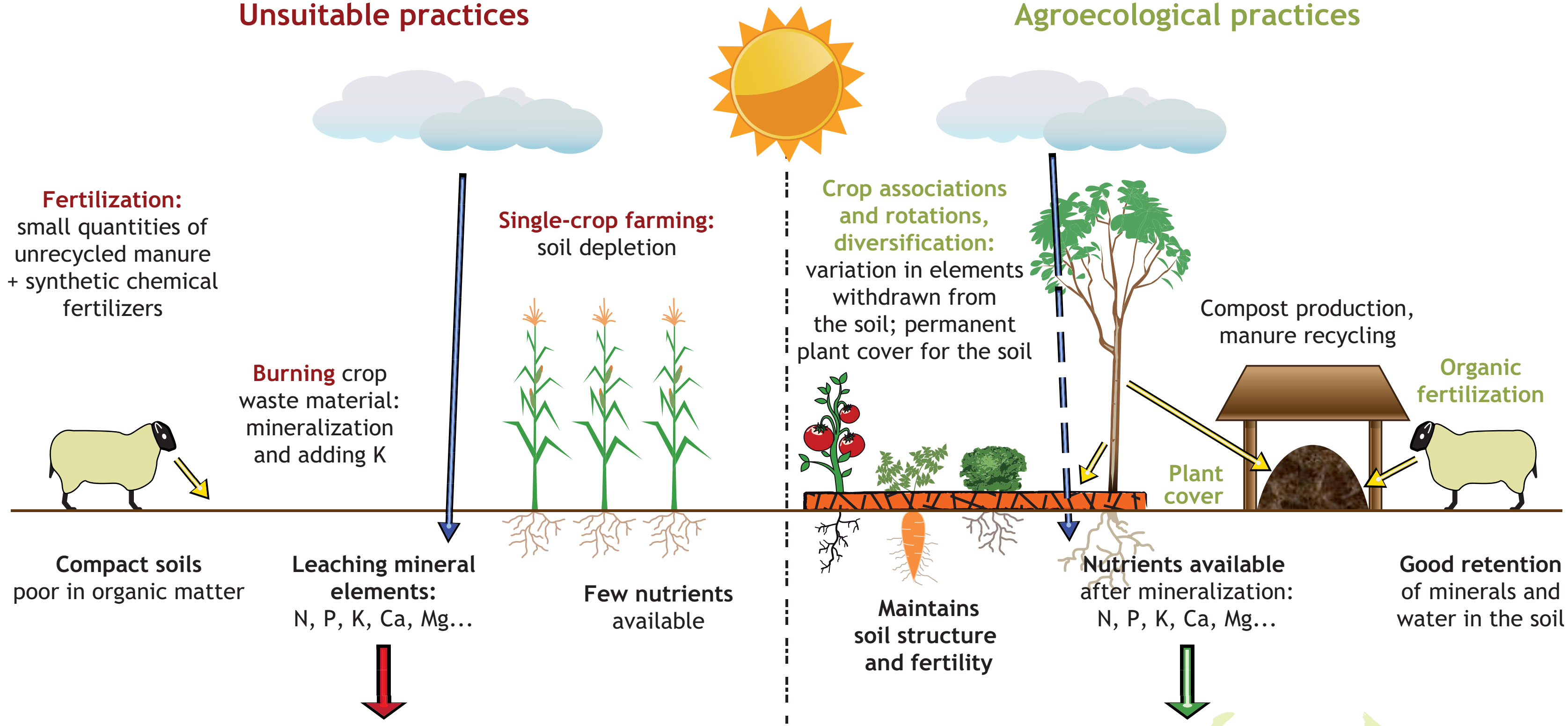


Banana trees on Brachiaria

Natural phosphate contribution

Eggplants on plant cover

Consequences of various practices on the soil



Unsuitable practices

Fertilization: small quantities of unrecycled manure + synthetic chemical fertilizers

Burning crop waste material: mineralization and adding K

Single-crop farming: soil depletion

Compact soils poor in organic matter

Leaching mineral elements: N, P, K, Ca, Mg...

Few nutrients available

Little life in the soil: accentuates compacting and depletion

Agroecological practices

Crop associations and rotations, diversification: variation in elements withdrawn from the soil; permanent plant cover for the soil

Compost production, manure recycling

Organic fertilization

Plant cover

Maintains soil structure and fertility

Nutrients available after mineralization: N, P, K, Ca, Mg...

Good retention of minerals and water in the soil

Dynamic soil life: recycling organic elements, creating humus; aeration / decompacting

Insufficient organic matter additions
(significant costs for artificial chemical inputs)
No crop diversity

Substantial organic matter additions
(reducing the expense of artificial chemical inputs)
Crop diversity

- → **Soil structure deterioration**
- → **Soil exhaustion (unsustainable farming)**

- → **Preserving soil structure stability**
- → **Maintaining soil fertility (sustainable farming)**

In farmers' words...

Pasteur Léon

Producer in Andranomavo, Madagascar

Pasteur Léon tells us about compost…

> "Compost production represents a lot of work. So at first I didn't really want to follow the advice of Agrisud's technicians.
>
> I tried, with a very small compost pile, that I used to fertilize about fifteen tomato plants in my field.
>
> I saw a very big difference: tomatoes planted with manure and chemical fertilizer grow much faster to start, but they lose their leaves after the third harvest and we get a total of 6 harvests.
>
> However, for the tomatoes planted with compost, the leaves remain through the twelfth harvest and the plant keep growing producing new flowers and therefore fruit."

Pasteur Léon is assisted as part of an **agriculture professionalization project in the Itasy region** in Madagascar. Today, he is one of the master-farmers in his fokontany (village).

After pilot projects in 2008, since 2009, the project has entered an expansion phase in 8 communes and involves 720 farmers in the following domains:

- Intensive irrigated Rice-farming System (IRS) ;
- rainfed food corps;
- vegetable and fruit crops.

A system for monitoring agricultural sectors and markets accompanies production reinforcement and diversification most of which is sold on regional markets and in Antananarivo.


Irrigating a vegetable garden, Laos

Water

“Don’t throw away your stored water and jar just because it’s going to rain”
- African Proverb -

Without water there are no crops or livestock.

The water cycle is also the life cycle. Whether liquid or vapour, in the soil or atmosphere, it gives the soil life, carrying nutritional elements for plants and watering men and animals.

Water can also be destructive: it erodes land with runoff ; in strong rain, it destroys crops; sometimes, it floods.

→ *So integrated practices must be adopted to manage this resource's excesses and / or insufficiencies.*

Four major principles should be taken into account by implementing various complementary practices

1. Mobilizing water resources economically and responsibly; integrated, organized irrigation.

Example of associated agricultural practices:

- Organizing water distribution
- Suitable facilities, irrigation networks, and pumping equipment

2. Integrated water usage to avoid excess (preserving the resource) and unnecessary energy expenses.

Example of associated agricultural practices:

- Shaping the land (levelling, evacuation channels, bed profiles, basins...)
- Crops following contour lines

3. Groundwater conservation benefiting cultivated plants.

Example of associated agricultural practices:

- Adding basal manuring (compost and recycled manure)
- Hoeing
- Ridging
- Direct seeding Mulch-based Cropping system (DMC): cover crops and mulching
- Crops association
- Hedging (live hedges and windbreaks)

4. Protecting water from pollution (organic or chemical effluents).

Example of associated agricultural practices:

- Natural degradable treatments and fertilizers
- Collecting and appropriate use of stock manure and excrement
- Reduced use of artificial chemical pesticides through an integrated phytosanitary approach

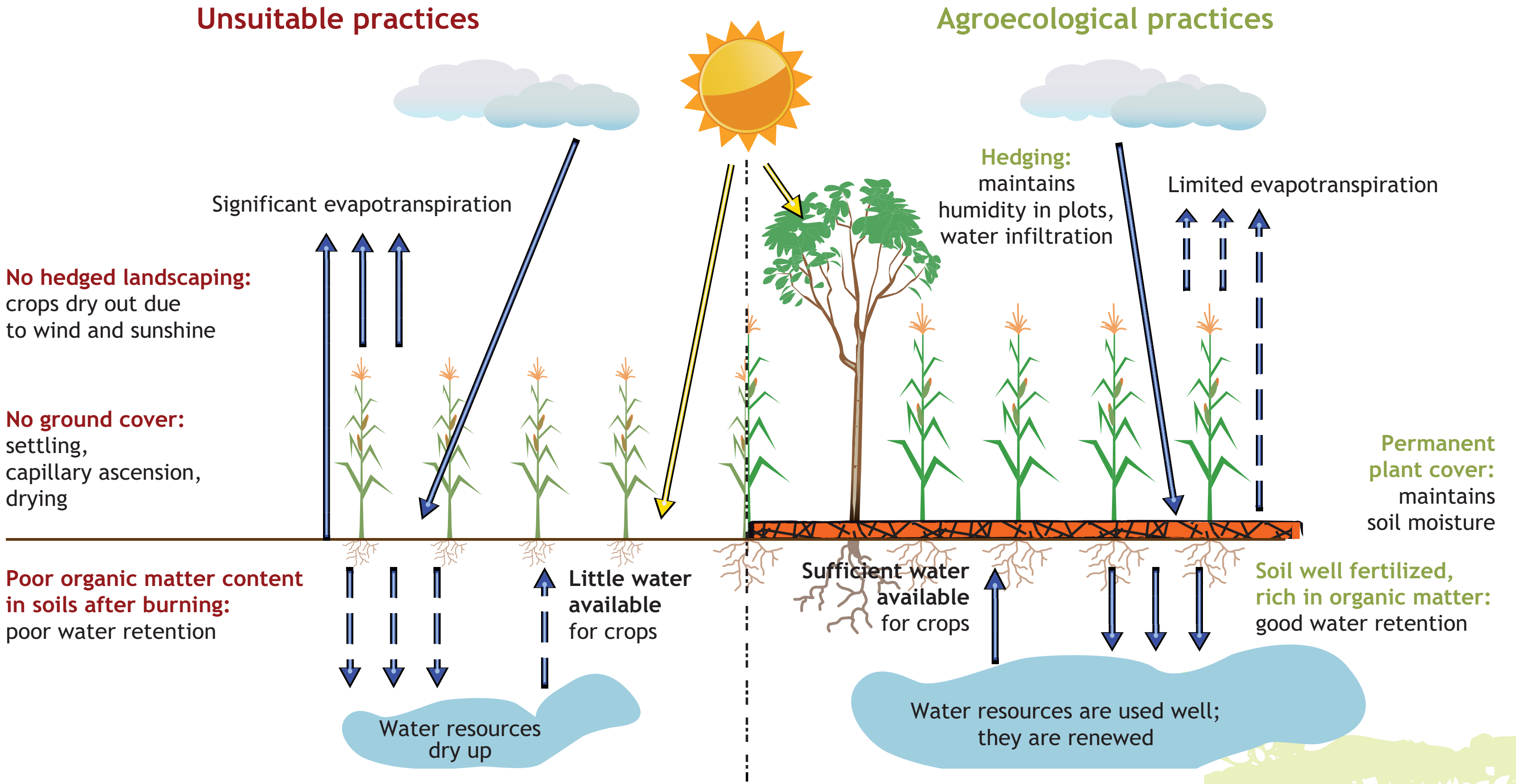
Well, Niger

Pedal-pump, Niger

Bowls farming, Madagascar

IRS paddy field, Madagascar

Consequences of various practices on water



Unsuitable practices

Significant evapotranspiration

No hedged landscaping:
crops dry out due
to wind and sunshine

No ground cover:
settling,
capillary ascension,
drying

Poor organic matter content in soils after burning:
poor water retention

Little water available for crops

Water resources dry up

Agroecological practices

Hedging:
maintains
humidity in plots,
water infiltration

Limited evapotranspiration

Permanent plant cover:
maintains
soil moisture

Sufficient water available for crops

Soil well fertilized, rich in organic matter:
good water retention

Water resources are used well;
they are renewed

Major construction work and irrigation expenses
High water consumption
Reduced counter-season crop periods (lack of water)

→ Water resource depletion (unsustainable exploitation and crops regularly subject to water stress)

Limiting irrigation times and amounts
Economical practices and measures for conserving the water in the soil
Off-season crops possible (water control)

→ Maintain water resources (sustainable exploitation and water stress-free crops)

Norbert

Producer in Avaradalana, Madagascar

Norbert tells us about mulching...

> "Growing on mulch, watering frequency is reduced four-fold.
>
> In the off-season, mulch is available in large quantity, there isn't much farming activity and the weather is very dry, mulching helps a lot.
>
> However, during the rainy season, we don't need to save water as much and, mostly, we have too much work with rainfed food crops. Nevertheless next year, I'll be trying because during the rainy season, the weeds grow fast and mulching helps cut them down."

Norbert is one of the first farmers to have joined the pilot **professionalization project in the Itasy region** in Madagascar. Begun in 2008, this 18-month project was aimed at reinforcing farming systems and diversifying production according to the market supply needs.

An initial group of 86 farmers in 16 fokontany (villages) were involved, improving rice farming, rainfed food crops, and open field vegetable crops. An agrarian diagnostic of the area and its farms was conducted; 7 major sectors were identified: tomato, potato, onion, rice, papaya, pineapple, maize.

The initial actions involved assimilation by the producers of the agroecological best practices in order to, among other things, improve and maintain soil fertility (compost production) and water management (mulching).

Thanks to this projects achievements, an extended phase was launched in 2009.

Pineapple crop under banana trees, Sri Lanka

Plants

> *“Hoe all your sorghum plants, you don’t know which will give you seeds”*
>
> - Nigerien Proverb -

Plants, wild or domesticated, rich in diversity, are the basis for agro-systems.

Plants nourish Man and animals. Through photosynthesis, they produce oxygen and sequester carbon. Their roots colonize the soil and favour subterranean life, their aerial parts protects the soil and maintains an environment suitable for living beings.

➔ *They can be bad, uncontrolled, thorny, sometimes poisonous, but their presence is never random. Plant diversity must be preserved.*

Two major principles should be taken into account by implementing various complementary practices

1. Adapting plant production to the ecosystem, fulfilling producers' and consumers' needs.

Example of associated agricultural practices:

- Productions whose requirements are suitable for the available resources (water and soil)
- Productions oriented towards local markets
- Knowledge of suitable local varieties
- Developing local know-how
- Local seed production

2. Mastering farming systems favouring complementarities in time and space.

Example of associated agricultural practices:

- Crops association
- Crops succession
- Hedging (hedges and windbreaks)
- Crop / livestock integration
- Organic fertilization
- Phytosanitary treatments as natural as possible (based on neem, tobacco, hot pepper...) or products that degrade without damaging the environment

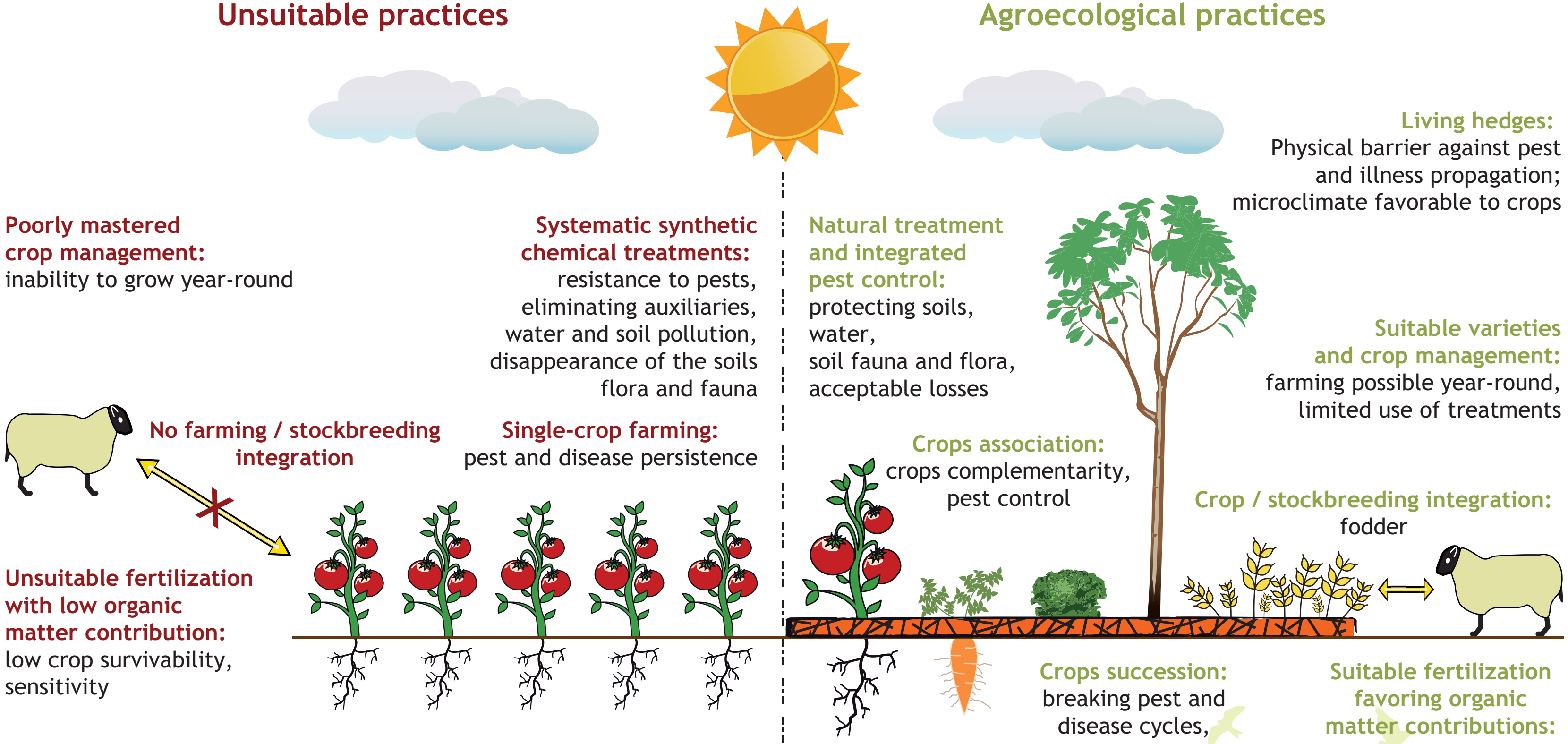

Alternating pineapple/banana tree strips, Sri Lanka


Okra farming, Gabon


Vegetables shopkeeper, Laos


Lemongrass farming, India

Consequences of various practices on plants



Unsuitable practices

Poorly mastered crop management:
inability to grow year-round

Systematic synthetic chemical treatments:
resistance to pests,
eliminating auxiliaries,
water and soil pollution,
disappearance of the soils flora and fauna

No farming / stockbreeding integration

Single-crop farming:
pest and disease persistence

Unsuitable fertilization with low organic matter contribution:
low crop survivability,
sensitivity

Agroecological practices

Natural treatment and integrated pest control:
protecting soils,
water,
soil fauna and flora,
acceptable losses

Living hedges:
Physical barrier against pest and illness propagation;
microclimate favorable to crops

Suitable varieties and crop management:
farming possible year-round,
limited use of treatments

Crops association:
crops complementarity,
pest control

Crop / stockbreeding integration:
fodder

Crops succession:
breaking pest and disease cycles,
balanced use of soil nutrients

Suitable fertilization favoring organic matter contributions:
robust,
resistant crops

Lack of crop diversity
Periods of abundance and product shortages poorly controlled
Significant costs for artificial chemical inputs: inappropriate fertilization; chemical pest control
Poor crop / livestock synergy

→ Short-term exploitation and creating imbalance

Crops diversification
Crops complementarity in time and space
Lower operating expenses: appropriate fertilisation, preventive methods, and natural products
Crop / livestock integration

→ Sustainable farming and promoting equilibrium

In farmers' words...

Brahim Meskaoui

Farmer in Afra, Morocco

Brahim tells us about diversifying his crops...

> "My parents were already farmers. I learned much from them, but I have also observed what the neighbours and farmers in the village where I rented and purchased plots were doing. With my sons, we have also tried new techniques that have been effective.
>
> We spread crops out as much as possible over the entire year. My wife can cook various vegetables to feed the 17 people in our household, and we can sell our vegetables and aromatic plants at a good price, when the local offer at the souks is lower. My eldest son, Mohamed, is in charge of transporting and selling each week, our production at 2 souks in winter and 3 in summer.
>
> I learn new practices with the technicians that come as part of the Agrisud project. We have learned to make compost and treat plants with natural, simple, and inexpensive products: garlic, ginger, black soap, etc."

Brahim Meskaoui is assisted as part of an **improvement project for farming practices in oases**, in southern Morocco. He is a reference farmer in his douar (village).

191 other farmers are also assisted in the Ouarzazate and Zagora provinces as part of Agrisud's projects in the following domains:

- fruit tree farming (olive-growing);
- vegetable farming;
- small sheep farm.

The technical and economic assistance and support for professional organization provide for securing, reinforcing, and diversifying farming activities whose productions are sold at souks (local markets) in Skoura, Agdz, and Ouarzazate.

Ewe, Morocco

Animals

“Give me grass, I’ll give you milk”

- Moroccan Proverb -

Animals, precious allies for farmers and farm equilibrium,

Livestock performs different function that fulfil Man's needs: food (meat, milk), utilitarian (wool for weaving, animal energy for traction…), economic (cashflow, additional income…).

Livestock activity is an element of balance in agricultural systems: exchanges between crops and animals (feed, providing organic matter).

→ *So synergies must be created and maintained between plant production and livestock activities.*

Two major principles should be taken into account by implementing various complementary practices

1.Adapting animal production to the ecosystem, fulfilling producers' and consumers' needs.

Example of associated agricultural practices:

- Productions whose requirements are suitable for the available resources
- Productions oriented towards local markets
- Knowledge of suitable local species
- Developing local know-how
- Local cattle production

2. Mastering livestock system that use local food resources and create organic matter.

Example of associated agricultural practices:

- Crop / livestock integration
- Developing local resources to feed cattle
- Producing organic matter used on plots

Poultry, Congo

Pig farm, Cambodia

Sheep farm, Morocco

Pig farm, Laos

Dim Touch

Poultry farmer in Anlong Tasek Leu, Cambodia

Dim Touch tells us about his poultry farm...

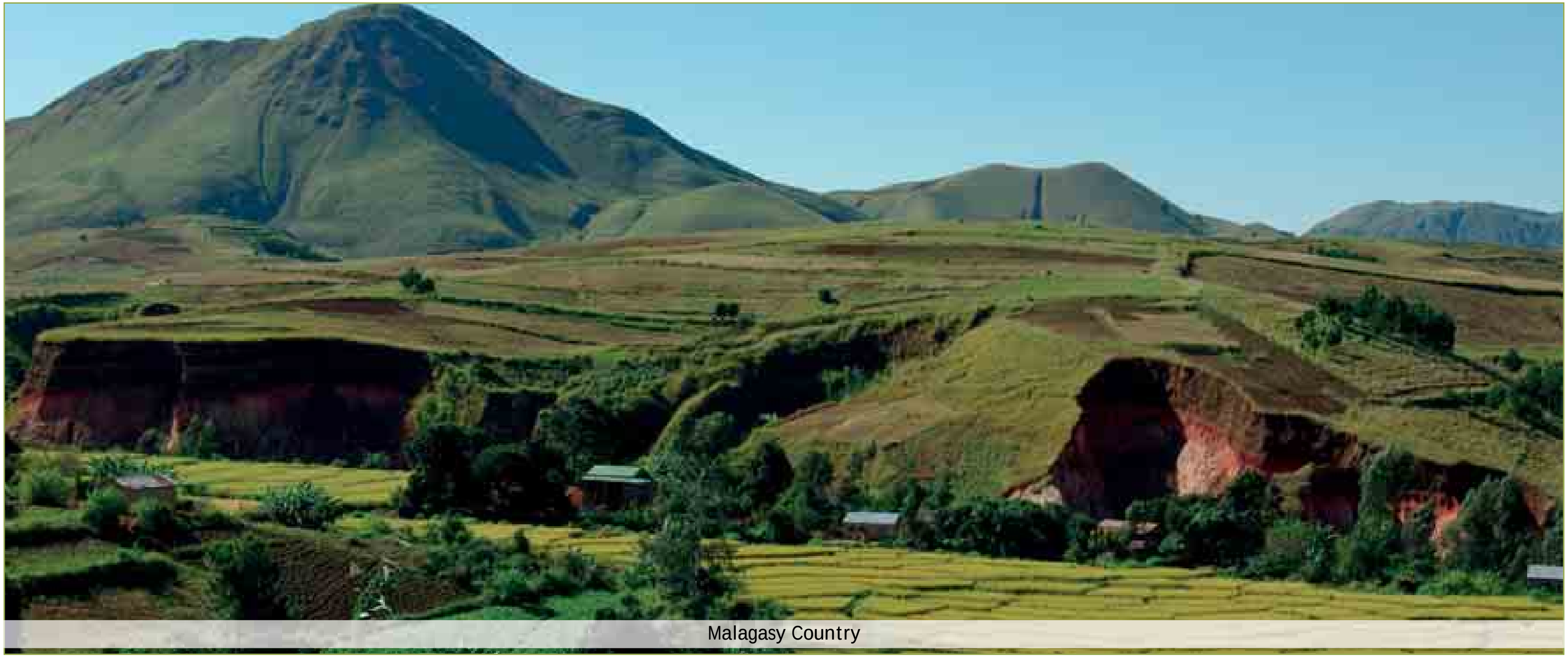
> "With special care given to maintaining the chicken house, feeding the animals, and ensuring their well-being, and anticipating chicken rearing for sale during Khmer and Chinese festivals, I realized that raising chicken coulb be an interesting economic activity.
>
> Today, I want to increase my production. I have a site a little bit away from the village with a favourable shaded environment where I would like to build a larger chicken house."

Dim Touch is one of the farmers supported as part of the **project combating poverty by promoting agriculture sectors oriented towards the hotel-restaurant market** in the Siem Reap and Kandal provinces in Cambodia.

Between 2004 and 2008, 120 farmers reinforced and diversified their production system specifically targeting the hotel-restaurant market. In 2009, 73 new farmers joined this process and contribute to supplying local markets and hotels in Siem Reap and Phnom Penh:

- vegetable products (head cabbage and leaf cabbage, Welsh onion, yardlong bean, cucumber...) ;
- mushrooms (pleurotus) ;
- meat (pork and poultry).

All of the 73 beneficiaries supported in 2009 produced 215 tons of agricultural products in one year which they sold at local markets in and round Siem Reap and Phnom Penh.



Malagasy Country

Landscapes

“Plant trees in your youth and you will have shelter in your old age.”

- Malagasy Proverb -

The landscape, a fundamental element of the land and its various production units.

The landscape is fashioned by Man who leaves his footprint. The footprint left by farming activities may be positive when these activities maintain a balance with their environment or negative when they contribute to destroying the landscape that houses them, sometimes endangering themselves.

From Man's actions and nature's effects an agroecologically sustainable system will be born, or not.

→ *Therefore it is essential for production activities to be a part of a global landscape development vision.*

Three major principles should be observed by implementing various complementary practices

1. Creating anti-erosion facilities to preserve cultivated areas, favours the hedged farmland aspect and diversity of plants grown, recovers rain water, combats erosion, and flooding, recharges the water table.

Example of associated agricultural practices:

- Grassy strips
- Farmed terraces and crops following contour lines
- Forest plantations

2. Maintaining biodiversity by tending and developing suitable fauna and flora, in balance with their environment.

Example of associated agricultural practices:

- Locally suited varieties
- Crops association and rotations
- Promoting the use of local species and materials
- Crop / livestock integration

3. Reforesting and revegetating available bare surfaces to favour a diversity of species for service wood or fire wood, for craftsmen, human and animal food, regenerating soils…

Example of associated agricultural practices:

- Rehabilitating orchards and forest plantations
- Soil cover (mulch bedding)
- Hedges and windbreaks
- Nursery techniques
- Fixing dunes
- Agroforestry

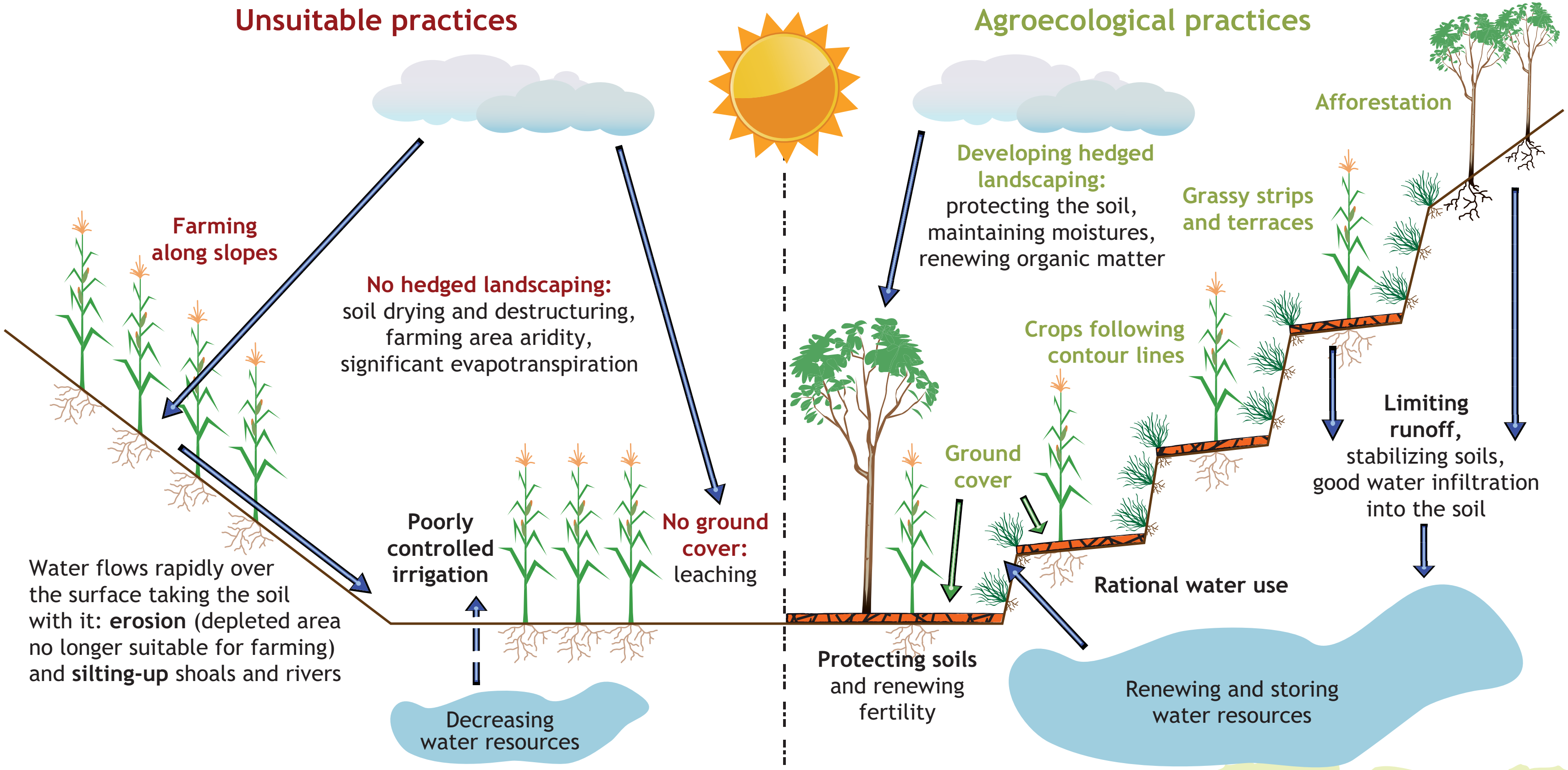
Crops at the foot of Mount Bangu, DRC

Moroccan Landscape

Paddy fields and orchard, India

Living Gliricidia hedge, Sri Lanka

Consequences of various practices on the landscape



Unsuitable practices

Farming along slopes

No hedged landscaping: soil drying and destructuring, farming area aridity, significant evapotranspiration

Water flows rapidly over the surface taking the soil with it: **erosion** (depleted area no longer suitable for farming) and **silting-up** shoals and rivers

Poorly controlled irrigation

No ground cover: leaching

Decreasing water resources

Agroecological practices

Afforestation

Developing hedged landscaping: protecting the soil, maintaining moistures, renewing organic matter

Grassy strips and terraces

Crops following contour lines

Ground cover

Limiting runoff, stabilizing soils, good water infiltration into the soil

Rational water use

Protecting soils and renewing fertility

Renewing and storing water resources

Erosion
Lack of soil protection
Poor farming practices on slopes
Poor water resource management

→ Land potential threatened

Combating erosion on slopes
Soil protection
Best farming practices
Sustainable water resource management

→ Land potential preserved / improved

Chanthramanikay

Vegetable and tree farmer in Thampalakamam, Sri Lanka

Chanthramanikay tells us of the intensive development of her plot…

> "I have 2 children I take care of myself since my husband is not able to work. I own my own land, but before, I was not able to cultivate; I was constantly going to work in the neighbouring paddy fields to work.
>
> Today, my harvests are good and I would like to acquire another site in the village to set it up like the first and no longer be required to work in other people's fields.
>
> Thanks to Agrisud's support, my situation has changed. They allowed me to dig a well. Then, I planted a live hedge of gliricidia and other fruit crops: coconuts, papayas, pineapples, bananas…
>
> The techniques I learned also help me to grow vegetables under the fruit trees."

Chanthramanikay is one of the producers who benefited from the **farming activity recovery and agriculture sector strengthening project after the tsunami catastrophe**, in the Trincomalee district (northwest Sri Lanka).

Between 2005 and 2009, this project involved 988 small producer families in 36 villages in the district, who were directly affected by the coastal zone tsunami or displaced during 25 years of civil war. In both cases, farming activity needed rebuilding…

The actions involved reinforcing and diversifying farming systems for food security and supplying local markets:

- shallot crops in coastal zone fields;
- vegetable crops: diverse vegetables (tomatoes, cabbage, carrots, beets, onions…) ;
- fruit crops: coconuts, papayas, bananas, pineapples, citrus…;
- small income generated activities: agricultural craftsmanship, product transformation, small poultry farms.

Tahoua Region, Niger

2 / Farming systems

Example from Cambodia

Agroecological situation

Climate:

Tropical, hot and humid with alternating seasons:
- dry season: November to April, 30°C to 40°C
- rainy season: May to October, 25°C to 30°C, significant precipitation (1,500 to 2,000 mm / year).

Soil:

Good agronomic potential near the banks. Alluvial soils are the place for growing rice. Lower potential soils are covered with forests.

Water:

Two hydrographic particularities:
- the Mekong River crosses the country for about 300 km;
- Tonlé Sap Lake swells with the Mekong's waters during the rainy season then in turn feeds the river during the dry season.

The majority of the population is concentrated around the lake, the Mekong's shores and its tributaries and distributaries. These zones constitute the heart of agricultural Cambodia.

Vegetation:

Two-thirds of the country is covered with tropical forest, denser on the plateaus. Sugar palms line the border levees around the paddy fields.

Agricultural activities:

Rice is the basic food crop. Vegetable crops, other annual crops are less common. Livestock is primarily a family-based activity.

Major constraints:
- Climate vagaries: lack of water and limited irrigation in the dry season / flooding and possible limited drainage during the rainy season;
- precarious agricultural practices: limited diversification, uncontrolled use of synthesis chemical inputs, low investment capacity;
- unequal land access: about 1 ha per family

Vegetable farming in humid areas

Vegetable farming activity

In Cambodia, the vegetable farming activity encouraged by Agrisud at the family level responds to a desire to diversify agricultural production, improve food security and create income-generating activities.

Most supported farmers have a garden or chamkar of about 0.5 ha, near the home, where any crops other than rice may be grown. Vegetable farming crops are more common during the cool dry season, after harvesting the rice and water level fall (December to March).

Vegetable farming requires mobilising financial resources for seeds, fertilizer, watering, and day workers in addition to family labour. In return it provides added value per surface area unit much important than other crops planted on the same plots.

Ta Khmao market,
Kandal Province

Main crops:
- leafy vegetables: lettuce, mustard, water spinach, leaf cabbage, Chinese kale… with short cycles diminishing risks;
- other productions: cucurbitaceae (cucumber, marrows, bitter melon), tubers (sweet potato, cassava, yams, taro), leguminous (yardlong bean, mung bean), liliaceae (onion, Welsh onion) and other crops such as cabbage, cauliflower, green sweet peppers, tomato, egg plant, and hot pepper.

The stakes

Vegetable farming can be a viable and sustainable farming activity for market purpose and / or for self-consumption if the constraints are mastered and resources used well.

With regards to agroecological conditions, the issues for a vegetable farmer are:
- → controlling the water resource (irrigation and drainage possibilities) ;
- → maintaining soil fertility (crop succession, using organic fertilizers) ;
- → production regularity in time and space (valorization of non-productive periods, off-season crops, raised nursery) ;
- → preventing diseases and parasites (diversifying crops, introducing new varieties).

Example from Madagascar

Agroecological situation
(High plateaus)

Climate:

Subtropical: annual temperatures between 7°C and 28°C; precipitation from 800 to 1,100 mm/year.

- cold, dry season: April to October;
- hot, rainy season: November to March.

Soil:

Two types:

- alluvial soils in the shallows and plains, quite fertile where rice production is concentrated;
- lateritic soils on slopes and the piemont plains, generally leached out and highly eroded.

Water:

Numerous lakes, rivers, and plains temporarily flooded and swampy areas.

Landscape:

Mountainous area (altitude: 600 to 1,700 m) with alternating deforested hills and valleys.

Vegetation:

Grassy savannah, few wooded areas except for reforested areas or eucalyptus and pine production areas.

Agricultural activities:

Rice growing is practiced during the rainy season and where irrigation is possible, in the off-season. The primary rainfed food crops are maize, cassava, beans, and bambara pea (voandzou). Vegetable farming is conducted in dry paddy fields and lower slopes. Tree farming and livestock (pigs, ducks, poultry) are practiced on a small-scale.

Major constraints:

- Strong rains and lack of tree cover: significant erosion on the hills and silting-up shallows;
- land occupation pressure around Antananarivo: decreasing available farming areas.

Vegetable farming activity

In Madagascar, vegetable farming encouraged by Agrisud is a family scale activity, concerned with diversifying farming production and families' food security.

Two dominant vegetable farming systems are supported and practiced:

- farming leafy vegetables (brede mafana, leaf cabbage, Chinese cabbage, black nightshade, lettuce…) providing the most vulnerable families a regular source of cash with the short farming cycle allowing for regular, repeated harvests; this system is practiced throughout the year on the fertile soils of the low slopes;
- higher-added value crops (potato, tomato, onion, leek, spring onion, headded cabbage…) that are farmed in paddy fields, in the off-season for rice production, in a highly seasonal manner (April to September).

The vegetable farming practice in the off-season on paddy fields fulfils two requirements:

- creating cash to finance the next rice cycle;
- tending and fertilizing the plot for the following crop.

In vegetable farming systems, the use of synthesis chemical fertilizers and pesticides – although dependent on the farmer's financial resources – is frequent and often disproportionate, sharply decreasing crop profitability.


Vegetable farming garden, Itasy Region

The stakes

Vegetable farming can be a viable and sustainable farming activity for market and / or for self-consumption if local resources are used well and valorized and if constraints are mastered.

With regards to agroecological conditions, the issues for a vegetable garden farmer are:

- → mastering technical itineraries based on market opportunities (often leading to farming during the rainy season, or at least conducting the nursery during the wet season) ;
- → mastering low-cost techniques (compost, preventive methods and natural pesticides, soil protection) ;
- → water control throughout the year to face flooding during the rainy season and lack of water during the dry season;
- → setting-up successive crops like high-season rice farming / low-season vegetable farming.

NOTE

Agroecology involves biological mechanisms: a practice has direct and indirect effects on various elements such as the soil, water, plants, the landscape.

The combination of these effects contributes to their success.

The final goal is to be able to **regularly produce quality vegetables in sufficient quantity with accessible production methods** (low cost, adaptability) **sustainably**.

Vegetable farming in bowls, Madagascar

Mulched tomato farming, Madagascar

Proposed agroecological practices

The agroecological practices proposed by Agrisud and implemented by producers in Cambodia and Madagascar can meet the challenge to produce vegetables in wet areas.

Direct effect 🟩

Indirect effect 🟨

	EFFECTS			
PRACTICES	Soil	Water	Plant	Landscape
Manure recycling	🟩	🟨	🟩	
Swath composting	🟩	🟨	🟩	
Crib composting	🟩	🟨	🟩	
Hedging production sites	🟩	🟩	🟩	🟩
Ground-level nursery			🟩	
Raised nursery			🟩	
Basal organic manuring	🟩	🟨	🟩	
Bowls farming	🟩	🟩	🟩	
Crops succession	🟩		🟩	
Crops association	🟩	🟨	🟩	
Mulching	🟩	🟩	🟨	
Liquid compost	🟩		🟩	
Integrated pest management	🟨	🟨	🟩	
Natural phytosanitary treatments			🟩	

Jar of liquid compost

Mulching, Cambodia

Vegetable farming in dry areas

Agroecological situation
(Southern Morocco oasis and Eastern Niger)

Climate:

Dry, semi-arid tropics with few precipitations and extreme temperatures:

- Southern Morocco: 110 mm / year on average; from 0°C with occasional freezing in winter to 45°C in summer;
- Niger: 150 to 500 mm / year concentrated during a short period (mid-June to mid-September); up to 50°C and significant thermal amplitude between the hot and cold seasons.

Soil:

Poor soils with an organic matter deficit.

Water:

The resource depends on the presence of a permanent or temporary river (dam releases, floods), ponds (permanent or temporary), or a shallow groundwater level.

Vegetation:

Mostly composed of grass and shrub steppes. Little forest cover outside oases.

Agricultural activities:

Rainfed cereal production (except in the oasis), date trees, sedentary or transhumant livestock, oasis vegetable farming.

Major constraints:

- Extreme climate conditions: rare rain and violent precipitations (southern Morocco); high heat ;
- deforesting issues and significant desertification ;
- bad farming practices: insufficient organic matter, water-wasting irrigation, inadequate crop successions, bad use of synthesis chemical inputs.

Vegetable farming activity

In Morocco and Niger, the vegetable farming activity encouraged by Agrisud corresponds to small family farms where the irrigated areas are collectively managed but each farmer has his own plot.

In Niger, vegetable farming is practiced in the off-season (outside the rainy season), when thermal conditions permit (outside the high heat season) and family labour is not occupied with rainfed crops. However, some farmers practice the activity all the time (specific case of oasis basins). **In southern Morocco**, vegetable farming is practiced throughout the year in oases.

In both contexts, the lack of production means directs the poorest producers towards a production system primarily based on added manure and local seeds.

Main crops:

- in Niger: onion, tomato, cabbage, potato, lettuce, marrow, sweet pepper, okra, sorrel;
- in southern Morocco: carrot, turnip, onion, broad bean, cabbage, and green pea in winter; tomato, eggplant, sweet pepper, and marrow in summer.


Sweet pepper, Niger

A particularity: oasis and oasis basins

In southern Morocco, oases are located along wadis (temporary rivers). The farming system is stratified: date palms / fruit trees / fodder crops / cereals and / or market crops.

In Niger, the presence of a shallow water table favours vegetation. In the form of a basin, the surroundings are wooded with trees and palms and is the location of vegetable garden.

➔ *Southern Moroccan oases, with significant farming potential, and oasis basins in Niger are favoured places for vegetable farming. These farming areas are now threatened by desertification and sand encroachment.*

With regards to agroecological conditions, the issues for a market gardening farmer are:
➔ controlling water (water-saving irrigation techniques) and soil fertility;
➔ spreading production throughout the year (out of oasis basins and oases);
➔ protecting production sites from the sun, wind, and animals.

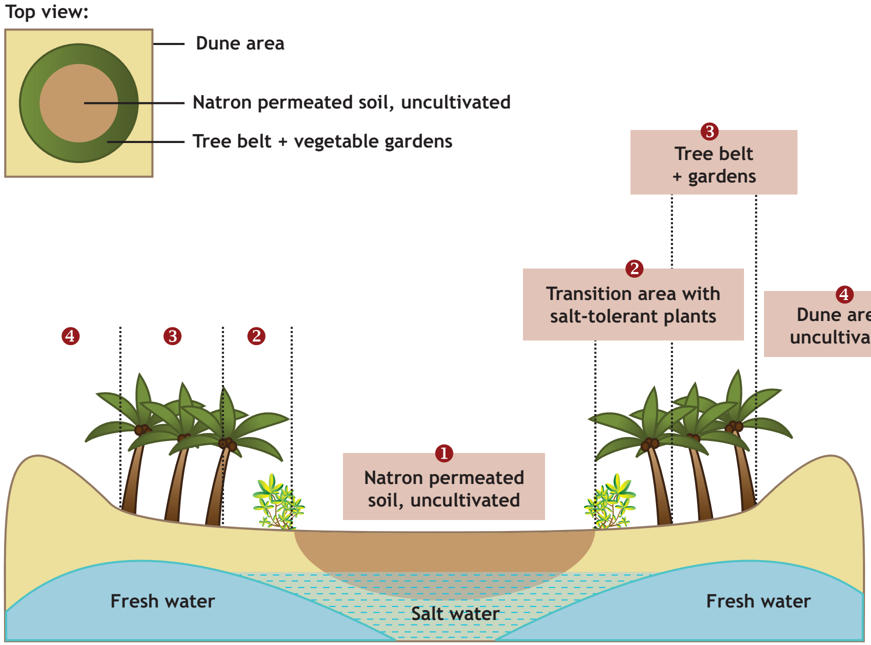
More particularly, in oases and oasis basins:
➔ sustainable water management and controlling salt ascension;
➔ combating sand encroachment.

Specific case of oasis basins

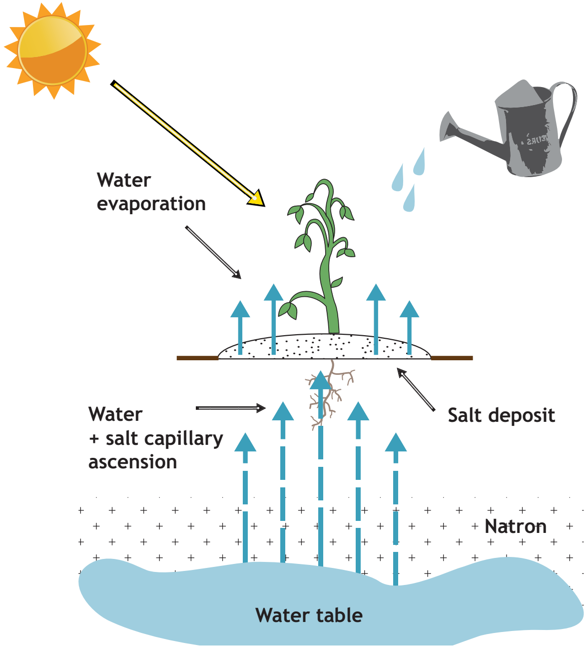
Oasis basins are often the only land suitable for vegetable farming in the dry eastern part of Niger. Indeed, the presence of a shallow water table has permitted the development of a tree belt where the microclimate may be favourable to crop growth.

Primary constraints: salt ascension (natron) at the centre of the basin.

Diagrammatic representation of an oasis basin:



Salt cycle representation of an oasis basin:



View of an oasis basin, Niger

Crops in an oasis basin, Niger

Cabbage farming – oasis basin, Niger

Salt ascension

Farming in sensitive areas (where natron is not visible on the surface but present in the soil and sub-soil), surface watering is subject to the intensity of solar radiation. Water evaporation creates capillary ascension in the soil carrying soluble salts (natron).

On the surface, the water evaporates leaving salt deposits behind: the soil is salinated threatening the possibility for growing crops.

It is possible to note salt ascension, even if the water table where the water is drawn in not salty: the salt is present in the soil and ascends by capillarity.

Land selection

Natron soil

- **Avoid farming in the transition zone**. If, before setting up a garden, the ground is bare and grey (or grey-green) and has a powdery structure, it is highly likely that the soil is subject to seasonal salt ascension.
- **Select land within the basin's tree belt**; remove brush without cutting trees.

NOTE

Oasis basins are fragile, protected ecosystems. The tree belt protects these zones from invasion by the dunes. It is not recommended to cut down the palm trees. All the more so since cutting-down the trees would lead to the disappearance of the farming potential.

Basin laying out

- **Prepare the land** by installing hedges and **hedge the plot** as needed to create a suitable environment for crops and for moisture retention (see Leaflet: Hedging vegetable farming sites p 93). For planting fruit trees, prepare 1 m^3 planting holes and enrich
- **Collect the water** as far as possible from the natron centre of the basin to prevent getting salt water unsuitable for farming. Pumping too much in the fresh water table at a single point will encourage progression of the salt front
- **Use many different water collection points** and limit the pumping flow rates to preserve the water resource
- **Carefully select the crops:**
  - → If salt is present in the soil, favour semi-tolerant crops (sorghum, marrow, carrot, eggplant, lettuce, tomato, onion) and tolerant crops (barley, red beets) for the first cycles: until effective reduction in salt ascension due to other practices;
  - → Avoid sensitive crops as long as the problem persists.

Tube well, pedal pump, lined channel

NOTE

The fragile basin ecosystem balance is based on water resources and maintaining the tree belt.

Consequently, water-saving irrigation systems should be favoured and the use of motorized pumps avoided as they remove too much water.

Salt ascension

Unmulched cassava plant

Tilling, Karangou oasis basin

Crops, Baboulwa oasis basin

NOTE

Agroecology involves biological mechanisms: a practice has direct and indirect effects on various elements such as the soil, water, plants, the landscape. The combination of these effects contributes to their success.

The final goal is to be able to **regularly produce quality vegetables in sufficient quantity with accessible production methods** (low cost, adaptability) **sustainably**.

Stratified crops, Southern Morocco

Compost pit, Niger

Proposed agroecological practices

The agroecological practices proposed by Agrisud and implemented by producers in Niger and Morocco can meet the challenge to produce vegetables in dry areas.

Direct effect 🟩

Indirect effect 🟨

	EFFECTS			
PRACTICES	Soil	Water	Plant	Landscape
Manure recycling	🟩	🟨	🟩	
Swath composting	🟩	🟨	🟩	
Liquid compost	🟩		🟩	
Hedging production sites	🟩	🟩	🟩	🟩
Raised nursery			🟩	
Ground-level nursery			🟩	
Basal organic manuring	🟩	🟨	🟩	
Crops succession	🟩		🟩	
Crops association	🟩	🟨	🟩	
Mulching	🟩	🟩	🟨	
Bowls farming	🟩	🟩	🟩	
Integrated pest management	🟨	🟨	🟩	
Natural phytosanitary treatments			🟩	

Crop bowls, Niger

Crop associations, Southern Morocco

Example from Cambodia

Agroecological situation

Climate:

Tropical, hot and humid with alternating seasons:

- dry season: November to April, 30°C to 40°C
- rainy season: May to October, 25°C to 30°C, significant precipitation (1,500 to 2,000 mm / year).

Soil:

Good agronomic potential near the banks. Alluvial soils are the place for growing rice. Lower potential soils are covered with forests.

Water:

Two hydrographic particularities:

- the Mekong River crosses the country for about 300 km;
- Tonlé Sap Lake swells with the Mekong's waters during the rainy season then in turn feeds the river during the dry season.

The majority of the population is concentrated around the lake, the Mekong's shores and its tributaries and distributaries. These zones constituent the heart of agricultural Cambodia.

Vegetation:

Two-thirds of the country is covered with tropical forest, denser on the plateaus. Sugar palms line the border levees around the paddy fields.

Agricultural activities:

Rice is the basic rainfed food crops, vegetable crops, other annual crops, and fruit crops are less common. Livestock is primarily a family-based activity.

Major constraints:

- Climate vagaries: lack of water and limited irrigation in the dry season / flooding and limited drainage facilities during the rainy season;
- precarious agricultural practices: limited diversification, bad use of chemicals, low investment capacity;
- unequal land access: about 1 ha per family

Fruit farming in humid areas

Fruit production activity

In Cambodia, fruit tree farming encouraged by Agrisud is on a family scale, concerned with diversifying farming production and families' food security.


Papaya farming

The Provinces where fruit tree farming is the most developed are Battambang and Kampong Cham. On the banks, most supported families have a small orchard close to the house (1 or 2 trees of different species: banana, papaya, guava, mango, citrus) and the fruit obtained are intended for the family's consumption (only a small part is sold on the local market).

Fruits produced in specialized orchards are intended for local markets. Several species have very short production periods (mango, rambutan, jackfruit, sapodilla…) and other produce throughout the year (banana, papaya, guava…).

Generally, producers who take up fruit production are those that have large surface areas and financial resources because installing an orchard requires significant investment funds. They are also the producers that master grafting, planting, and tending techniques.

Agrisud has primarily worked on farming citrus and mangos in Pursat, Battambang, and Banteay Meanchey provinces.

The stakes

Fruit production may be a viable and sustainable farming activity for selling and / or for self-consumption if the constraints are mastered and resources used well.

With regards to agroecological conditions, the issuesfor a fruit producer are:

- → mastering technical itineraries from crop installation through tending;
- → access to or production of quality young plants and seedlings;
- → mastering production plant pruning;
- → preventing disease and parasites;
- → controlling the water resource.

Example from Sri Lanka

Agroecological situation
(Northeast)

Climate:
Wet tropics alternating 2 seasons
- dry season: March to August, 28°C to 32°C;
- rainy season: September to February, 26°C to 28°C; high precipitation late in the day and frequent flooding (1,500 to 1,800 mm / year).

Soil:
Good farming potential in the plains and dips (rice farming). Dewatered soils often with lower potential (low-sloped colluvial soils, collinary soils, rice fileds surrounding, costal fringes) are dedicated to rainfed, market, and fruit crops.

Water:
3 differentiated sources:
- permanent rivers from mountainous massifs in the south centre of the country;
- large-capacity artificial reservoirs dedicated to irrigated intensive rice farming and small reservoirs dedicated to "downstream" rice farming as well as market and fruit crops;
- water tables, accessed with wells, dedicated to market and fruit crops.

Vegetation:
Forested groves near inhabited areas, degraded forests in areas with poor, dewatered soils and more dense on mountain hillsides ; coconut trees present in inhabited and cultivated areas (excluding paddy fields), and the costal fringes.

Agricultural activities:
Rice farming is the primary activity; vegetable farming, other annual crops, and tree farming are also practiced; livestock is primarily a family-based activity.

Major constraints:
- Climate vagaries;
- bad use of synthesis chemical inputs ;
- unequal land access: 0.5 to 1 ha per family.

Fruit production activity

In Sri Lanka, fruit production encouraged by Agrisud is highly varied: tree farming (citrus, guava, coconut, mango...) and semi-perennial crops (papaya, banana, pineapple).

Supported families are poor, often displaced or reinstalled after successive periods of war. Their land availability is limited and the goal is to establish diversified production on small, dewatered surfaces.

The production obtained is mostly destined to be sold (local markets) even if self-consumption is common.

Orchard in Trincomalee District

Two fruit tree systems complement each other:

- small, low-density orchards allow for underlying vegetable farming (tomato, bean, cabbage) ;
- crop plots in alternating strips of different fruit crops or alternating strips of fruit crops and special crops (ginger, hot pepper...).

In all cases, the cropping areas are small: 1,000 m² to 3,000 m^2 and the activity provides additional incomes to provide, among other things, for limiting family member salaried activity in the paddy fields ("coolies").

The stakes

Fruit production can be a viable and sustainable farming activity for selling and / or for self-consumption if local resources are used well and recovered and if constraints are mastered.

With regards to agroecological conditions, the major issues for a fruit producer are:

→ mastering crop technical itineraries;
→ access to or production of quality young plants and seedlings;
→ mastering production plant pruning;
→ preventing disease and parasites;
→ controlling the water resource;
→ the choice of suitable varieties for the environment and market needs.

NOTE

Agroecology involves biological mechanisms: a practice has direct and indirect effects on various elements such as the soil, water, plants, the landscape. The combination of these effects contributes to their success.

The final goal is to be able to **regularly produce quality fruit in sufficient quantity with accessible production methods** (low cost, adaptability) **sustainably**.

Coconut trees, Sri Lanka

Banana trees

Ginger under papaya trees, Cambodia

Proposed agroecological practices

The agroecological practices proposed by Agrisud and implemented in Cambodia and Sri Lanka by producers provide for responding to fruit production issues in wet areas.

Direct effect 🟩

Indirect effect 🟨

	EFFECTS			
PRACTICES	Soil	Water	Plant	Landscape
Manure recycling	🟩	🟨	🟩	
Swath composting	🟩	🟨	🟩	
Crib composting	🟩	🟨	🟩	
Potted tree nursery			🟩	🟨
Planting fruit trees	🟩	🟨	🟩	🟩
Tending an orchard	🟩	🟩	🟩	🟩
DMC alternating strips of permanent cover	🟩	🟨	🟨	

Pineapple and banana trees, Sri Lanka

Fruit farming in dry areas

Examples from Morocco and Niger

Agroecological situation

(Southern Morocco oasis and Eastern Niger)

Climate:

Dry, semi-arid tropics with few precipitations and extreme temperatures:

- Southern Morocco: 110 mm / year on average; from 0°C with occasional freezing in winter to 45°C in summer;
- Niger: 150 to 500 mm / year concentrated during short period (mid-June to mid-September) ; up to 50°C and significant thermal amplitude between the hot and cold seasons.

Soil:

Poor soils with an organic matter deficit.

Water:

The resource depends on the presence of a permanent or temporary river (dam releases, floods), ponds (permanent or temporary) or shallow water table.

Vegetation:

Mostly composed of grass and shrub steppes. Little forest cover outside oases.

Agricultural activities:

Rainfed cereal production (excluding in oases where irrigation is needed), date palms, sedentary or migratory livestock, oasis vegetable farming.

Major constraints:

- Extreme climate conditions: rare rain and violent precipitation (Southern Morocco) ; high heat ;
- deforesting issues and significant desertification;
- poor farming practices: insufficient organic matters, water-wasting irrigation, inadequate crop successions, bad use of synthesis chemical inputs.

Fruit production activity

The fruit production activity encouraged by Agrisud in the Moroccan and Nigerien contexts corresponds to an effort to rehabilitate existing orchards and / or diversify crops. In collectively managed irrigated perimeters, planting trees also presents a technical advantage: protecting associated crops.

In southern Morocco, 3 situations may be identified:

- stratified oasis systems, particularly in the Draa Valley where date palm farming is the pillar of the farming system; under the palm trees, almond trees and pomegranate trees shelter fodder, cereal, and, to a lesser extent, market crops;

  N.B.: *Bayoud (fungus) has been devastating palm orchards progressively for more than a century; in certain areas, palm trees are giving way to olive trees.*

- orchards in the Dades Valley, primarily composed of olive, almond, fig, apricot, and peach trees;
- association of vegetable farming / fruit production in irrigated domains.

In Niger, fruit product is little developed: its implementation depends primarily on the farmer's ability to free up land to plant trees and take advantage of water resources until production commences. Therefore supported activities most often complement vegetable farming (hedged farmland suitable for irrigated crops and contribution to farm's economic development). The primary species are mango, papaya, pomegranate, and citrus trees as well as date palms in oasis basins.

In the 2 contexts, without appropriate support, farming practices remain summary: farmers pay little attention to the trees which benefit indirectly from the nearby vegetable farming supplements (water, organic matters). Moreover, tending techniques are often unknown (bowl cropping, mounding, pruning…).

Better off farmers master fruit crop farming and generally use chemical phytosanitary products, in small quantities.

Date palms, Morocco

Pomegranates, Morocco

Banana tree farming, Niger

The stakes

Fruit production may be a viable and sustainable economic and / or self-consumption activity if it is well mastered and if the resources are well used.

With regards to agroecological conditions, the major issues for a fruit producer are:

For stratified oasis systems:

- → mastering specific date palm farming techniques (pollination) ;
- → access to quality plants to replant areas attached by Bayoud.

For orchards:

- → controlling organic matters additions;
- → controlling irrigation;
- → mastering tending techniques;
- → mastering diseases and pests prevention techniques ;
- → access to quality plants to renew orchards.

In the case of joint vegetable farming / fruit production:

- → access to good quality plants;
- → controlling water (water-saving irrigation techniques) ;
- → regular plant tending before production.

Proposed agroecological practices

The agroecological practices proposed by Agrisud and implemented by farmers in Morocco and Niger provide for meeting these challenges.

Direct effect 🟩

Indirect effect 🟨

	EFFECTS			
PRACTICES	Soil	Water	Plant	Landscape
Manure recycling	🟩	🟨	🟩	
Swath composting	🟩	🟨	🟩	
Potted tree nursery			🟩	🟨
Planting fruit trees	🟩	🟨	🟩	🟩
Tending an orchard	🟩	🟩	🟩	🟩

NOTE

Agroecology involves biological mechanisms: a practice has direct and indirect effects on various elements such as the soil, water, plants, the landscape. The combination of these effects contributes to their success.

The final goal is to be able to **regularly produce quality fruit in sufficient quantity with accessible production methods** (low cost, adaptability) **sustainably**.

Pollination, Morocco

Vegetable farming / fruit production, Niger

Fruit plant, Niger

Fruit plant, Morocco

Rainfed food crops farming systems

Example from Gabon

Agroecological situation
(Estuaire Province)

Climate:

Low-altitude humid tropical

- high temperatures throughout the year: 25°C on average;
- significant precipitations: 2,700 mm / year over 8 to 9 months (440 mm in November); high relative humidity throughout the year (> 80%) ;
- dry season from June to September

Soil:

More or less depleted lateritic soils

Water:

Limited availability along the coast; presence of brackish water.

Vegetation:

Large degraded forest areas.

Agricultural activities:

Itinerant food crops farming (slash-and-burn), per urban vegetable farming, extensive fruit growing.

Major constraints:

Specific agroecological conditions are responsible for:

- quickly degrading organic matter;
- leaching nutritional elements;
- eroding slopes;
- significant weeds in plots.

Traditional farming systems are not very productive and unbalanced (fallowing times not observed) given the continuously increasing urban food demand.

Rainfed food crops farming

Rainfed food farming production

Gabon has experienced, and continues to experience, significant rural population migration towards urban centres. These population flows have generated significant demand in agricultural products on the markets, primarily satisfied by imported food goods and per urban vegetable production.

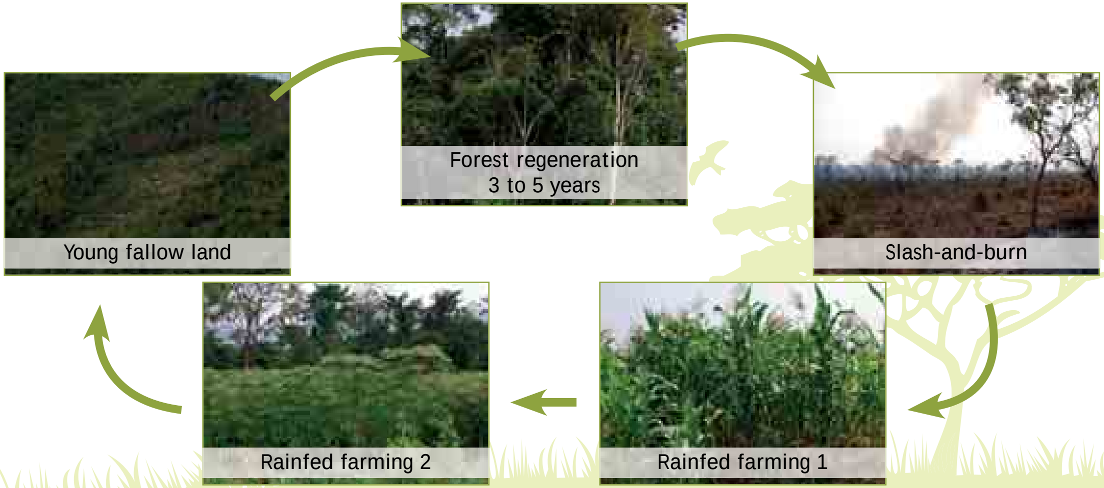
The traditional slash-and-burn practice, previously in balance, is no longer so today die to the increased land pressure and growing food demand. In order to maintain their income, producers must reduce the forest regeneration time and / or increase the cultivated areas.

Rainfed food crops farming systems, supported by Gabon's Development Support Institute (a member of the Agrisud network), are based on sendentarizing farming systems and continuous soil cover.

E.g. Direct seeding Mulch-based Cropping system:

- mid-cycle vegetable crops in fields (hot pepper, eggplant, okra...) on dead cover or in alternating strips with cover crops (Pueraria, Mucuna, Brachiaria, Stylosanthes...) ;
- long-cycle crops (cassava) in alternating strips with Brachiaria or Stylosanthes
- semi-perennial crops (banana trees) in alternating strips with Brachiaria.

Itinerant farming slash-and-burn cycle



The stakes

Rainfed farming may sustainably meet the challenges of farming development in Gabon, particularly improving coverage of the population's food needs, if, and only if, constraints are mastered and resources used well.

With regards to agroecological conditions, the major issues for a food producer are:

- → protecting the soil and managing its fertility;
- → controlling plot weeds;
- → limiting use of artificial chemical inputs;
- → sedentarizing farming activity to sustainably manage the environment;
- → developing and diversifying production to fulfil the urban population's food needs

NOTE

Agroecology involves biological mechanisms: a practice has direct and indirect effects on various elements such as the soil, water, plants, the landscape. The combination of these effects contributes to their success.

The final goal is to be able to **regularly produce quality food products in sufficient quantity with accessible production methods** (low cost, adaptability) **sustainably**.

Pineapple under banana trees

Cassava on Brachiaria

Proposed agroecological practices

The agroecological practices proposed by Agrisud and implemented by farmers in Gabon as well as Angola, Madagascar, and RD Congo, provide for meeting these challenges.

Direct effect 🟩

Indirect effect 🟨

*DMC: Direct seeding Mulch-based Cropping system

	EFFECTS			
PRACTICES	Soil	Water	Plant	Landscape
Manure recycling	🟩	🟨	🟩	
Swath composting	🟩	🟨	🟩	
Crib composting	🟩	🟨	🟩	
Crops following contour lines	🟩	🟩	🟨	🟩
Hedging rainfed Plots	🟩	🟩	🟩	🟩
Terraced Crops	🟩	🟩	🟨	🟩
DMC*: Cover crops	🟩	🟨	🟩	
DMC alternating strips of permanent cover	🟩	🟨	🟨	
DMC dead cover produced on-site	🟩	🟨	🟨	

Taro on Brachiaria

Crops arranged in corridors

Irrigated rice farming

Example from Madagascar

Agroecological situation *(High plateaus)*

Climate:

Subtropical: annual temperatures between 7°C and 28°C; precipitation from 800 to 1,100 mm/year.
- cold, dry season: April to October;
- hot, rainy season: November to March.

Soil:

Two types:
- alluvial soils in the shallows and plains, relatively fertile where rice production is concentrated;
- lateritic soils on slopes and the foot of slopes, generally leached out and highly eroded.

Water:

Numerous lakes, rivers, and plains temporarily flooded and swampy areas.

Landscape:

Mountainous area (altitude: 600 to 1,700 m) with alternating deforested hills and valleys.

Vegetation:

Grassy savannah, few wooded areas except for reforested areas or eucalyptus and pine production areas.

Agricultural activities:

Rice growing is practiced during the rainy season and where irrigation allows, in the off-season. The primary rainfed food crops are maize, cassava, beans, and vuandzou pea. Vegetable farming is conducted in dry paddy fields and lower slopes. Tree farming and livestock (pigs, ducks, poultry) are practiced on a small-scale.

Major constraints:
- Strong rains and lack of tree cover: significant erosion on the hills and silting-up shallows;
- land occupation pressure around Antananarivo: decreasing farming areas.

Rice farming activity

Main crop in **Madagascar**, rice is the basic food cereal: it is therefore given priority both in allocating land resources and mobilizing labour.

Rice farming is practiced by most farmers, however there are significant differences: surface area, paddy fields property status, and water control levels (ability to irrigate and drain a rice paddy field). The rice farming schedule depends on these factors and involves 1 or 2 cycles.

Three rice farming schedules are possible:

- Vary Aloha: transplanting in August / harvest in November-December; this off-season cycle is practiced in paddy fields providing sufficient irrigation during the dry season, with the advantage of ending sufficiently early to allow for preparing a high-season cycle, but with very low yield (heading during the cold season) ;
- Vary Salasala: transplanting in November / harvest in February-March. This other off-season cycle is practiced on flooded plots during the rainy season;
- Varibe: transplanting in December-January / harvest in May. This is the primary rice cycle in Madagascar and provides the best results.

Paddy fields, Itasy Region

Most producers practice traditional low-production itineraries (1 to 2 t/ha) compared to the potential (4 to 6 t/ha in IRS- Intensive Rice-farming System).

The stakes

Irrigated rice production is primordial to fulfil families' food requirement and may represented an economic activity. These crops are viable and sustainable if local resources are used well and if constrains are mastered.

With regards to agroecological conditions, the major issues for rice farmers are:
- → mastering the most productive technical itineraries, particularly IRS (paying careful attention to the fertilization aspect, primordial for system durability) ;
- → following succession rules to favour alternating irrigated rice farming with vegetable or leguminous farming to benefit soil improvement and maintain fertility;
- → water control to compensate for flooding during the rainy season and lack of water during the dry season.

Rice threshing

Proposed agroecological practices

The agroecological practices proposed by Agrisud and implemented by farmers in Madagascar provide for meeting the challenges of irrigated rice production.

Direct effect 🟩

Indirect effect 🟨

	EFFECTS			
PRACTICES	Soil	Water	Plant	Landscape
Manure recycling	🟩	🟨	🟩	
Swath composting	🟩	🟨	🟩	
Intensive Rice-farming System, IRS	🟨	🟩	🟩	
Rice nursery	🟨	🟨	🟩	

NOTE

Agroecology involves biological mechanisms: a practice has direct and indirect effects on various elements such as the soil, water, plants, the landscape. The combination of these effects contributes to their success.

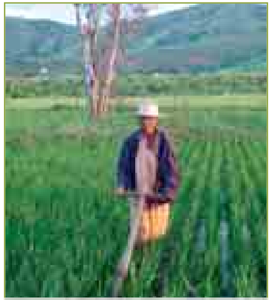
The final goal is to be able to **regularly produce quality rice in sufficient quantity with accessible production methods** (low cost, adaptability) **sustainably.**

Composting

Ploughing

Furrowing

Transplanting in line



Mechanical weeding

Anofy Region, Madagascar

3 / Practices

Mobilizing water resources and irrigation systems

In certain contexts, the weakness and / or irregularity in precipitation makes farming difficult, even impossible, without irrigation. The issue of mobilizing water resources is raised.

Different types of facilities may be built: wells, pumps, storage tanks, ponds... But in every case, the irrigation systems must fulfil the crops' needs and the water source's potential. They must be capable of protecting this water resource.

In most of the countries where Agrisud's is present, hydro-agricultural infrastructures have been carried out. Some of these are presented in this Leaflet.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Efficiently mobilizing the water resource
- Setting-up long-term infrastructures
- Limiting irrigation expenses (work time and water quantity used)

Conditions for implementation:

- Knowing the water resource potential in the area
- Availability of technical and economic reference data for existing infrastructures (if available)
- Knowing the water requirements for crops in the local context (climate, soil quality...)
- Availability of resources (material and human) to create the facilities

Principle

Irrigation systems provide for capturing underground or surface (lakes, rivers, springs..) water for use in farming. The development must be efficient to fulfil production needs at acceptable cost and without imperilling the resource on the long-term.

To do so, you must:

- choose an **appropriate site** ;
- identify a **suitable scheme for mobilizing this water resource** (capture type and pumping means, water collection if surface water) ;
- identify a **water supply scheme** that limits losses;
- define an efficient **distribution network**.

Method

1-Location selection

Facility placement is not random. Several criteria must be taken into account, including:

- **property status:** conflict risk if water users do not own the land where the facilities are created;
- **soil and surface and underground water types:**
  - to adapt the infrastructures to soil characteristics (e.g. without specific equipment, it is difficult to dig a well in very rocky areas; or in the context where rivers are subject to strong flooding, it is difficult to create water catchment points) ;
  - to avoid salinity risks (e.g. in oasis basins, do not dig a well near the natron area) ;
- **the presence of other users** sharing the resource.

River, Morocco

Crops on the Nam Khan banks, Laos

- **distance from the area to be irrigated:** avoid excessive costs related to bringing the water to the edge of the cropping area;
- **distance from any pollution sources:** for example, do not build a well near areas where animals are penned (existing or previous) ; do not capture water from rivers immediately downstream from washing houses…;
- **for wells, check for the presence of water and potential water table flow rates:** check other nearby wells, sound first if necessary.

NOTE

For any development, you must take into account nearby existing works and / or studies: soundings, water quality tests…

You must also take into account the presence of other users sharing the resource.


Well, Sri Lanka

2-Water resource mobilization scheme

The mobilization scheme include the collection type (drilling, well, hydrant) and means of pumping (dippers, pedal-driven pumps, motorized pumps…).


Building a well, Morocco


Building a well, Sri Lanka

NOTE

Except for specific cases, building a well does not necessarily require significant resources. They may be constructed at low-cost by local masons.


Undeveloped slump, DR Congo

A few example of pumping equipment:

Vertical axis pump, Morocco

Drawing equipment, Niger

Pedal pump, Niger

Brace and pulley well, Sri Lanka

NOTE

There is a wide variety of pumping systems: from the simplest equipment (dippers) to the most sophisticated (solar pumping). It is important to adapt the equipment to water supply needs. For example, a pedal pump cannot irrigate more than 3000 m², a dipper can irrigate a maximum of 500 m².

3-Water supply scheme

The water supply system "carries" the water from its collection point to the beginning of the area for irrigation.

In certain cases, this headrace channel or pipe may be fairly long, implying significant construction costs. Solutions to avoid water loss in the water supply scheme should be systematically favoured.

Setting-up a headrace channel, Cambodia

Cement seguia, Morocco

4-Distribution network

The distribution network "distributes" to water to each plot (racks, beds...).


Buried PVC pipe, Morocco


Cement water supply channel, Morocco


Watering can irrigation, Cambodia

NOTE

When water is carried (water can irrigation), ensure that producers do not travel more than 50 m between the irrigation water source (storage or hydrant) and their plot.


Water tank, Morocco


Water tank, Morocco


Intermediate basin, Niger


Cistern construction, DR Congo

5-Related facilities

Often, hydro-agricultural infrastructures requires related facilities that must be established to ensure the quality, maintenance, and security of the work.


Protecting a well, Morocco


Setting-up a sump, Sri Lanka


Water quality test (Veolia Env. skill sponsorship), Niger

Advantages and Drawbacks

Technical

- ↗ Ensures sufficient water availability
- ↗ Reduces work time for drawing water and transporting it by hand: Availability for better crop tending
- ↘ Certain simple, economical irrigation technique do not provide for irrigating large surface areas

Economical

- ↗ Limits watering costs (temporary labour)
- ↘ Certain irrigation structures may be costly to install (concrete networks, drip irrigation, solar pump)
- ↘ Significant operating costs for motorized pumping

Environmental

- ↗ Sedentarizes farming activities: irrigated farming is an alternative to itinerancy and burning
- ↘ May lead to excessive drawing on the resource

POINTS TO REMEMBER

Each irrigation system must be adapted to the situation: before choosing the systems, you must think about the water needs and construction techniques that may be used locally.

Two types of cost must also be taken into consideration: the cost of building the infrastructures and their equipment (motorized pump, surface devices…) and operating and maintenance costs for the irrigation systems (motorized pump maintenance, channel repair, well cleaning…)

Agro-well water is never potable. Users and support organizations must take this into account.

TAKING IT FURTHER

Leaflet: Water management on cultivated plots (p. 69)
Leaflet: Protecting water from pollution (p. 73)

Water management on cultivated plots

Sustainable development for farming activities depends on water resource management.

Integrated management, appropriate for crop requirements and environmental conditions, provides for using the resource while preserving it.

“Best practices” for efficient water management and control are systematically promoted as part of Agrisud’s programs.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Optimizing water resource use
- Resource preservation
- Limiting irrigation expenses (work time and quantity of water used)
- Limiting the effects of waterlogging soils, harmful to crops
- Limiting soil leaching
- Limiting the effects of erosion due to water streaming

Conditions for implementation:

- Availability of a water source (well, pond, pump, temporary or permanent river...)
- Availability of suitable water capture and pumping means (channels, pump, dipper...)
- Knowing the resource capacity (available quantity, water table recovery time)
- Knowing the water requirements for crops in the local context (climate, soil quality...)

Principle

Water resource management, guarantying farming activities and their long-term development, requires:

- choosing **a suitable scheme for water distribution** ;
- **adopting farming practices** that ensure **water retention in the soil** in favour of cultivated plants and **limiting losses** by evapotranspiration;
- **dosing and supplying** as needed by the plant and according to physical environmental conditions;
- **adopting practices aimed at reducing the negative effects of water** during heavy rains.

Method

1-Selecting a distribution scheme

The distribution scheme should provide for sufficient water supplies to cover crop needs while limiting losses.

- Select **a water-saving distribution system:**
  - furrow irrigation rather than submersion (except for irrigated rice farming) ;
  - localized irrigation (drip irrigation, micro-spraying, bowls watering...) ;
  - for rice farming, favour IRS systems in correctly flattened and set-up paddy fields (low water layer).

- **Adapt facilities and water transportation techniques** to physical environmental conditions and the materials available to limit losses:
  - lined channels (cement, compacted clay, brick) ;
  - piping networks (PVC, polyethylene) ;
  - carrying in watering cans...

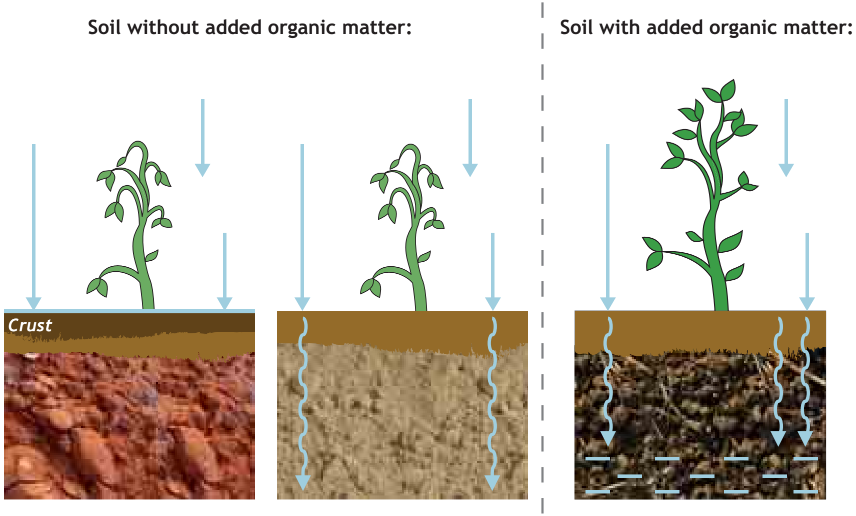

Micro-sprayers, Sri Lanka


Watering can irrigation, Cambodia

2-Farming practices for irrigated crops

Certain practices provide for improving soil water retention capacity, limiting evaporation loses, favouring seeping, and limiting erosion (for sloped ground).

- **Add basal organic manuring** (recycled manure, compost).
  With the addition of organic matter, the soil – well structured and rich in humus – will act as a sponge and better retain water. Better water retention in soils limits additional quantities needs and their frequency.


Soil without added organic matter:

Soil with added organic matter:

Clayey soil:
the water remains on
the surface and runs off

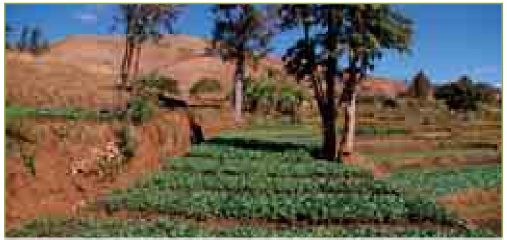
Sandy soil:
the water seeps
through and is lots

The water seeps
in and is held
by the soil

- **Mulch crops.**
  Soil cover limits drying caused by the wind and sun; it provides better conservation of water by the soil and, consequently, reduces the need for supplemental water.
  Moreover, mulching becomes, after decomposition, a source of organic matter positively improving the soil's water retention capacity (see previous paragraph).
- **Associate crops.**
  Associating crops plays a dual role. Root systems preserve good soil structure and therefore maintain its water retention capacity. The aboveground parts cover the soil; they limit evaporation and protect the soil from the effects of compaction due to watering.
- **Ensure good crop rotation.**
  Crop rotation provides both permanent soil cover (no settling and less evaporation) and conserving good soil texture (maintaining sufficient organic matter content).
- **Hoeing: "One hoeing is like two waterings."**
  Hoeing breaks up the top layer of the soil and favours water seepage. This prevents capillary ascension which causes significant evaporation and even salt ascension.
- **Set-up crop plots on slopes.**
  In irrigated farming systems on slopes, land laying out is often required to limit runoff: creating terraces, crop beds perpendicular to the slope… These techniques provide for limiting erosion and favour water seepage.
- **Arrange the crops on the slope.**
  In sloped areas, the crops are planted along contour lines to prevent channelling water in the direction of the slope and to favour its dispersion.


Watering on mulch, Cambodia


Weeding, India


Terraced vegetable crops, Madagascar

- **Hedging production sites.**

  Developing hedged farmland by installing live hedges, windbreaks, and fruit trees limits water evaporation and crop drying (maintaining environmental humidity).

  Hedging also provides a regular supply of organic matter, limiting humus losses (slowing mineralization) and therefore better soil water retention capacity.

3-Correct water dosage

The supplemental water required for crop growth depends on environmental conditions and the crop species.

A lack of water leads to wilting and drying. Excess water leads to asphyxia, root and crown rotting, and constitutes a major risk for the appearance of bacteriosis and cryptogrammic diseases.

When irrigation is practices, crops must receive a useful quantity of water without excess, based on climatic demand (rainfall minus evapotranspiration) and soil quality (texture and structure = water retention capacity).

During the rainy season, irrigation is composed **of supplemental additions** ; during the dry season, irrigation covers **losses** by evapotranspiration (between 5 and 10 litres of water / m² /day in low hygrometry areas).

- **Adapt irrigation** (dose and frequency) to plant needs based on their development stage and soil characteristics.

  E.g. For young plants, prefer low doses frequently. Conversely, for a well-developed eggplant with a deep root system and soil with good water retention, favour larger doses less frequently.


Vegetable farming gardens, Madagascar

Other Examples If the soil's water retention capacity is low, favour low doses and more frequent additions.

- **Adapt farming practices** to water resource availability for demanding crop or if the resource is limited.

  E.g. Practices IRS farming for rice.

- **Localized watering.**
  In dry areas (high climatic demand) or if the resource is rare, watering should be localized: create beds so as to water only in bowls.

- **Create vegetable crop beds or racks** based on farming season.
  In the dry season, set-up sunken beds concentrating the water on the crop. In the wet season, set-up mounded beds providing good draining and preventing excess water-related risks.

- **Ensure good crops association.**
  Associating crops with the same water requirements (but that may use different soil layers) to adapt the quantity of water proved and enhance its valorization.

- **Prefer "soft" irrigation** for spraying or sprinkling.


Watering, DR Congo

Use a rose with fine perforations or sprinklers projecting fine drops in a fairly small spray radius to prevent excessive splashing (mud spatter and destructuring the soil with water impacts) and to distribute the irrigation water uniformly.

REMARKS

→ **Watering periods** are selected outside periods of significant insolation If not, there are plant burning risks and significant evaporation loss. Moreover, plants are incapable of absorbing the water because the stomata are closed (protective reflex to prevent excessive transpiration).

→ Except for young transplanted plants which should be water twice a day for 10 days following transplanting, **favour watering in the morning** to the evening to prevent maintaining a high degree of humidity at night which favours disease development (such as mildew).

4-Practices for reducing negative effects during heavy rains

Whether in dry or wet areas, producers must often cope with intense rains which are important factors in soil and crop deterioration.

Best practices must therefore be implemented in order to benefit from the water and limit the damage from the rain (runoff and erosion).

- **Work along contour lines** for slopes (tillage and sowing) to limit runoff.

  For rainfed crops in sloped areas, the crop planting method plays a decisive role:
  - in maximizing the valorization of water (favouring water seepage);
  - and in protecting fields against erosion which remove the top layers, disappearance of fine elements, creating ravines, and destroying crops (favouring the dispersion of runoff).

- **Create anti-erosion facilities** to slow runoff.

  Develop cultivated slopes (terraces, half-moon, benches, stone lines...) for dispersing runoff, reducing its speed and limiting its erosive strength. They also favour water seepage and optimally recharging the soils' usable reserve.

- **Hedging farming areas** to reduce the negative effects of heavy rains.

  The presence of trees plays a dual role controlling runoff and improving surface water seepage. In addition, hedging protects the soil from the direct effects of settling under the effects of heavy rains.

- **Ensuring continuous soil cover.**

  Continuously covered soil (crops association and rotation, mulching, cover crops) is protected from the direct effects of rain and erosion due to runoff. Any period during which the soil is bare in the rainy season is a period at risk.

NOTE

Favouring water seepage rather than channelling it for evacuation protects soil from erosion. Downstream runoff in farming areas carries less suspended material and does not threaten lower areas with silting (shallows, rice farming valleys...). Moreover, water quality is preserved, benefiting river and river delta aquatic ecosystems.

Advantages and Drawbacks

Technical

↗ Ensures sufficient water availability

↗ Limits the risks of leaching and waterlogging the soil

↗ Prevents erosion due to runoff and soil settling

↘ Certain simple, economical irrigation technique do not provide for irrigating large surface areas

Economical

↗ Limits expenses related to irrigation and consequently "frees up" work time for tending crops

↗ Limits the quantity and energy cost for motorized pumping (thermal or non-solar electrical motor)

↘ Some irrigation infrastructures may be costly to set-up (cement networks, drip irrigation)

↘ May involve other labour (mulching, hoeing)

Environmental

↗ Ensures water resource sustainability

↗ Ensures maintaining humidity favourable to fauna and flora

↗ Limits the significant use of polluting energies (water pumping)

POINTS TO REMEMBER

Water resources, whether limited or not, should not be wasted.

Practices should be adapted to the environment, crop needs, and the need to preserve the resource and the environment.

In order to ensure good water availability, a set of practices should be implemented providing for limiting losses and optimizing the quantities used.

TAKING IT FURTHER

Leaflets: Manure recycling (p. 77) / Basal organic manuring (p. 105)

Leaflet: Hedging vegetable crops sites (p. 93)

Leaflet: Bowls farming (p. 109)

Leaflet: Crops association (p. 117)

Leaflets: Mulching (p. 121) / Direct seeding Mulch-based Cropping system (DMC) (p. 157)

Protecting water from pollution

Implementing agroecological practices provides for protecting underground and surface water by limiting the pollutant effects of farming activity.

The interest lies in conserving resource quality.

Indeed, quality water provides for preserving ecosystems and guarantees users the resource's availability without health risks.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting livestock effluent, chemical, and organic pollutant dispersion
- Protecting the water resources against often irreversible contamination

Conditions for implementation:

- Availability of the infrastructures required to collect animal faeces: pens, evacuation channels, liquid manure collection pits…
- Availability of straw for bedding in animal pens
- Availability of tools and infrastructures for recovering the collected animal faeces
- Knowing how to prepare organic matter
- Familiarity relevant plants and natural fertlizers and their preparation and use to limit the use of chemicals

Principle

Preserving water from farming pollution represents a major issue. Water provides for balance in ecosystems, irrigating crops, watersupplying cattle, and supplying the population with water.

To ensure its protection with regards to farming pollution, several headings for action should be jointly implemented:

- **promoting inputs** (fertilizers, phytosanitary products) **that are easily degradable** and without danger to the environment as alternatives to chemicals and **not using herbicides** ;
- **recovering livestock effluents** ;
- **implementing practices to limit soil leaching** which may be a source of pollution for the water table and rivers.

Method

1- Using natural inputs and not using chemical herbicides

For fertilization and phytosanitary protection of crops, producers may use natural inputs:

- compost made from local biomass, crop waste and manure, or recycled manure, which are excellent fertilizers; they may be supplemented by natural products such as ash, crushed limestone, and natural phosphate in order to improve their effects;
- plant-based (neem, tobacco, papaya…) or mineral-based (copper, sulphur..) solutions as alternatives to chemical treatments, against pests and disease.


Hot pepper, garlic, and ginger based treatment, Morocco


Compost unit, Madagascar

NOTE

Just because the products used are natural, does not mean they are not harmful. For example, in high concentrations, poultry excrement may produce nitrogen effluents that, carried by irrigation water or strong rain, pollute the water table and rivers.

If poultry excrement is used pure, as a regular fertilizer, producers must split-up the doses: 40 g of dry excrement at most per dose per m² at a minimum of 3-week intervals.

To tend their cultures, producers can stop the use of herbicides in favour of:

- physical pest control (mechanical hoeing, manual weeding);
- mulching and cover crops limiting weed progression;
- crop associations and rotations preventing self-propagating plant invasions.

artificial chemical fertilizers have a “destructuring” effect on the soil (destroying the clay-humus complex) thereby decreasing its water retention capacity.

If producers nevertheless intend to use them, they should first add organic matter (and limestone where appropriate) to retain them (adsorption by the clay-humus complex). If not, it may pollute the water table (by leaching) and crop yields may not be improved (leached elements not absorbed by plants).


Pen, Laos

2-Recovering livestock effluents

Livestock effluents (liquid manure and slurry) quickly produce water-soluble nitrates. In high concentrations, they may cause pollution in underground water reserves and rivers.

To prevent pollution risks, you must:

- **pen animals** and regularly collect solid faeces; regularly cleaning pens is mandatory to preserve collected product quality as well as preventing pollutants from being carried away by rains (seepage into the water table, runoff into rivers);
- **cover the floor** in livestock buildings with bedding (straw, glumes…) to absorb and limit liquid manure discharge;
- if possible, provide for **installing a** slightly inclined slab in pig rearing buildings, water evacuation channels, and collection containers for liquid manure and slurry.

The matter collected (bedding collected from pens, poudrette, manure, and liquid manure) may then be recovered in the form of recycled manure or compost (see paragraph 1).

3-Practices for limiting soil leaching

The mineral elements present in the soil are easily leached by rain and irrigation water, all the more so if the soil has low fixing capacity. The leached elements then find their way to the water table.
Certain practices should be implemented to improve soil fixing capacity (ability to adsorb minerals) thereby preventing leaching.

- **Limit working the soil and ensure it has continuous cover.**
  Limited working of the soil and continuous cover provide for ensuring stable structure, favourable to clay-humus complex formation, and therefore maintaining good mineral adsorption capacity.


Deteriorated soil, Niger


Cover crops, Gabon

- **Dose and split the supplements in chemical and organic fertilizers.**

  Overdosing fertilizer is an element favouring losses as well as pollution through leaching. Fertilizer should be added as a supplement if necessary but divided up. The more the soil structure is fragile (texture with a low clay and /or humus content, low calcium content), the less the adsorption capacity will be good. In this case, the fertilizer additions must be split up.

- **Add basal organic manuring** (recycled manure, compost).

  As the organic matter decomposes through the action of living organisms in the soil, humus forms, which, bound to clay particles, constitutes the clay-humus complex. This complex adsorbs mineral elements and protects them from leaching. After adsorption, they are progressively liberated and assimilated normally by cultivated plants.

Malabar spinach on mulch, Sri Lanka

NOTE

Burning is strongly discourage since it directly mineralizes the organic matter. Fire accelerates the loss of organic matter in the soil leading to destructuring and altering their biological properties and physical chemistry: reducing the work of living organisms, the water retention capacity, and the mineral element adsorption capacity.

Advantages and Drawbacks

Technical

↗ Improves soil structure (contributing organic matter) and thereby favours fixing mineral elements

↗ Easy to implement practices

↘ Requires the availability of significant quantities of organic matter

↘ Labour-intensive for penning animals and collecting organic matter

Economical

↗ Reduces the cost of using phytosanitary treatments, chemical fertilizers, and herbicides

↗ Reduces leaching losses and avoids the purchase of fertilizers to replaces the losses

↘ Represents a cost if the producer does not have organic manure available

Environmental

↗ Limits the use of chemicals and herbicides with harmful effects on the environment

↗ Favours good livestock effluent, often highly pollutant, management

POINTS TO REMEMBER

Farming practices may be pollutant and endanger water quality: poorly managed livestock effluents, uncontrolled fertilizer additions, abusive use of chemical pesticides and herbicides. Producers must be sure to implement practices aimed at limiting such pollution:

→ using natural products and proportioning additions;
→ not using or abandoning herbicides;
→ recovering and / or promoting the use of livestock effluents;
→ preserving good soil structure which favours fixing mineral elements and limits leaching.

TAKING IT FURTHER

Leaflets: Crib composting (p. 89) / Manure recycling (p. 77)
Leaflet: Basal organic manuring (p. 105)
Leaflet: Natural phytosanitary treatments (p. 127)
Leaflets: Crops association (p. 117) / Crops succession (p. 111)
Leaflet: Mulching (p. 121)
Leaflet: Direct seeding Mulch-based Cropping system (DMC) (p. 157)

Manure recycling

Manure recycling is an operation that consists of preparing the raw manure before burying it in the soil for fertilization.

It has the advantage of improving the quality of the buried organic matter.

This practice has been primarily implemented as part of Agrisud's programs in Morocco, Niger, Cambodia, and India.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Making nutritional elements easily available to pants by improving manure decomposition
- Limiting the risk of heating during manure decomposition
- Limiting the risks of propagating weeds, pests, bacteria, and other mould contained in the manure

Conditions for implementation:

- Availability of raw manure or bedding 1.5 and 3 kg per m² depending on crop type and cycle duration (average 2.5 kg per m² for poly-crops on the same plot)
- Availability of a place in the shade and mulch to cover the manure (recycling manure in piles)
- Availability of the necessary equipment (shovel to dig the pit, break-up the manure, and make the piles, and a watering can)
- Availability of a water source nearby

Principle

In general, manure (raw faeces or mixed with bedding, poudrette from pens…) is stored by producers in open-air piles for an extended period. It is then added, as it is, to the plot.

The consequences of this storage method are:

- **loss of manure quality** given the exposition to heat and rain (freeing nitrogen into the atmosphere, leaching fertilizing elements, destroying useful micro-organisms…) ;
- **incomplete and heterogeneous decomposition** of the manure;
- **plot contamination risk** when fertilizing (hot bed for disease and weed seeds).

Yet, using manure is generally the most common fertilization method because it is available locally and low-cost (contrary to chemical fertilizers).

Therefore it is recommended to use manure by first recycling it in order to:

- **preserve its quality** through better storage conditions;
- **improve its decomposition** in order to use it effectively without risk to plants.

Method

The practice consists of fermenting the manure as for composting (in the presence of air and increasing the temperature).

Two techniques are possible depending on weather conditions in the area (ambient humidity, rain, heat…).


Preparing raw manure


Pile of recycled manure


Raw manure


Manure being recycled

1-Recycling in highlight areas

- Dig a pit and place the previously broken up manure in 20 to 30 cm layers
- Dampen each layer without soaking before moving to the next
- Cover the pit with earth
- Water once per week and turn over the manure twice at 3 week intervals (when the manure cools)
- The manure is usable when it no longer gives off heat

2-Recycling in wet areas

- Collect the manure in the shade, under a tree for example, and break it up
- Progressively dampen without soaking (risk of leaching soluble elements)
- Make small piles of manure (1 m high, 1.5 m diameter) or in a swath (1 m high, 1 m large, length depending on the quantity of manure available) and lightly pack
- Protect the manure from the sun and wind with mulch (savannah grass that has not gone to seed, palms...)
- Water if it dries out
- Rollover after cooling (2 weeks)
- Make piles again, water, and cover
- Manure is usable after complete cooling

Once recycled, the manure may be kept for later use.

REMARKS:

→ If the manure is full of straw, it is possible to mix manure with less straw or add a source of nitrogen to accelerate its decomposition (poultry or excrement, liquid manure, slurry...).

→ It is possible to enrich recycled manure by adding ash (potassium), natural phosphate (phosphorous), glumes... depending on soil requirements (lacking elements, improving its structure) and / or crops (specific requirements for one or more elements).


Step 1: Digging the pit


Digging the pit (cont.)


Step 2: Add manure


Step 3: Check the temperature

3-Using recycled manure

Depending on development stage, recycled manure may be used:

- **coarse, young** : for recovery manuring (restoring basal fertility);
- **mature** : mixed with soil, at the edge of the root exploitation level (if low quantities, make localized additions);
- **well decomposed** : use in tree farming to fill pots and as a sowing cover in vegetable and rice nurseries.

Depending on its intended purpose, recycled manure is used and dosed as follow:

- **for vegetables**: 25 to 30 kg per 10 m² bed or rack, spread on the ground before ploughing. If quantities are low, reduce the doses and pinpoint around recesses (a double handful);
- **for rainfed crops**: 10 to 20 t / ha spread on the ground before ploughing or added locally;
- **for nurseries**: plough in 3 to 5 kg /m² in the bed.


Adding recycled manure, DR Congo

Advantages and Drawbacks

Technical

- ↗ Easy technique to implement (compared to composting)
- ↗ Assures good decomposition of straw-based manure
- ↗ Better quality than raw manure
- ↘ Not as rich as compost

Economical

- ↗ Not very labour-intensive
- ↗ Low implementation cost if the farmer has manure

Environmental

- ↗ Ensures farming / livestock complementarity
- ↗ Improves soils without using chemical fertilizers
- ↗ Practice suitable for livestock areas
- ↗ Provides for recycling livestock effluents
- ↘ Presents pollution risks if over watered (runoff chilling juice)

NOTE

Each plant has differing capabilities for benefiting from recycled manure. So each plant types has its preferences **depending on material decomposition**.

POINTS TO REMEMBER

Manure recycling is easy to implement, necessary and effective for maximizing the value of this livestock by-products.

Although it has lower performance than composting, this practice is probably better suited to Sahel areas with regards to socio-economic and environmental conditions, i.e.: competition for plant matter, low availability of mulch, and size of livestock activities.

TAKING IT FURTHER

Leaflet: Swath composting (p. 81)

Leaflet: Basal organic manuring (p. 105)

Swath composting

Swath composting consists of placing a mixture of raw materials in long narrow piles called “swaths.” The method provides for composting larger quantities of organic matters than the pile method.

This practice has been primarily implemented as part of Agrisud’s programs in Niger (dry areas) and Madagascar (wet areas).

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Develop a high-quality organic fertilizer with locally available raw materials
- Making nutritional elements easily available to plants after humification and mineralization
- Limit the risks of propagating weeds, pests, bacteria, and other mould contained in the manure and straw

Conditions for implementation:

Dry areas:

- Availability of a land with access to water and the required tools (wheelbarrow, watering can, shovel, pitch fork, sieve)
- Availability of the materials to create the compost (manure, straw, clay or sand depending on soil type, wood ash, bone powder...)

Wet areas:

- Availability of a land with access to water and the required tools (watering can, machete, basket, pitch fork, shovel)
- Availability of materials to create the compost (manure, straw, grass, banana tree trunks, sugar cane waste after distillation, ash...)

Principle

Composting is an acceleration of the natural decomposition process for organic waste. Intense bacterial activity is primarily responsible for decomposition; it requires oxygen and releases heat. The resulting compost acts as a supplement and fertilizer. There are different composting techniques includes swath composting.

Swath composting method in dry areas

This method consists of decomposing organic and plant materials by aerobic fermentation.

1-Location selection

The composting platform must be located near **gardens** (site where compost is used), **near a water source**and animal pens (availability of manure), in **the shade** of a hedge or a tree (to favour moisture retention).

2-Composting area

Dig 4 neighbouring pits **1.5 m wide, 3 to 6 m long** and **20 cm deep**. If shade is provided by a tree, move 2 m away from the tree presence of roots in the soil).

The composting area must include **a soaking basin** for wetting the straw before composting. If the soil is clayey, the water will be held better; if not, cover the walls and soil with a plastic tarpaulin.

3-Material preparation

- **Soak the straw** 2 days in the basin provided for this purpose or water it abundantly. Similarly, wet the other piled materials (glumes, leaves...)
- **Break-up the manure** and moisten (without leaching)
- **Burn and crush the bone** to make a powder

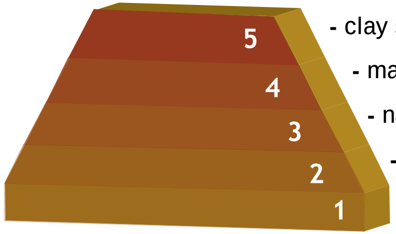
Creating compost pits, Niger

Filling the soaking pit

Moistening millet glumes

4-Assembling the swath (method tested in Niger)

Abundantly water the bottom of the pit (until puddles form). The compost swath is then composed of a **succession of 5 layers**, each composed of a succession of several sub-layers of uniform materials.



Layer composition:

- clay sub-layer (sandy soil) or sand (clay soil);
- manure sub-layer;
- natural phosphate or bone powder sub-layer;
- wet stray sub-layer;
- ash sub-layer

For 800 kg of compost (1 m x 3 m swath):

17 wheelbarrows of straw

7 wheelbarrows of dung, straw manure, or poudrette

1 wheelbarrow of clay or sand (depending on soil type)

15 to 18 watering cans of water

20 handfuls of wood ash

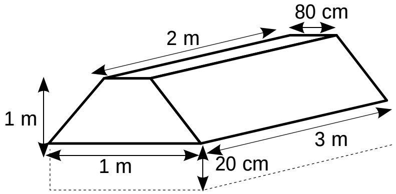
20 handfuls of bone powder, feathers, fish waste, or natural phosphate

Other possible materials: grass, ground palms, leguminous, tree leaves, glumes, peanut shells, peelings…

After assembling various layers, the swath has a trapezoid shape (diagram below).

The dimensions (indicative) must provide for:

- easily manipulating the swath with a pitch fork;
- holding water without requiring major digging effort;
- good fermentation at the swath core (moisture, ventilation, heat).



5-Protection

In order to protect the swath from drying caused by the wind and / or sun, it is advisable to cover with:

- An earth cover, mats, woven canvas bags, or finely chopped straw (do not use impervious plastic materials);
- a layer of short straw covering the entire swath.

If it rains, the swath may be covered (plastic tarpaulin) to prevent compost leaching. It must be uncovered after the rain to facilitate ventilation.

Water

Manure

Straw

Feathers

Bone powder + ashes

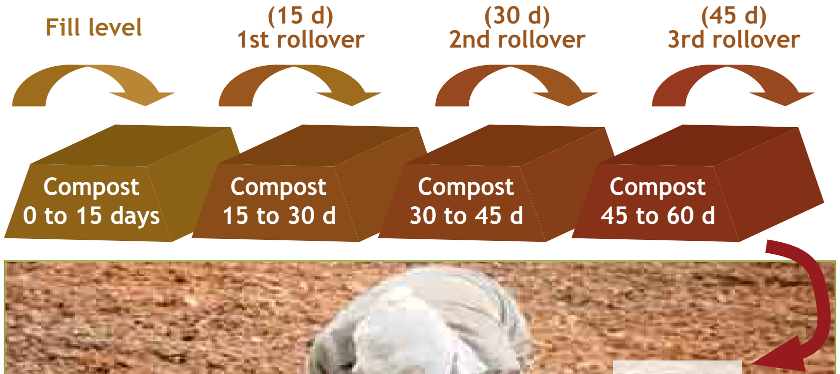
Water

6-Compost tending

- **Rollover the compost every 15 days** moving it from the first pit to the second, then the second to the third, and so on. The top layers move to the bottom of the next pit and the outside edges of the swath move to the core.
- **Water** with 1 to 2 watering cans as each layer is rolled over

Rolling over serves to **restart fermentation** by mixing the elements, ventilating them, and moistening them.

When rolling over the first pile, the second pit is filled, freeing the first. It may then be filled again with fresh composting matter... and so on until the 4 pits are filled, all at a different composting stage.



Localized compost addition

7-Monitoring

After assembling the swath and for each rollover, you must **check the temperature increase**. This indicates correct fermentation.

Every 15 days, the compost swath must heat and then cool as activity decreases.

Check by touching: plant rods in the core of the swath, in the middle, and on the sides. Remove the rods, they should be hot.

If the check indicates no heat 2 days after assembling or rolling over, open the swath:

- if it is partially or totally dry, add water (without water fermentation cannot take place);
- if it is not dry, add manure, or water with slurry, which are both activators (the nitrogen and bacteria they contain will ensure decomposition).

8-Compost development

During the composting process:

- **the volume decreases as** the plant matter decomposes;
- **composition becomes uniform** preventing identification of the initial elements.

In the end, the compost is **light, moist, and aerated, with a dark brown colour.**

Good compost does not smell bad (no rotting); its odour is similar to forest mulch.

9-Conservation

If the compost is not used immediately, it is recommended to dry it in fine layers, in the shade, for 2 days then **keep it in piles or in sacs** sheltered from the sun and moisture.

Check the compost temperature using a wooden stick

Swath composting method in humid areas

As for dry areas, the method consists of decomposing organic and plant matter in aerobic fermentation.

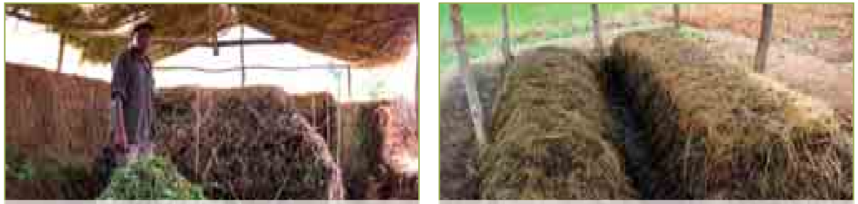
1-Location selection

The composting area must be located near **gardens** (site where compost is used), **near a water source** and **animal pens** (availability of manure), in a flood-free zone

2-Set-up

- **Weed** and **level the land**
- Build a sufficiently high shelter to be able **to protect the compost** and manipulate the materials while standing
- **Dig water evacuation channels around the composter**
- **Plant live hedges** around the shelters (retain humidity and provide plant matter)

Example of composting facilities in Madagascar



Other examples of composting facilities in Madagascar

3-Collecting and preparing materials

The diverse elements a compost contains the richer it will be. It must be composed of the following materials:

- **cellulose-rich matter:** straw, stalks, leaf stalks;
- **nitrogen-rich (N) matter:** green matter (especially leguminous, azolla, excrements…) ;
- **phosphorous-rich (P) matter:** bone powder;
- **potassium-rich (K) materials:** banana tree trunks, ash;
- **activators:** manure, sugar cane waste after distillation.

In order to facilitate their decomposition, large sized matter (straw, grass, banana trees) must be chopped.

Preparing compost, Madagascar

REMARKS:

→ The powdered bone and ash may be incorporate in the compost during assembly, when rolling over, or when adding the compost to the field.

→ If azolla is used, wilt the plant in the sun (3 days) or mix it with ash to bring out the water it holds.

4-Assembling the swath

The compost pile is composed of a **succession of layers,** themselves composed of a succession of sub-layers of uniform material as seen in the following diagram:

1. Lay out the **cut banana tree trunks** in a strip 1.5 m wide and at least 2 m long: swath length depends on the length of the composter (length of the composter decreased by 1.5 m to facilitate rollover) and the quantity of composting materials.
Lay out the coarse elements at the base of the compost pile provides for improved ventilation.

2. Lay out a layer of about 20 cm of **dry material** on the banana tree fragments.

WATERING

All layers must be watered. Water quantities vary based on the initial moisture in the materials and the swath size.
The compost swath must be sufficiently moist but not dripping.

3. After watering, lay out a layer of about 5 cm of **manure**.

WATERING

4. After watering, lay out a layer of about 15 cm of **green matter** of the manure. Then water again.

WATERING

Repeat these operations until you have a**1.5 m high swath**.

The measurements and materials are indicative and may be changed based on experience and quantities available.

Compost unit, Madagascar

REMARKS:

After assembling various layers, the compost swath measures 1.5 m wide by 1.5 meters high.

Its length depends on the space available as well as the quantities of the various composting materials. However, its length should never be less than 1.5 m.

These dimensions are indicative and should provide for:

→ manipulating the swath easily with a pitch fork;

→ good fermentation at the core of the swath (moisture, ventilation, heat).

5-Protection

Cover the swath with a layer of straw (about 10 cm) in order to maintain constant humidity.

6-Compost tending

Rollovers are performed about every 10 days after noting the increased heat and its progressive cooling.

When rolling the swath over:

- **keep the layer order** such that those on the top end up on the bottom;
- **bury materials** on the edge towards the centre of the swath;
- **water** new layers ever 20 to 30 cm.

After rolling over, the compost is again in a swath, it starts to ferment again in the following days (heat production).

Compost rollover

7-Monitoring

Check temperature increase (verifying fermentation).

Check by touching: plant rod in the sides and in the middle to the heart of the swath in order to check for heating.

3 days after assembling the swath or rolling over, remove the rods and check by touching:

- **if it is hot:**
  - fermentation has begun, return the rods, all is well;
- **if it is cold:**
  - check that the swath is moist; if it is not moisten (without water fermentation cannot occur);
  - if the swath is already moist: increase the quantities of manure and green matter or water with slurry (add nitrogen) to activate fermentation.

The compost is mature when the swath no longer makes heat after rolling over. Expect about 1 and a half months (3 to 4 rollovers).

At maturity, the compost has a fine composition and is brown in colour. The various materials are no longer identifiable. Its odour is similar to underbrush mulch.

8-Conservation

For correct conservation, the compost must be stored:

- **sheltered from the sun** in order to limit nitrogen leakage;
- **sheltered from rain** in order to prevent leaching mineral elements.

In these conditions, the compost may be conserved for several months.

Compost conservation

Compost use

Depending on development stage, compost may be used:

- **coarse, young:** used for recovery manuring (restoring basal fertility);
- **mature:** mixed with soil, at the edge of the root exploitation level (if low quantities, make localized additions);
- **well decomposed:** use in tree farming to fill pots and as a sowing cover in vegetable and rice nurseries.

Depending on its intended purpose, compost is used and dosed as follows:

- **for rice farming (IRS):**
  - basal manuring: spread (at least 10 t / ha) for the 1st ploughing;
  - maintenance manuring: spread in the rows before weeding (about 5 t / ha);
- **for vegetables:** 25 to 30 kg per 10 m^2 bed or rack, spread on the soil before ploughing. If quantities are low, reduce the doses and pinpoint around recesses (a double handful);
- **for rainfed crops:** 10 to 20 t / ha spread on the soil before ploughing or added locally;
- **for nurseries:** plough in 5 to 8 kg /m^2 of bed, then after sowing, uniformly spread a fine layer 0.5 kg / m^2.

NOTE

Each plant has differing capabilities for benefiting from compost. Each type of plant has its preferences **depending on material decomposition.**

Composting time (indicative)	Plants
15 - 30 d (coarse compost, yellow)	Potato, marrow, cucumber, tomato, eggplant, okra, hot pepper, watermelon, maize, melon, leak, sweet pepper
30 to 45 d (mature compost)	Lettuce, cabbage, spinach, turnip, cereals
45 to 60 d (well decomposed compost)	Carrot, radish, garlic, onion, celery, strawberry, medicinal, aromatic and culinary plants, vegetable nursery

Advantages and Drawbacks

Technical

- ↗ Achievable with various types of local organic matter
- ↘ Requires sufficient know-how in order to control fermentation
- ↘ In competition with livestock for using straw

Economical

- ↗ Produces quality fertilizer that positively and durably impacts yields
- ↗ Provides for maximizing the value of locally available materials
- ↗ In certain contexts, reduces expenses related to purchasing artificial chemical fertilizers if the organic fertilizer is produced locally
- ↘ Labour-intensive
- ↘ Representing an expense in humid areas (shelter construction)

Environmental

- ↗ Improves soils without using artificial chemicals
- ↗ Provides for promoting the use of natural biomass
- ↗ provides for maintaining fallow areas without burning (mowing straw)

POINTS TO REMEMBER

Swath composting is easily adaptable and provides for maximizing the value of numerous plant sub-products.

The resulting compost may be used for all crops. According to the maturity level, its usage differs; it may be added as basal manuring or maintenance manuring.

However, the quantity to be added to the plot must be sufficient. If low quantities are available, it is preferable to reduce the cultivated surface area and / or add the compost locally rather than spread in small doses. Experience has shown that the primary difficulty lies in the ability to mobilize plant matter particularly during dry periods and produce sufficient compost.

TAKING IT FURTHER

Leaflet: Manure recycling (p. 77)
Leaflet: Crib composting (p. 89)
Leaflet: Basal organic manuring (p. 105)

Crib composting

Crib composting consists of placing a mixture of raw materials in a cell with woven walls called a "crib."

This method provides uniform decomposition of the composting materials and a quick composting process.

This practices has been primarily implemented as part of Agrisud's programs in Cambodia and Sri Lanka.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Develop a high-quality organic fertilizer with locally available raw materials
- Limit the risks of propagating weeds, pests, bacteria, and other mould contained in the manure and straw

Conditions for implementation:

- Availability of a shaded site with access to water
- Availability of the necessary equipment (watering can, machete, pitch fork, shovel)
- Availability of the following materials:
  - Bamboo or wood lathing for the crib
  - Dry materials: straw, grass, glumes, or dry leaves (not eucalyptus)
  - Green materials: grass, easily decomposed leaves, banana trunks
  - Manure, mulch, sugar-cane residue after distillation, slurry, liquid compost…
  - Ash, bone powder, fish waste…
  - Sorted, fermentable household waste

Principle

This practice consists of decomposing organic and plant materials by aerobic fermentation ; the process is accomplished in a crib.

Method

1-Crib production

- **Build a** 1 m^3 with wooden sticks or bamboo (no bottom)
- **Select a** shady spot, near a water source and livestock buildings
- **Turn over the soil** to aerate the spot where the crib will be located
- **Plant a** wooden stake (2 m) at the centre of the crib

The crib must be able to be opened in order to move it easily without moving the compost it contains.

2-Material preparation and crib filling

- **Cut the materials** (dry and wet organic matter) in sections less than 25 cm
- **Collect livestock manure:** ruminants, chicken, pigs
- Lay down in alternation **a layer of dry material, a layer of fresh material, and a layer of manure:**
  - 25 cm of dry material followed by watering
  - 10 to 15 cm of wet material with light watering
  - 5 cm of fragmented or damp manure
  - 0.5 cm of ash
- **Water** abundantly without leaching the pile
- **Repeat the layers** until the crib is filled
- **Stir and remove the wooden stake** from the centre in order to create a vent-hole (favouring aerobic conditions)

Cribbed compost, Cambodia

Crib, Sri Lanka

Crib, Cambodia

3-Composting

- **Maintain** constant humidity by periodically watering the crib
- Every 10 days, **perform a rollover:**
  - turn over the earth 1 m² beside the crib
  - move the crib and put it over the turned earth
  - fill the crib by turning the compost over layer by layer (the top layer is on the bottom)
  - water

Compost must be correctly moistened but not dripping; limit the quantity of water provided in order to not leach the compost.

4-Monitoring

Drive in the wooden stick into the compost to record the temperature increase, a sign that the plant matter is fermenting. If the compost does not heat up within 3 days after filling the crib or after the rollover, **moisten** and **increase the quantities** of manure and green matter (nitrogen contribution).

It is possible to activate decomposition by watering the compost with slurry or liquid compost.

The compost matures after 30 to 45 days:
- the colour is brown;
- the material is at ambient temperature (no heat);
- there are no unpleasant odours;
- earthworms are present.

Remove the crib to be reused, do not leave a “cube of mature compost” in the rain (leaching) or the sun (desiccation and nitrogen loss).

The compost is used the same was as if produced by swath composting (p. 81).

Reusing a crib, Cambodia

Advantages and Drawbacks

Technical

↗ Achievable with various types of local organic matter
↗ Quick composting process producing very uniform material
↗ Provides for progressively adding material (over 2 or 3 days)
↘ Requires sufficient know-how in order to control fermentation
↘ In competition with livestock for using straw

Economical

↗ Produces quality fertilizer that positively and durably impacts yields
↗ Provides for maximizing the value of locally available materials
↘ Labour-intensive

Environmental

↗ Improves soils without using artificial chemicals
↗ Provides for promoting the use of natural biomass
↗ provides for maintaining fallow areas without burning (mowing straw)

POINTS TO REMEMBER

Crib composting is an easily adaptable practice for maximizing the value of numerous plant sub-products.

Depending on maturity level, the compost is used differently; it may be added as basal manuring or maintenance manuring.

If low quantities are available, it is preferable to reduce the cultivated surface area and / or add the compost locally rather than spread in small doses.

The primary difficulty lies in the ability to mobilize plant matter, particularly during dry periods and produce sufficient compost.

TAKING IT FURTHER

Leaflet: Swath composting (p. 81)
Leaflet: Basal organic manuring (p. 105)
Leaflet: Manure recycling (p. 77)

Liquid compost

Liquid compost is a fermented aqueous mixture, which may be used as a fertilizer and/or treatment product depending on the materials it contains.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Improving soil fertility
- Improving mulch decomposition
- Protecting plants against insects, bacteria and other nuisances

Conditions for implementation:

- Availability of manure: poultry or bat droppings, pig manure, cow dung, sheep manure, etc.
- Availability of plant material (leaves):
  - *Chromoleana odorata* (Eupatorium): nematode control
  - *Nicotiana tabacum*(tobacco) insect control
  - *Tetradenia riparia:* bactericide
  - Neem: insecticide
  - *Tithonia diversifolia:* pesticide
  - Leguminous (*sesbania grandiflora and rostrata, leucaena leucocephala, cassia siameaor* and *spectabilis, moringa olifera*): enhance nitrogen input
- Availability of a woven fibre sack and a drum or earthenware jar
- Availability of a wooden stick

Principle

Making liquid compost involves a fermentation process for plant materials in an aqueous environment.

Method

1 - Making liquid compost

- **Step 1:** Find a drum or jar with a minimum capacity of 100 litres
- **Step 2:** Fill a woven fibre sack with the following
  - 10 kg mixed leaves
  - 6 kg manure
- **Step 3:** Fill the drum or jar with 100 litres water
- **Step 4:** Place the closed sack in the water with a large stone on top so that it is completely immersed
- **Step 5:** Close the drum or jar with the lid or a mat to avoid flies and foul smells as well as for safety reasons (child-related risks); do not seal (otherwise, anaerobic fermentation will result, producing acid which could burn the leaves)
- **Step 6:** Two days after step 5, stir the water for 5 minutes and add more water if necessary (the sack must remain immersed); repeat this operation at least once a week
- **Step 7:** After 3 - 6 weeks (the length of the process varies according to outside temperatures), the liquid compost is ready for use; it is clear and odour-free

Liquid compost may be kept for one month in a protected, shaded place.


Step 2


Step 3


Step 6

2 - Use of compost

- **Directly on the plot of land:** apply the liquid compost 2 weeks after transplanting, or 3 weeks after emergence of seedlings, at the time of flowering or when the symptoms of deficiency appear (lack of green colour due to nitrogen deficiency); 50/50 dilution; dosage: 2.5 to 3 litres per m^2 or 0.3 litres per recess if applied locally.
- **On the foliage** (avoid on young plants): dilute 1/4 liquid compost in 3/4 water and apply 1 - 2 litres/m² (fine watering can rose). Liquid compost may be used as a leaf fertilizer with a spray provided it is filtered beforehand using a fine cloth.

The compost may be applied each week until flowering.


Drum, Sri Lanka


Brick liquid compost pit, Madagascar


Liquid compost jar, Cambodia


Using liquid compost, Cambodia

Advantages and Drawbacks

Technical

- ↗ Can be made with many different plant materials depending on the desired effects and complementary interactions
- ↘ Requires sufficiently large, watertight containers which are not necessarily available cheaply

Economical

- ↗ Cheap to make (if containers are available)

Environmental

- ↗ Improves soil structure if the liquid compost is added over mulch
- ↗ Reduces the need for artificial chemical pesticides if pesticide plants are used to prepare the compost

POINTS TO REMEMBER…

Liquid compost is a beneficial fertilizer for maintenance and an effective leaf fertilizer.

The use of liquid compost on mulched plots enables rapid mulch decomposition, thus enriching the soil with organic matter.

Using plants which form part of the make-up of organic pesticides can also help to regulate crop parasites.

TAKING IT FURTHER:

Leaflet: Mulching (p. 121)
Leaflet: Natural phytosanitary treatments (p. 127)
Leaflet: Bowls farming (p. 109)

Hedging vegetable crops sites

Hedging is an agroforestry technique consisting of planting shrubs and trees around and in cultivated plots. Depending on their density, layout, and type, they limit insolation and wind, thereby favouring soil water retention and creating a micro-climate favourable to crops.

The root system of these plants allows the absorption and recycling of mineral elements that have migrated into deep soil layers. Biomass produced may also be used as organic fertilizer and mulching vegetable crop beds.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting damage from wind and / or caused by animal pasturing
- Creating an environment (hedged landscape) favourable to crops (humidity, shade, diversity)
- Recycling leached mineral elements
- Availability of usable biomass source on the farm
- Creating ecological habitats conducive to maintaining agroecological balances

Conditions for implementation:

- Availability of a water source nearby
- Availability of plants favouring quality local varieties
- Availability of tools (shovel or hoe, watering equipment) and protective equipment for young plants

Principle

Planting shrubs and trees like living hedges, or sparsely in vegetable crop areas, allows creating hedge farmland favourable to crop growth.

Living hedges and trees have an effect that is both:

- **protective**: they protect crops from damage caused by the wind and / or wandering animals
- **regulating**: with their shade and windbreak effect, they participate in maintaining humidity in the soil and improve hygrometry in the dry season and during the rainy season; their deep root system allows underground water ascent;
- **improving**: by producing biomass, trees – more particularly leguminous (nitrogen contribution) – participate in the organic matter cycle directly (mulch decomposition) or indirectly (composting) ; moreover, their root system allows soil airing (structuring properties of trees such as acacias) and recycling of mineral elements leached in the soil's deep layers;
- **economical**: whether from forest or fruit tree products and sub-products may be used or sold on the market (fruit, firewood, wood for construction…) .

Hedging provides for significantly increasing cultivated land productivity (number of production cycles per year, crop diversity and association) and authorizes sustainable intensification of farming systems without endangering the natural resources used.


Hedging a vegetable site, Niger

Zones	Examples of usable species
Dry	*Acacia senegal* (rubber plant), *Prosopis africana*, *Parkinsonia aculeata*, *Calotropis procera* (Euphorbia), *Agave sisalana* (sisal), *Azadirachta indica* (Neem), *Jatropha curcas*
Wet	*Crotalaria grahamiana*, *Cajanus cajan*, *Acacia dealbata*, *Dodonaea madagascariensis*, *Gliricidia sepium*, *Leucaena leucocephala*, *Sesbania rostrata*, *Tephrosia candida*, *Flemingia congesta*, *Acacia mangium* and *auriculiformis*

Method

Hedges are rows of shrubs or trees around plots or partitioning large-sized plots.

1-Various hedge types

- **A windbreak hedge:** hedge perpendicular to the dominant wind; it "breaks" the dominant wind to protect crops.

A windbreak protects crops over a distance behind the hedge of about 10 to 20 times its height (i.e. 20 to 40 m for a 2 m high hedge).

Sample species: Jatropha, Acacia, Azadirachta (Neem), Parkinsonia, Tephrosia… to be planted in association.

- **Protective hedges:** generally planted to supplement barriers such as barbed wire and chain-link fences, they are composed of thorn trees or species that are not appetizing to wandering animals; they serve to prevent cattle from entering gardens.
  Sample species: Euphorbia, rubber plant, Prosopis, Ziziphus, cactus, sisal…
- **Biomass production hedges:** generally planted near compost units or plots, they are periodically trimmed; trimmings are used to produce compost or applied as mulch.
  Sample species: leguminous shrubs, Tephrosia, Leucæna, Flemingia, Gliricidia, Acacias…

2-Sizing

The number of plants depends on the type of tree, their purpose, and tree pruning.

SOME REFERENCE DATA

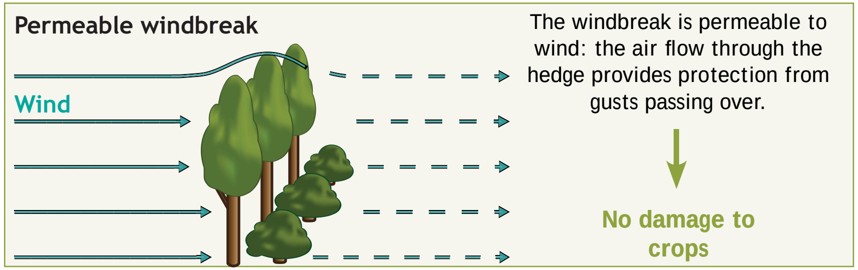
→ **Protective hedges** are planted around gardens. **Biomass production hedges** are planted along cultivated plots. They must be dense: 2 to 3 plants per linear m. Plant the young trees at a rate of 1 plant every meter in 2 staggered rows. These two rows are separated by 0.8 m.

→ **Windbreaks** are planted in single lines or double rows. Tree spacing is generally higher than for protective hedges (1 plant per m²). For double rows, plant staggered rows spaced 1.5 m apart.

NOTE

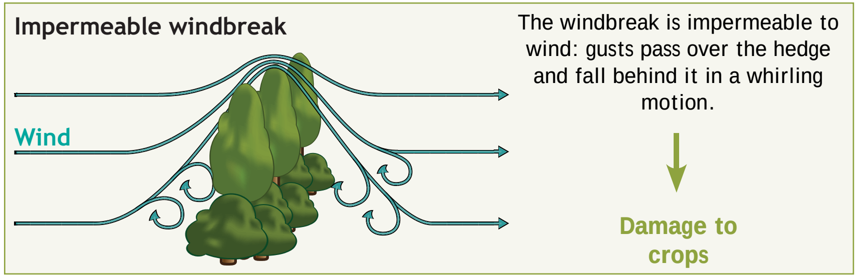
An overly dense, and therefore impervious, windbreak causes damage to the crops (creating wind eddies).

A windbreak hedge



The windbreak is permeable to wind: the air flow through the hedge provides protection from gusts passing over.

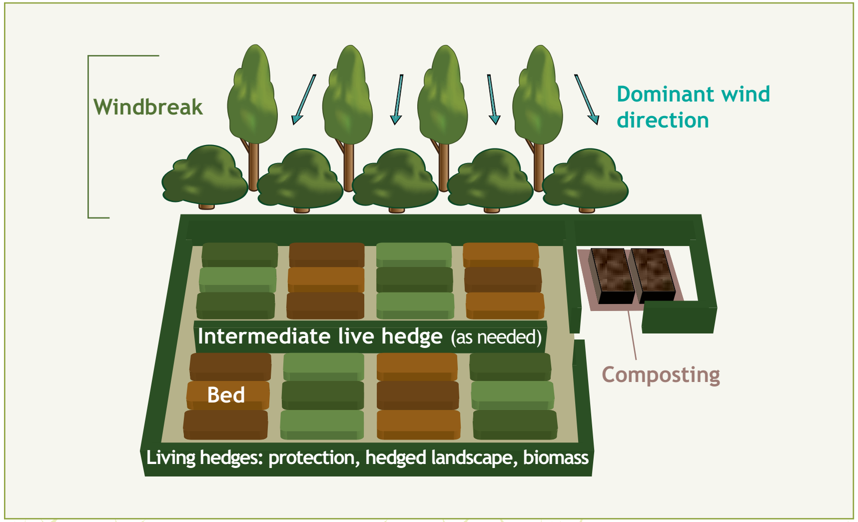
No damage to crops



The windbreak is impermeable to wind: gusts pass over the hedge and fall behind it in a whirling motion.

Damage to crops

Implantation Scheme of hedging in a vegetable farming garden



3-Installing hedges and windbreaks

Hedges may be installed:

- by direct sowing (bunches spaced 50 cm to 1 m depending on hedge purpose). E.g.: moringa, *acacia mangium* and *auriculiformis*, leucaena;
- by cuttings (e.g.: gliricidia);
- by planting in clumps.

Hedges are planted at the beginning of the rainy season (right after a good rain), in order to allow the plant to recover before the dry season. For planting in clumps:

- **Make a trough** about 30 cm x 30 cm x 30 cm (based on future plant growth);
- **Plant the plant** maintaining the crown at ground level. In dry areas, leave a sunken area to collect rain water and keep the soil humid. In humid areas, plant on mounds. (sunken area at the top of the mound);
- **Water** if there is low rainfall, watering must be done at least once a week (twice during the first weeks). The plants will then be able to resist drought;
- **Protect the young plants** that are not sheltered from wandering animals (boughs, nets, baskets...).

4-Tending

- **Replenish** after a month or at the beginning of the following rainy season. Experience shows that a certain number of plants die during the first year, so replenishing is necessary;
- **Prune** the trees depending on the desired carriage:

Hedge type	Characteristic carriage	Pruning
Protective hedge	Bush	Pollard regularly to 1.2 – 1.5 m
Windbreak	High	Cut excess branches to preserve 40% wind permeability (visual assessment)
Biomass production hedge	Bush	Pollard regularly to 1 – 1.2 m

Maintenance trimming (pruning) should generally be done at the beginning of the rainly season. However, for biomass production and site protection, pruning should be performed periodically based on hedge growth.

5-Associations

Beyond simply planting hedges, **the producer may benefit from complementarities between crops and trees**. Tree planting density should not hinder crops.

The trees benefit from the fertilization of the underlying crops, constant humidity due to irrigation, periodic weeding and hoeing (tending). Underlying crops benefit from the trees' regulating and beneficial effects: shade, mulch, recycling water and leached elements, improving and protecting soil structure.

Producers may plant various types of trees:

- **shrub leguminous** (agro-forestry systems): leguminous enriching the soil with nitrogen (gliricidia, *acacia mangium* and *auriculiformis*);
- **fruit trees** (fruit / vegetable income complementarity): small trees are recommended inside plots (e.g. guava, pomegranate, citrus), large trees are placed on the periphery if space permits (e.g. mangos);
- **fodder trees** (crop / livestock complementarity): leguminous species should be favoured (*Faidherbia albida*, Glyricidia, Leucaena...).

Specific cases:

- **Moringa:**particularly interesting as it can be regularly cut giving it a narrow carriage with numerous branches producing edible leaves;
- **Neem:** usable for producing bio-pesticides, service wood, and firewood. However, its size should incite producers to control it on the site or confine it to the exterior as a windbreak.


Banana tree – okra association


Fruit – vegetable association

Advantages and Drawbacks

Technical

- ↗ Conserves ground water and protects the plant (reducing evapotranspiration)
- ↗ Protects from wind and animals
- ↗ Increase vegetable matter disponibility for mulching and composting
- ↗ Creates a micro-climate conducive to crops
- ↗ Allows recycling leached minerals
- ↗ Favours soil aeration and improves the soil's microbial life
- ↘ Requires a relatively long implanting, implantation, establishment ? period (1 to 2 season)
- ↘ Requires regular tending
- ↘ Space-intensive practice
- ↘ Requires land ownership

Economical

- ↗ Limits fencing repairs and deterioration by animals (living hedge protection)
- ↗ Provides a variety of resources (fruits, wood, bio-pesticides...)
- ↗ Allows extending farming periods and improves yields
- ↗ Allows saving on watering (by reducing evapotranspiration)
- ↘ Represents an expense if the plants must be purchased
- ↘ Requires signifcant labour (planting, watering, pruning)

Environmental

- ↗ Restores plant cover
- ↗ Protects against water and wind erosion
- ↗ Limits abusive tree cutting
- ↗ Improve biodiversity (fauna and flora)

Planting a windbreak, Niger

Windbreak hedge along a vegetable garden, Laos

POINTS TO REMEMBER

Hedging plots markedly improves farming conditions (improving soils, recycling water and mineral elements, favourable micro-climate) and provides diversified products (wood, fruit...).

After planting, protection and supplemental water allow young plants to quickly and sustainably get installed. These trees must be tended so they can play their role: protecting crops, providing biomass...

Fruit trees benefit from the producer tending to underlying crops. However,the space must be organized in order to ensure that the trees do not provide too much competition for vegetable crops.

The association of vegetable and fruit crops provides better promotion of the plot.

TAKING IT FURTHER

Leaflet: Potted tree nursery (p. 131)

Leaflet: Planting fruit trees (p. 137)

Leaflet: Tending an orchard (p. 141)

Ground-level nursery

Some crops need a growing phase in the nursery: hot pepper, eggplant, tomato, beet, lettuce, cabbage, onion…

The nursery is a delicate stage that is decisive in the success of production cycles (healthy, vigorous plants in sufficient quantity), compliance with crop periods (farming schedule) and the farm's economy (productivity, product quality).

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Producing quality plants
- Having healthy, vigorous plants that limit the use of phytosanitary treatments (reducing costs)
- Ensure the startup of crop cycles and a maximum production

Conditions for implementation:

- Availability of a lightly shaded site during high insolation hours and with access to water
- Ensure that the site is protected from animals and strong rain
- Availability of quality seeds and organic manuring
- Availability of equipment (shovel or hoe, rake, watering equipment, strainer or sieve)
- Provide a protective net for the plants as necessary

Principle

A ground-level nursery consists of producing healthy, vigorous plants in a developed site, with sufficient mastery of the water, soil and farming techniques.

Method

1-Location selection

Young plants are fragile: they must be in an a protect area where the environment is controlled. To this end, the select site must fulfil the following conditions:

Site selection	Justification
Near a permanent water source	→ Availability of the water throughout the nursery's duration → Facilitate irrigation
Close to the home (if possible)	→ Ensure regular nursery tending → Keep the nursery away from production areas (phytosanitary risk)
Without a previous nursery	→ Limit phytosanitary risks
Not floodable	→ Avoid flooding risks
Protected from wind and animals	→ Avoid losses due to wind gusts and wandering animals
Lightly shaded	→ Limit evaporation → Protect plants from hard insolation and excessive heat

Tomato nurseries, southern Morocco

Nurseries, southern Morocco

2-Preliminary steps for setting-up nurseries

- **Cleaning:** weed (do not plough in weeds) and level the site
- **Ploughing:** prepare the soil (aerate and loosen the soil to facilitate root penetration and growth, remove rocks, plough in organic matter present on the surface)

3-Sizing and scheduling

Setting-up nurseries depends on crop scheduling in order to manage crop successions and optimal farm development.

The surface area for cultivation and the type of production crop determines the **size and time in the nursery.** For example, for 180 m² of transplanted tomato plants = 1 m² in the nursery for 15 to 20 days; for 50 m² of transplanted onion plants = 1 m² in the nursery for 40 to 45 days.

4-Bed preparation

Nursery bed height varies by season: **during the rainy season**, the beds are mounded (15 to 20 cm) to provide for good drainage; **during the dry season**, they are slightly sunken (5 to 10 cm) in order to retain moisture.

- **Size and make** the beds (about 1 m wide to facilitate tending)
- **Loosen, remove rocks** and add sand to hard soils
- **Plough in organic manuring:** well-decomposed compost (5 to 8 kg/m²) or well-decomposed recycled manure (3 to 5 kg/m²)
- **Level** with a rake
- **Disinfect the soil** with boiling water (10 l/m²) and let cool before sowing

Dug-out nursery, southern Morocco

Mounded nursery, Angola

5-Sowing

Depending on plant, 2 techniques are possible:

- **in line sowing:** for easier weeding and removing plants before transplanting
- **broadcast sowing:** saves time sowing

After sowing: cover the seeds with a thin layer of earth or sand (thickness about 3 times the size of the seed) and water using a fine watering can rose (violent irrigation or submersion may move seeds).

Crops	Seeds (g)	Recommended sowing	Number of days in the nursery	Number of plants to transplant	Transplanting spacing (interspacing x in line, in m)	Transplanted surface area (m²)
Cabbage	3	In line	25 - 30	400	0.4 x 0.6	96
Tomato	4	In line	15 - 20	600	0.7 x 0.6	252
Lettuce	0.4 - 0.6	Broadcast	15 - 20	400	0.3 x 0.3	36
Onion	1.25 - 2	Broadcast	40 - 45	250	0.1 x 0.2	5
Sweet pepper	2	In line	35 - 40	300	0.6 x 0.4	72
Hot pepper	2	In line	35 - 40	300	0.6 x 0.4	72
Eggplant	0.8	In line	35 - 40	160	0.7 x 0.6	40

Transplanting onions in Madagascar

6-Protection

- To protect the nursery from cold, heavy rain, and drying, it is necessary to cover it with mulch (straw or palm) and remove it when it hinders plant growth (mulching may be retained between rows).


Palm mulch


Protecting with straw

- To protect the nursery from insects, lizards, and other pests, it is possible to install protective netting.


Protective netting

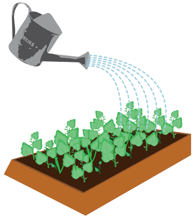

Protective netting

- To protect the nursery from strong rain and cold in certain contexts, it is possible to install a protective tarpaulin.


Protective canvas


Covered nursery, southern Morocco

7-Tending

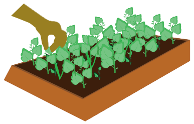


Watering:

- the nursery must always be damp without soaking
- prefer cooler times (morning and evening) for watering
- use a fine watering can rose to avoid damaging plants

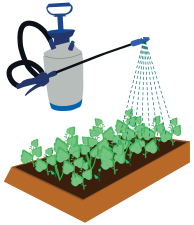
NOTE

Watering in the evening in hot, damp areas risks favouring cryptogrammic and bacterial rot.



Weeding - singling:

- periodically weed to prevent invasion by weeds. Mulching between rows may prevent weed growing
- Single to keep just the robust, well-developed plants (single after 15-20 days in general… adapt to crops)



Treatments:

- pull-up plants that have been attacked and treat as necessary
- prefer preventive measure and using natural products (see Leaflet: Natural plant protection treatments p. 127)

A few days after transplanting, the unused plants must be destroyed to limit the risks of disease.

REMARKS

Although disinfected, nurseries on the ground may be subject to a new contamination by ground-based pests and diseases. In this case, make raised nurseries (see Leaflet: Raised nursery p 101).

In order to facilitate field recovery, it is possible to strengthen plants in the nursery before transplanting. This occurs in the nursery by:

→ significantly reducing watering;
→ avoiding nitrogen supplements;
→ removing protective veils.

Advantages and Drawbacks

Technical

- ↗ Easy practice to implement
- ↗ Easy to maintain
- ↗ Produces robust plants
- ↗ Provides for reserving plants in the nursery, after transplanting, to replace dead or attacked plants (complantation)
- ↘ Sensitive to attacks by ground-based pests (even if the site was disinfected to start)

Economical

- ↗ Provides seed savings
- ↗ Reduces treatment costs for transplanted crops (robust plants resistant to attacks)

Environmental

- ↗ Reduces the use of pesticides by producing robust plants and applying preventive methods for pests and diseases

POINTS TO REMEMBER

The nursery is a delicate step that requires attention and care in preparation and execution.

The success of this step will determine the technical (respect of the crop schedule) and economic (seed and treatment expenses) success of the production.

Producing robust plants is the first rule in preventing disease and pests.

TAKING IT FURTHER

Leaflet: Swath composting (p. 81)
Leaflet: Crib composting (p. 89)
Leaflet: Manure recycling (p. 77)
Leaflet: Raised nursery (p. 101)
Leaflet: Natural phytosanitary treatments (p. 127)


Nursery, Sri Lanka


Sweet pepper / cabbage nursery, Sri Lanka


Sowing in line under a shade house, Sri Lanka


Nursery on the ground, southern Morocco

Raised nursery

Producing healthy, robust plants in the nursery constitutes the first key step in a successful crop.

So it is wise to place the plants in a healthy, controlled environment from sowing to transplanting.

To this end, a nursery on piles (raised nursery) is recommended.

Effects:

Soil	Water	**Plant**	Landscape

Objectives:

- Obtain quality plants
- Having healthy, vigorous plants that limit the use of phytosanitary treatments (reducing costs)
- Ensure the startup of crop cycles and a maximum production

Conditions for implementation:

- Availability of a land with access to water
- Availability of sand, earth from forest compost, and recycled manure, or well decomposed compost
- Availability of quality seeds ready for sowing in a nursery
- Availability of equipment (shovel, fine watering can rose, sieve or riddle)
- Availability of wood, cereal stems, banana leaves, planks of wood, bamboo… to make a table

Principle

The nursery on piles allows the production of plants protected from damage frequently encountered when the nursery is conducted on the ground healthy and high-quality substrate renewed for each cycle, non-waterlogged soil during the rainy season, ease of covering the nursery to protect young plants.

Method

1-Location selection

Nursery location is **strategic** ; its choice should fulfil a majority of the following criteria:

Site selection	Justification
Proximity to a water source	→ Facilitate irrigation
Near the home (if possible)	→ Facilitate nursery surveillance and tending → Keep the nursery away from production areas (phytosanitary risks)
Protected from wind and animals	→ Avoid losses due to wind gusts and / or wandering animals
Away from plots at the end of the crop cycle	→ Avoid attacks by parasites present in the crops
Protected from the rain and sun, but ventilated	→ Avoid over-watering and thermal stress on the plants as well as deteriorating the pots and plants with strong rains

2-Table construction

Build a table that can hold substrate 5 to 10 cm thick at about 1 m from the ground (bamboo table with a bed of banana leaves, table of maize or sorghum stem bundles…).


Banana tree trunk table and maize stems, Madagascar


Bamboo table, DR Congo


Wooden plank table, Sri Lanka

3-Substrate preparation

The substrate must be **uniform** (well mixed) and **finely composed.**

Component	Proportion	Properties
Sand	1/4 of the substrate	Loose structure, water draining
Recycled manure or well decomposed compost	1/4 of the substrate	Moisture retention, nutritional elements
Soil (from forest mulch if possible)	1/2 of the substrate	Basic substrate elements

The proportions for various materials should be adapted based on the initial quality of the soil.

Substrate preparation steps:

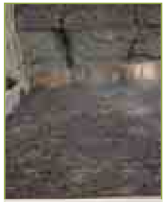
Sieve the various elements → Mix the components → Place the substrate on the table (5 to 10 cm thick) → Disinfect the substrate

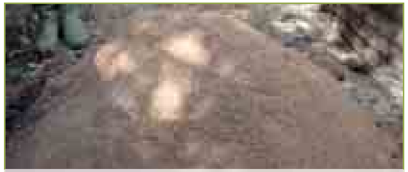

Sieving


Sieving


Bring the water to a boil


Pour boiling water on the substrate


Let cool


Fine sand


Compost

4-Nursery operation

Sowing:

- trace furrows in the substrate at a depth 3 times the size of the seed
- sow in lines separated by 10 to 15 cm
- cover the furrows with white sand previously disinfected with boiling water
- cover and pack the sown lines with a small board
- water sufficiently but not to excess (2 waterings at 30 minute intervals) with good quality water

Protection:

As needed, cover the nursery to protect the seed bed or young plants:

- from strong rain: plastic film;
- from significant insolation and heat: shade cloth;
- from insects and other pests: netting.

The protection should be installed on bamboo or wooden arches.

NOTE

Remove the protective film when conditions permit.


Sieve and substrate


Setting-up a protective net


Nursery covered with a plastic film

5-Tending

- **Watering:** keep the soil damp without soaking, prefer less hot times (morning and evening) to save water; avoid overwatering in the evening during the rainy season or in wet areas; to prevent plant damage, use a fine watering can rose
- **Mulching:** cover the seed bed with finely chopped dry straw after sowing and before growth, then clear away from plants and maintain mulch between rows (conserves humidity and protects young shoots)
- **Weeding:** pull-up weeds to prevent competition and invasion, repeat periodically to prevent pulling up the plants at the same time as weeds with highly developed root systems
- **Check health:** cull diseased or puny plants

These stages take place regularly based on requirements until the plants are ready for transplanting. Production cycle duration depends on the crop.

REMARKS

In order to facilitate field recovery, it is possible to strengthen plants in the nursery before transplanting. This occurs in the nursery by:

- → significantly reducing watering;
- → avoiding nitrogen supplements;
- → removing protective veils.


Mulched nursery


Vigorous, health plants

Advantages and Drawbacks

Technical

- ↗ Prevents soil infestations (root-knot nematodes and damping-off) and reduces the risks of bird attacks and other pests
- ↗ Provides for reserving plants in the nursery, after transplanting, to replace dead or attacked plants (complantation)
- ↗ Provides for good fertilization ensuring vigorous young plants
- ↗ Controls the crop environment
- ↗ Favours normal growth in young plants
- ↘ Requires building an infrastructure
- ↘ Difficult to implement for large surface area nurseries

Economical

- ↗ Limits losses due to damping-off and attacks by pests
- ↘ Represents an expense for building the infrastructures for large nursery surface areas

Environmental

- ↗ Controls the crop environment without specific use of chemical inputs

POINTS TO REMEMBER

A raised nursery is a practice that allows producers to stagger their production during the rainy season while controlling nursery success. Producers are able to harvest ahead of others and benefit of advantageous pricing.

By limiting damping-off and nematode infestations with a health, periodically renewed substrate, producers decrease their operating costs and are therefore able to invest efficiently in quality seeds.

TAKING IT FURTHER

Leaflet: Swath composting (p. 81)
Leaflet: Crib composting (p. 89)
Leaflet: Manure recycling (p. 77)
Leaflet: Natural phytosanitary treatments (p. 127)

Basal organic manuring

One of the first stages in planting a vegetable crop is to add basal organic manuring (recycled manure or compost).

Manuring is called “basal” when it is added before planting the crop and acts over time.

Intended to enrich the soil and ensure the availability of the elements required for good crop development, the basal manuring supplement is primordial and will provide for significantly (even totally) limiting the use of artificial chemical fertilizers.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Improving the physical structure and the soil biological and chemical characteristics and its fertility
- Provide the elements required for plant growth, renewing elements removed by the previous crop (limiting the use of chemical fertilizers)
- Favouring crop rooting for a good supply of mineral elements

Conditions for implementation:

- Availability of compost or well decomposed manure in sufficient quantity (2 to 3 kg / m² and by supplementing given that one application covers about 4 to 6 months of crops depending on their requirements)
- Availability of equipment (hoe or daba, cart or wheelbarrow, shovel)
- Apply at least 15 days before sowing or transplanting

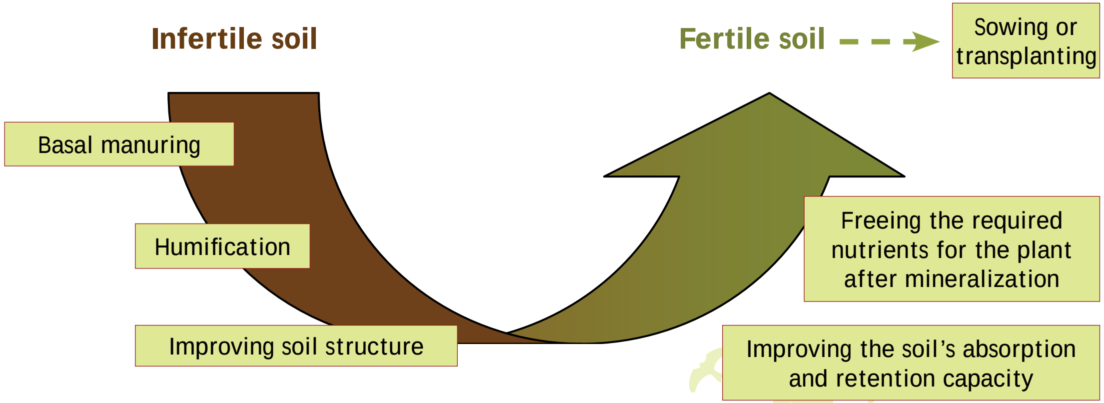
Principle

Basal manuring **improves soil structure**:

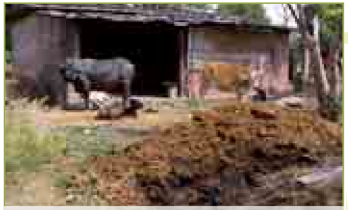
- increases water retention capacity;
- increases absorption (fixing) and mineral elements liberation capacities;
- soil ventilation, improving porosity;
- increas the soil’s biological activity (micro-and macro-fauna).

Basal manuring provides the nutritional elements required by crops and compensates exportations by previous crop cycles.

Diagrammatic representation of the supplement and its effects:




Preparing compost, Niger


Recycled manure, India


Adding manure, Madagascar

1 / Basics
2 / Farming systems
3 / Practices

Method

Basal manuring (organic manuring + natural mineral supplements) is ploughed under with deep ploughing (25 to 30 cm) **at least 15 days before planting** to reduce heating risks that may cause burns on young plants.

Preferably it is applied at the beginning of major seasonal cycles:

- 1 or 2 times a year in dry areas;
- 2 or 3 times a year in wet areas.

Materials	Comments	Proportioning
Well decomposed manure	Do not leave the manure exposed to the sun and rain	2 to 3 kg/m² based on crop requirements
Solid compost	Select compost with little decomposition. If low quantities are available, reserve compost for use as basal manuring for high-demand or high added-value crops	1 to 3 kg/m² based on crop requirements
Dry mulch and diverse leaves + liquid compost	Do not use eucalyptus leaves (phytotoxicity)	5 l solution of pure liquid compost + 5 l of water Apply 2.5 to 3 l/m²
Dry mulch and diverse leaves + poultry or bat excrement	Water the dry matter before ploughing under	80 g of dry excrement / m²
Wood ash	In addition to organic matter supplements (compost, manure, mulch) Be careful, too much ash increases soil acidity	200 to 300 g/m²
Crushed limestone	In addition to organic matter supplements (compost, manure, mulch) in acidic soils	60 to 80 g/m²
Natural phosphate	In addition to organic matter supplements (compost, manure, mulch)	100 to 120 g/m²

The practice in images…

Adding ash, Madagascar

Burying compost, DRC

Advantages and Drawbacks

Technical

- ↗ Allows plants to easily obtain the elements required for growth from the soil as the organic matter humification / mineralization process unfolds
- ↗ Improving soil structure and fertlity, and, by this way stabilizes and / or improves yields
- ↗ Simple practice to implement
- ↗ Greater effectiveness if supplements are localized
- ↘ Requires the availability of significant quantities of organic matter
- ↘ Requires significant handling

Economical

- ↗ Stabilizes and / or improves activity income and reduces expenses
- ↗ Limits the use of phytosanitary treatments and chemical fertilizers due to crop growth rates and robustness
- ↘ Represents a cost if the producer does not have organic manure available

Environmental

- ↗ Compensates nutritional element exportations and preserves fertility
- ↗ Limits the use of chemical fertilizers
- ↗ Favours biodiversity and biological life in soils

Recycled manure, Niger

Adding manure, Madagascar

POINTS TO REMEMBER

By providing a reserve of progressively deteriorating and mineralized organic matter, easily assimilated, producers ensure that crops have good growth and development; they sustainably preserve the soil's agronomic qualities.

Healthy plants limit the application of phytosanitary treatments and improves yields.

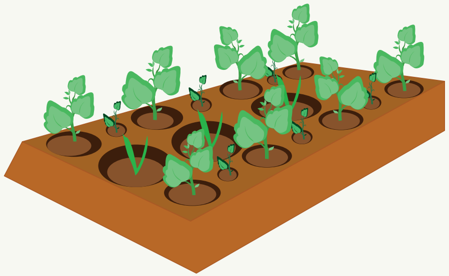
Each type of vegetable crop (fruits, leaves, roots) has different needs: it may be interesting to add a mineral supplement (natural products) to organic matter.

TAKING IT FURTHER

Leaflet: Swath composting (p. 81)
Leaflet: Crib composting (p. 89)
Leaflet: Manure recycling (p. 77)

Bowls farming

In contexts where organic matter and water resources are limited, bowls cultivation is particularly recommended to provide for meeting the plant's needs while limiting resource waste.



This practice is particularly implemented in Madagascar.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Locating organic matter supplies
- Locating water supplies
- Optimizing resource use
- Limiting crop tending

Conditions for implementation:

- Availability of seeds or plants for transplanting
- Availability of the necessary equipment (shovel, hoe or daba)
- Availability of compost or recycled manure
- Availability of a water resource

Principle

Crops are planted so as to localize organic matter and water supplements. This allows to preserve these rare resources for the benefit of crop.

Method

The **bed where the bowls are made** is a "classic" vegetable farming bed: bowls are dug in order to sow in bunches or transplant while localizing water and fertilizer supplements.

- **Mark out the bed** and perform **the required soil preparation**
- **Dig a bowl** for each plant to transplant (20 to 30 cm in diameter and 15 to 20 cm in depth); spacing depends on the root system and the aboveground growth of the selected crops
- In each bowl, add the **compost or recycle manure in suitable quantities** (a double handful, i.e. about 300 g): such pinpointed supplements provide for concentrating the organic matter when it is available in limited quantities (resource optimization)
- **Mix** with a little bit of broken-up earth and water
- **Sow or transplant** the plant after 2 week in the centre of the bowl and keep the slightly convex shape of the bowl
- **Pinpoint various practices, supplements, and tending in the bowl:** watering, weeding, mulch, fertilization…

NOTE

For compact clayey soils, it is possible to shape bowls with a round jar. **Interest:** the shaped bowls requires little labour for the following crops, only compost additions and bowls cleaning is required.

It is possible to make crops association, including within these bowls and adapt the size of the bowl based on plant types and numbers.

The practice in images…

Advantages and Drawbacks

Technical

- ↗ Provides for making suitable supplements for crop requirements despite resource shortages (organic matter and water)
- ↗ Additional technique for other agroecological practices (mulching, fertilization…)
- ↗ Provides for preventing water and organic matter supplements from benefiting weeds (reducing weeding between bowls)
- ↘ Requires significant labour if the soil is compact
- ↘ Tending is difficult if the soil is sandy

Economical

- ↗ Provides for efficient supplements and water, favours water savings
- ↗ Significantly reduces the surface area worked by pinpointing the various operations
- ↘ Requires time when preparing the soil compared to simple ploughing

Environmental

- ↗ Provides for saving water resources

POINTS TO REMEMBER

Competition for organic matter may be significant and the water resource exhaustible. Cultivating in bowls significantly limits supplements and plant reserves.

Using bowls is an interesting alternative for producers who tend to spread manure (available in limited quantities) on broad beds (fertility effects are diluted).

TAKING IT FURTHER

Leaflets: Swath composting (p. 81) / Crib composting (p. 89)

Leaflet: Manure recycling (p. 77)

Leaflet: Mulching (p. 121)

Leaflet: Crops association (p. 117)

Crops succession

Thoughtful plant succession in the same plot is very important.

Not using it may decrease soil fertility and increase diseases, pests, and weeds; not using it may cause an ecological imbalance and economic losses for producers.

Effects:

Soil	Water	Plant	Landscape

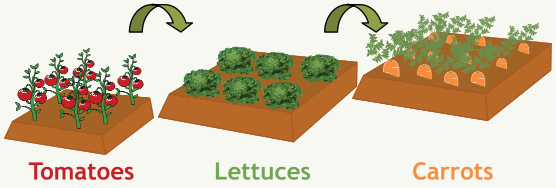
Objectives:

- Maintaining and improving soil structure and fertility
- Breaking pest and disease cycles and limiting the use of pesticides
- Diversifying production
- Benefiting from natural mechanisms to limit tending and artificial input costs

Conditions for implementation:

- Knowledge of the rules for implementing crop rotations
- Willingness to produce diversified crops

Example of plant succession in the same plot



Principle

In the succession, different crops follow each other on the same plot.
E.g.: tomato > turnip > broad bean

Rotation is repeating the same succession in cyclically on the same plat.
E.g.: tomato > turnip > broad bean > tomato > turnip > broad bean...

Crop planning and succession is established according to the following rules:

- **Avoid cultivating plants of the same family two times in a row** in order to limit pest and illness propagation often specific to a plant family;
(see the following pages, Theoretical summary: different plant families)
- **Avoid cultivating a plant for the same organ two times in a row** (fruit, leaf, root) so that the same mineral elements are not exported. Soil fertility is promoted and maintained and soil structure is preserved;
(see the following pages, Theoretical summary: plants and organs)
- **At the "head" of the succession, plant greedy crops** in order to take advantage of the supplies of organic matter, compost, or recycled manure;
(see the following pages, Theoretical summary: Vegetables and their physiological requirements)
- **Alternate "clean" and "dirty" plants** in order to limit plot weeds;
(see the following pages, Theoretical summary: Clean" and "dirty" plants)
- **Wait a sufficient period** before cultivating the same plant in the same spot.
(see the following pages, Theoretical summary: Replanting times for crops of the same plant)

Vegetable garden, Laos

Theoretical summary

Presentation of the primary plant groups and families cultivated in vegetable gardens

BRASSICACEAE

Radish
Turnip
Colza
Cresson
Arugula
Cauliflower
Leaf cabbage

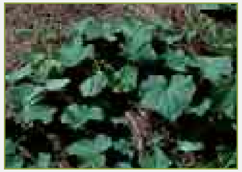
LEGUMINOUS

Broad bean
Pea
Clover
Catjang
Bean
Lentil
Alfalfa

LILIACEAE

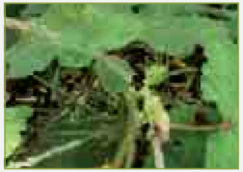
Garlic
Onion
Welsh onion
Leek
Asparagus
Shallot
Chive

CUCURBITACEAE



Melon
Marrow
Pumpkin
Watermelon
Zucchini
Cucumber

MALVACEAE



Okra
Roselle

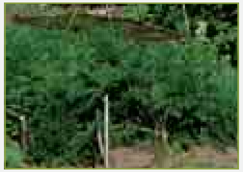
LAMIACEAE

Thyme
Basil
Mint
Sage

CHENOPODIACEAE

Amaranth
Beat
Malabar spinach
Spinach

APIACEAE



Parsley
Celery
Carrot
Fennel
Coriander

ASTERACEAE

Lettuce
Sunflower

SOLANACEAE

Hot pepper
Tomato
Morel
Sweet pepper
Eggplant
Potato

PLEASE NOTE:

Solanaceae are very present due to their significance in food consumption in households and in the farming economy.

However, it is recommended to not cultivate them on more than half the land in order to have sufficient space to alternate with other plant families.

Succession provides for breaking the cycles of harmful species and diseases very often specific to a family by introducing non-host crops.

For example: cultivating red radishs or peanuts (trap plants) breaks the cycle of nematodes that grow when solanaceae are cultivated.

Another example: cultivating tomatoes breaks the cycles of the white carrot fly.

Plants and organs

3 main groups of vegetable crops exist depending on the part consumed, they express varying mineral needs:

Fruit vegetables	**Leaf vegetables**	**Root vegetables, tubers, and bulbs**
Tomato, eggplant, sweet pepper, hot pepper, cucumber, marrow, zucchini, okra, melon, watermelon…	Lettuce, head cabbage and leaf cabbage, amaranth, morel, sorrel, parsley, branch celery, leek…	Potato, garlic, onion, radish, turnip, carrot, beet, ginger…
Significant phosphorus (P) requirements	**Significant nitrogen (N) requirements**	**Significant potassium (K) requirements**

The following order is suggested for crop successions:

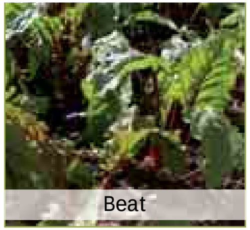
1. Fruit vegetable >

Tomato

2. Leaf vegetable >

Malabar spinach

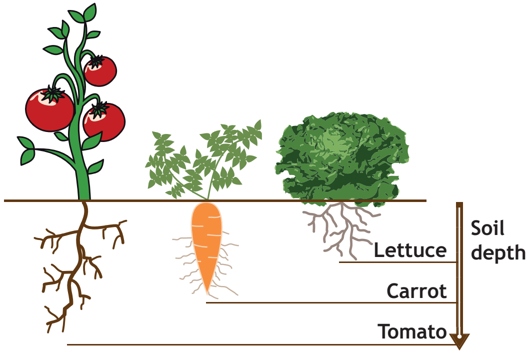
3. Root vegetable



Beat

Plants get the elements from the soil differently depending on their roots (see the diagram below) and their requirements. Crop successions provide for avoiding the use of the same elements in the same spot.

Supplemental fertilization corrects the previous withdrawals.



Vegetables and their physiological requirements

In agroecology, a large part of the fertility is provided by the producer in the form of organic matters (compost, recycled manure) when preparing the soil and / or when manuring. The quantity varies based on soil quality, and other practices for improving soil fertility (coverage fertilizer cycles…).

Often, the low quantity of organic matter available to the producer is a limiting factor, which is why you must be familiar with plant requirements in order to optimize supplements.

Greedy vegetables

(organic matter additions more than 2 kg/m²)

Eggplant, celery*, cabbage*, cucumber, marrow, spinach*, fennel, maize, melon, leak, sweet pepper, potato, pumpkin, tomato, zucchini

Somewhat greedy vegetables

(organic matter additions less than 2 kg/m²)

Asparagu, beet*, carrot, lettuce*

Not greedy vegetables

(organic matter added as needed)

Garlic, broad bean, shallot, turnip, onion, radish, bean, pea

* Plants required well decomposed compost; the other plants tolerate semi-mature compost and marrows require low maturity compost (or even fresh manure).

Sweet pepper

Lettuce

Onion

It is recommended to make crop successions in **decreasing order of crop requirements.**

The crop cycles at the beginning of the succession are abundantly fertilized (organic basal manuring); the following cycles have less organic matter (they may therefore be less demanding).

“Clean” and “dirty” plants

Crops are called “**clean**” when they suffocate weeds by covering the ground or when their growth allows weeding or to install a mulch.

Crops are called “**dirty**” when they do not sufficiently cover the ground to limit weeds and when it is difficult to weed or install mulch.

To limit weeds, it suggested to alternate:

- clean crops (e.g.: tomato, pea, potato...) ;
- and **dirty crops** (e.g.: carrot , turnip, onion...).

Delays in planting the same plant on the same plot

A Moroccan proverb says: « straw on straw do battle” meaning that a crop cannot follow itself in sufficient time between each cycle.

Some examples:

- **carrots** may be farmed in the same plot every other year; they grow well after a row or cover crop, particularly a solanaceae (e.g.: tomato) ;
- **onions** may be farmed in the same plot every other year; they grow well after a row crop;
- **potatoes** may be farmed every 2 to 3 years; they are an excellent plant to “head” the succession. It is a good preceding crop for maize;
- **melons** may be farmed on the same land after 3 or 4 years...

Some advice

Introducing Leguminous

Due to their capacity for fixing nitrogen in the air, leguminous cycles may be inserted into crop successions. Their production may be consumed, served as fodder, ploughed under as coverage fertilizer, or used as a cover crop.

Leguminous cycles may be inserted at various times

- **before a plant that has significant requirements** (solanaceae, fruit vegetables, “greedy” vegetables) ;
- **at the end of the rotation to enrich the soil**

Introducing anti-parasite plants

Certain plants have anti-parasite virtues. Beyond the effects of crop succession on pests and diseases, they can “clean” a plot.

E.g. : planting a cycle of French marigold (*Tagetes patula*), a plant that repels nematodes before a sensitive crop such as potatoes or tomatoes;

Or: planting a cycle of peanuts, radishes, or turnips, which are nematode trap plants.

If there is an actual attack or risk of proliferation after a very “attractive” crop, a cycle of anti-parasite plants may be introduced into the succession.


Green peas, leguminous


Beans, leguminous


Potatoes, cleaning plant


Groundnuts cycles against nematodes

Crop succession scheduling

In addition to the rules listed in the first part (Principle), **2 factors** should be taken into account when scheduling successions:

- **the previous effect:** positive effects that the harvest crop (previous) may have on the crop to be planted.

  E.g.: the positive effects of a leguminous crop on a tomato or marrow crop;
- **following sensitivity:** not every crop reacts the same way to the effects of the previous crop.

  E.g.: onion does not do well following a leguminous.

🟩 Succession recommended

🟥 Succession not recommended

	Following crops																
Previous crops	Amaranth	Eggplant	Malabar spinach	Carrot	Celery	Cabbage	Welsh onion	Zucchini	Lettuce	Morel	Sorrel	Parsley	Hot pepper	Leaf cabbage	Sweet pepper	Radish	Tomato
Amaranth	🟥	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Eggplant	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩	🟥	🟩	🟥	🟩	🟥
Malabar spinach	🟥	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Carrot	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩
Celery	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩
Cabbage	🟩	🟥	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩
Welsh onion	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Zucchini	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥
Lettuce	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩
Morel	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟩	🟥	🟩	🟥
Sorrel	🟥	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩
Parsley	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩
Hot pepper	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟩	🟥	🟩	🟥
Leaf cabbage	🟩	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩
Sweet pepper	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟩	🟥	🟩	🟥
Radish	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩
Tomato	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟩	🟥	🟩	🟥

Advantages and Drawbacks

Technical

- ↗ Basic principles simple to apply
- ↗ Adapted to farmers' requirements
- ↘ Difficult to implement on farms with small surface areas
- ↘ Requires the availability of a diversified range of seeds

Economical

- ↗ Reduces input purchases (pesticides, herbicides)
- ↗ Contributes to increasing yields

Environmental

- ↗ Favours crop diversification
- ↗ Favours biodiversity
- ↗ Reduces parasite pressure and limits the use of phytosanitary products
- ↗ Maintains and improves soil structure

POINTS TO REMEMBER…

With its action on the soil and parasite and weed control, crop succession is economically and environmentally interesting.

There is no standard pattern for crop succession: everything depends on the crop environment, production system selection, and the producer's manoeuvring margin. However, scheduling must take into account:

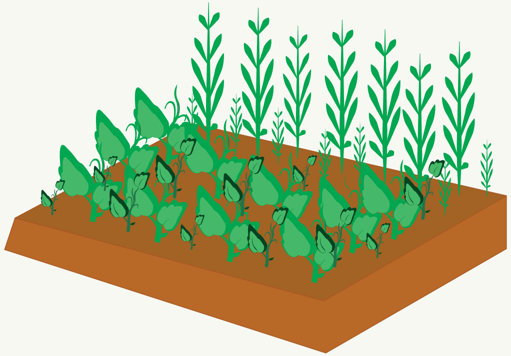
- → crop families;
- → their nutritional element requirements;
- → their characteristics ("clean" or "dirty");
- → crop replanting times;
- → previous effects and following sensibilities.

TAKING IT FURTHER:

Leaflets: Swath composting (p. 81) / Crib composting (p. 89)
Leaflet: Crops association (p. 117)
Leaflet: Manure recycling (p. 77)
Leaflet: Integrated pest management (p. 123)

Crops association

Mixing different plants on the same plot constitutes a **crop association**. This practice provides optimal development for farming surfaces and favours complementarity between cultivated plants.



Effects:

Soil	Water	Plant	Landscape

Objectives:

- Optimizing the use of farming space
- Protecting soil and crops, limiting the use of artificial chemical inputs
- Diversifying production and securing income
- Improving production quality and quantity

Conditions for implementation:

- Availability of diverse vegetable seeds
- Knowledge of the best and worst practices regarding crop associations

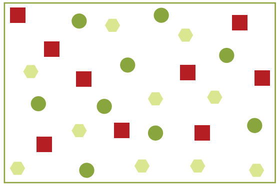
Principle

The practice of **crops association** consists of planting or sowing several crops in the same plot: crop cycles are parallel or overlapping.

These associations harmonize in different ways depending on their **configuration in space and / or time.**

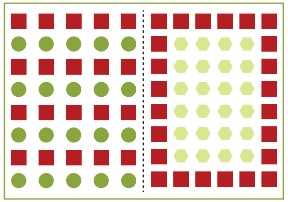
There are different types of crops association depending on plant characteristics and their complementarities in mobilizing nutrients in the soil and water, their development in space (above- and underground) and their ability to interact.

1-Association configuration



- **"mixed crops:"** mixture of several crops that grow at the same time without a specific spatial configuration but with specific densities. For example a mixture of leaf vegetables: amaranth, morel, leaf cabbage.

  Implementation: sowing or transplanting takes place at the same time without any specific spatial configuration.



- **"crops in alternating rows or strips:"** mixture of several crops that grow at the same time with a specific arrangement in alternating rows or strips (e.g. lines of zucchinis + strips of onions) or at the centre and around the edges of the plot (e.g. marrow + maize / coriander + garlic).

  Implementation: sowing takes place at the same time with a specific spatial configuration and according to the average spacing (e.g. onions + carrots = interspacing (40 cm + 30 cm) / 2 = 35 cm).

Maize / beans

Onions / cabbages

Zucchinis / turnips

- **"Intercalated crops:"** planting a short-cycle crop under cover or between the main crop (e.g.: radish + lettuce or onion + lettuce)

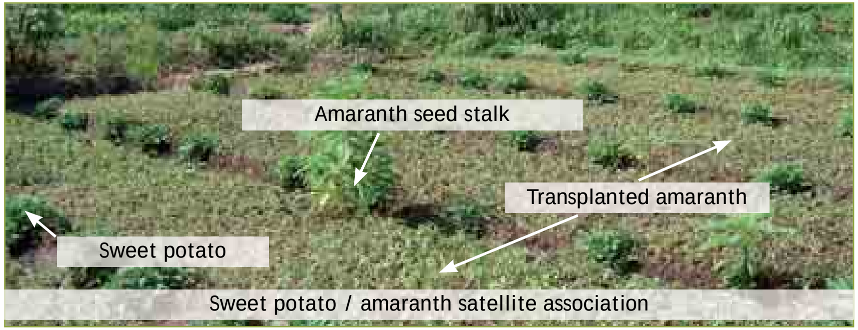
  Implementation: the plant with the shortest cycle is sown between the rows of the plant with the longest cycle, with normal spacing. Sowing should take place at the same time.

- **"intercropping:"** an initial crop is planted, then a second when the first crop has reached its reproductive stage but has not yet been harvested (e.g.: alfalfa + turnip); the second crop grows without hindrance after the first is harvested.

  Implementation: planting the second crop depends on its rate of growth and the first crop's cycle length.

- **"association with satellite plants:"** presences of a few plants of one or more specific crops in the middle of the main crop or around it. This configuration is suitable for inserting trap plants. For example: associating eggplants in a potato crop against the Colorado potato beetle on the potatoes.

  Implementation: comply with primary crop spacing.



Sweet potato / amaranth satellite association


Cabbage / lettuce intercalated crops


Lettuce / onion satellite association

2-Association selection

When several species are cultivated simultaneously on the same plot, they maintain **competitive and complementary relations** for access to environmental factors. Therefore, three factors must be taken into account to determine associations:
- root system (e.g.: cabbage + lettuce);
- access to water and mineral elements (e.g.: vegetable fruits + vegetable leaves);
- light requirements (e.g.: coriander, parsley, celery protected by broad beans or hot peppers; ginger under papaya).

The most interesting associations with regards to agroeconomics are those that, with regards to the above ground and below ground areas, promote complementarities and limit competition between species.

So, it is a question of promoting associations that ensure crop protection or favour synergy between crops.

A few examples of the protective effect

- Crops around the edges of the plot or hedging for a windbreak effect:
  - maize, rosemary hedges
- Associations of certain species for a protective effect (against diseases) or repulsive effect (against pests)
  - absinth against aphids
  - French marigold (*Tagetes patula*) against nematodes
  - liliaceae and aromatic plants with repellent properties
- Association of a particularly "attractive" plant on the edge of the plot to concentrate parasites and prevent their dissemination to the main crop (trapping):
  - eggplant attracts Colorado potato beetles around potato plots.


Intercalated crops
leaf cabbage / eggplant


Cabbage / lettuce intercalated crops

The selection of associated crops is very important.

Improper association may lead to:

- → competition between crops with the same growth rate (both above and below ground);
- → competition between a crop with high growth rate and one with a low-growth rate (shading);
- → risks of losses if they have common diseases or pests.

NOTE

Crops association provide for income that is:

- **diversified and secure** (if one crop has a poor yield or sells poorly, it is possible to compensate with the income from other crops);
- **spread out** (staggered harvests). It is interesting to favour short-cycle + long cycle associations that provide for regular income (short cycle), supplemented by a significant contribution from the long-cycle crop.

Leaf cabbage + coriander

Maize + bean

Advantages and Drawbacks

Technical

- ↗ Simple to implement, easily adapted practice
- ↗ Protects the soil (from solar radiation and winds) and crops
- ↗ Provides for maximizing the value of space over time (associating short-cycle crops and long-cycle crops)
- ↘ Requires familiarity with interesting associations and knowing how to implement them
- ↘ Sometimes increase the difficulty of labour

Economical

- ↗ Provides better production: quantity, quality, diversity
- ↗ Reduces the costs of artificial chemical inputs by promoting complementarities between crops (repellent effect, pesticide...)
- ↗ Optimizes the use of space, time and resources (soil, water, inputs...)

Environmental

- ↗ Promotes complementarities between plants
- ↗ Provides for promoting biodiversity
- ↗ Balances pest / predator populations

POINTS TO REMEMBER...

Diversity is a source of security.

Vegetable farmers may benefit from complementarities between plants in order to optimize the use of farm resources.

On the long term, promoting crops association limits the use of costly artificial inputs and improves yields (non-negligible economic savings).

TAKING IT FURTHER:

Leaflet: Hedging vegetable crops sites (p. 93)
Leaflet: Crops succession (p. 111)

Mulching

Mulching is the act of covering the soil with plants or plant waste material in order to protect it from climatic aggression. It is particularly effective to create an environment favourable to crop development.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting water loss by evaporation
- Protecting the soil during strong rain and limiting splattered soil on the plants
- Contributing organic matter to the soil
- Creating a favourable environment for developing biological life in the soil
- Reducing tending difficulty by limiting weeding and hoe operations

Conditions for implementation:

- Availability of plants or plant waste material: straw (25 to 30 kg for 10 m² of soil to cover 5 to 10 cm thick), tree leaves, rice glue and floral glumes, dried wild or cultivated grass (Brachiaria, Stylosanthes…), millet stems, palms, etc.

  Please Note: do not use plants that have borne fruit (presence of seeds that could germinate)
- Availability of small-scale equipment (wheelbarrow, pitch fork..)

Principle

The practice of **mulching** consists of cover the soil in vegetable beds so that it is never left bare. Beyond its **protective effect** against erosion and weeds, it directly influences added water and soil fertility and, in doing so, sharply favours biological life.

This practice must be implemented before sowing (if possible) and replanting.

Method

- **Mow grass** before going to seed (or collect other available materials), and let wither in the sun (2 to 3 days)
- **Prepare the beds** for crops
- **Lay out the mulch in layers** of 5 to 10 cm on the entire surface of the vegetable bed avoiding encumbering the plants if the crop has already been planted; for mulching before sowing or planting, bunches should be free to allow the plants to grow and limit the propagation of bacterial or fungal diseases


Tomato on mulch, Madagascar


Potato on mulch, Madagascar

Mulching may create a shelter for slugs and snails: provide for preventing and / or curative measures (e.g.: beer traps, ashes, powdered hot peppers…)


Ricks of straw, Cambodia


Mulch with sugar cane leaves, Cambodia

The practice in images…

REMARKS:

- Rice glumes and floral glumes, millet, and other threshing residual matter, often unrecovered, constitute effective mulch
- For termite attacks, mulch with a mixture of neem leaves
- To act on soil fertility, it is interesting to associate mulching and liquid compost; this will allow for quick decomposition of the straw thereby enriching the soil in organic matter
- “Silvery” mulch has a visual repellent effect on insects (thrips and plant lice)

Advantages and Drawbacks

Technical

↗ Simple practice to implement

↗ Achievable with various types of material found locally

↗ Reduces water quantities added by half in heavy soils and a third in light soils (decreasing the dose or frequency)

↗ Protects soils

↘ Competes with composting for raw materials

↘ Attracts slugs, snails and termites

↘ Presents a crown rotting risk if the mulch contacts the plants

Economical

↗ Reduces irrigation costs (fuel and / or labour)

↗ Eventually, increases yield (protecting soils and contributing organic matter)

↗ Limits the labour by reducing weeding and hoeing

↘ Requires mobilizing manpower if the surface area is large

↘ Competes with cattle feed

Environmental

↗ Protects soil structure against strong rain and drying by solar radiation

↗ Creates a favourable environment for biological life in the soil

POINTS TO REMEMBER…

Mulching provides for protecting the soil against strong rain (structure and fertility) or drying (maintaining moisture).

In order to ensure the dissemination of this practice, the appropriate material must be determined on site and mulching depth should be adapted to climate conditions.

TAKING IT FURTHER:

Leaflet: Liquid compost (p. 91)
Leaflet: Direct seeding Mulch-based Cropping system (DMC) (p. 157)
Leaflet: Cover crops (p. 159)

Integrated pest management

The abusive use of artificial chemical pesticides generate a problem:

- danger to the environment (risk of contaminating water and soil, depreciating biodiversity...) ;
- danger for human health caused by handling and consuming treated products;
- increased operating costs on the short-term and increasing long-term.

All reasons to favour integrated pest management where the use of artificial chemicals is a last resort.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Implementing a set of integrated measures aimed at containing phytosanitary risks for crops
- Limiting the use of artificial chemical pesticides
- Limiting input expenses through natural and preventive actions

Conditions for implementation:

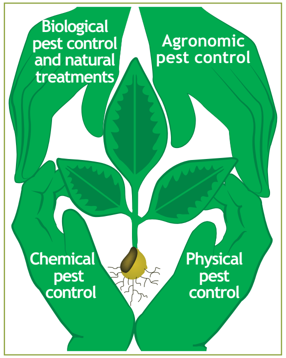
- Knowing pests and diseases
- Knowing the principles of integrated farming
- Knowing preparation method and availability of raw material for producing bio-pesticides

Principle

Integrated pest control associates all control methods available to protect crops from their enemies.

Various control methods exist:

- **agroeconomic pest control** favours the use of preventive agricultural practices (using organic matter, tending crops..) ;
- **physical pest control** uses traps, enclosures, scaring techniques, or manual elimination;
- **biological pest control** introduces predators or parasites for the pests, repellent plants or traps;
- **natural treatment pest control** uses bio-pesticides, generally on contact;
- **chemical pest control** uses artificial pesticides, on contact or systemic.



Integrated pest control is aimed at maintaining the populations of pests avoid sufficiently low levels to not cause economic prejudice. They favour **preventive methods** to prevent the appearance of crop enemies and using **curative methods** to combat a pest deemed harmful causing unbearable damage.

Method

1-Agronomic pest control

Implementing good farming practices to prevent the arrival or dissemination of pests and diseases.

→ Using quality seeds and plants

- Choosing **resistant and tolerant varieties**, subject to being suitable for the production zone's agroecological conditions
- Obtaining **quality seeds or plants** purchased from an approved supplier or produce in compliance with selection criteria and the seed conservation method
- For local seeds, **disinfecting with hot water** (50°C) before sowing may be useful to eliminate certain seed enemies


Tree-climbing ants nest tomato farming


Graffhopper

→ Create nurseries to produce healthy vigorous plants

- **Choose a ventilated spot, sheltered from strong insolation** but not totally shaded
- **Keep nurseries away from end-of-cycle crops** and orchards
- **Add organic fertilizer** and disinfect the substrate (boiling water: 10 l/m²)
- **Implement protective measures against pests:** netting against insects, raising the substrate to 1 m against ground-based pests, plastic film against bad weather
- **Comply with sowing densities**, thin as needed
- **Only transplant vigorous plants** then destroy the remaining puny plants to prevent attracting pests and disease
- **Change the soil** for each new nursery

→ Prepare the growing area to increase plant vigour

Basal manuring

- **Add basal organic manuring** well prepared (recycled manure, compost)
- **Prepare the land:** ploughing, mounding, clod breaking, draining based on the land and crop requirements
- **Comply with densities** to prevent competition
- **Mulch plots** to limit weeds, favour biological life, and maintain soil moisture
- **Provide shade houses** for crops sensitive to insolation and strong rain

→ Tend crops to prevent contamination and propagation risks

Weeding

- Weed, hoe, and water without excess, mulch, add maintenance manuring…
- When tending, avoid harming roots or leaves
- Pull up infected plants and burn them
- Do not water leaves of sensitive crops (e.g.: tomato, lettuce)
- Regularly weed the plots and their surroundings and bury the plant debris
- When production is complete, pull up the crop and bury or burn the infested remains to prevent pest propagation

→ Enhance crop diversity and complementarity in time and space

- Comply with crop rotation rules
- Make good associations for good space and parasite management

→ Respect seasons and good farming practices

- Schedule the crop's sensitive growth phase for a host plant outside periods when its parasite is proliferating
  E.g.: plant tomatoes such that they are not in full production during hot and dry periods (conducive to acari)
- Adapt farming practices to the seasons
  E.g.: cultivate on drained land and mound vegetable crop beds or cultivate on ridges during the hot and humid season to avoid excess water conducive to fungal diseases

Mulched vegetable farming bed

Weeding during the campaign starting phase

Compost

2-Physcial pest control

Set-up physical barriers and traps to prevent crop invasion by pests and their dissemination.

These physical barriers may be:

- an enclosure (hedge or fence) to protect the garden from wandering animals;
- a live hedge between plots to limit pest transfer; note that certain species have repellent properties (e.g.: tephrosia against plant lice);
- traps to capture (beer trap for slugs, mousetrap for mice...), destabilize or trap pests (pheromone traps), repel pests (ash for molluscs, scarecrows for birds...) ;
- collecting pests (slugs, Colorado potato beetle, crickets...); kill them before infestation.

3-Biological pest control

Maintain an effective level of predators to control the pest population.

- know pests and their auxiliaries (predators or parasites)
- do not treat with broad spectrum artificial products which may increase the plot's vulnerability
- increase the number of habitats for wild fauna (nest boxes, ponds...) to favour biodiversity in the garden and therefore balance between populations

For genuine effectiveness, it is recommended that you work on an area-wide basis.


Snail trap


Scarecrow

4-Pest control with natural phytosanitary treatments

Eliminate pests using bio-pesticides.

2 types of product exist:

- repellent products to keep pests away;
- products that kill pests on direct contact.

Facing photo: Spraying a mixture of garlic, ginger, and hot pepper to combat thrips on shallots (Sri Lanka).

5-Chemical pest control with artificial products

Eliminate pests using artificial chemical.

As for natural products, there are 2 types of artificial chemicals:

- repellent products to keep pests away;
- products that kill pests, either on direct contact (contact products), or when these pests consume the plant which has itself ingested the product (systemic products).

NOTE

The use of artificial products is only justified if a significant risk of loss exists: it must only be considered as a last resort, if a pest or disease is developing despite all natural preventive and curative measures.

For **integrated use** of artificial pesticides:

- refer to legislation so you only use authorized products;
- choose products with selective action, fewer harmful side effects for the environment and less toxic for human health;
- vary the active ingredients and their means of action;
- act when the enemy is most sensitive to the pesticide;
- respect pesticide usage measures (suitable, properly maintained equipment, protection, time before harvest).

Advantages and Drawbacks

Technical

- ↗ Protects crops
- ↗ Offers numerous complimentary practices and techniques
- ↗ Adapts based on raw materials available
- ↘ Requires good knowledge of pests and diseases as well as suitable control methods

Economical

- ↗ Offers a better harvest guarantee
- ↗ limits use of artificial chemical products (costly)
- ↘ Requires good observation in order to not allow an infestation to ravage the crop

Environmental

- ↗ Favours natural balances
- ↗ Favours promotes biodiversity

Vegetable farming area using integrated pest management techniques, DRC

Vegetable farming plot using integrated pest management techniques, Cambodia

POINTS TO REMEMBER…

In their crop protection strategies, producers must use various methods: physical, agronomic, biological…

The use of artificial chemical pesticides must only be considered as a last resort.

A healthy crop environment and rugged crops limit phytosanitary risks. Preserving natural balances should provide for maintaining an acceptable loss level, often more profitable than frantic use of pesticides.

TAKING IT FURTHER:

Leaflet: Crops succession (p. 111)
Leaflet: Crops association (p. 117)
Leaflet: Natural phytosanitary treatments (p. 127)

Natural phytosanitary treatments

In nature, certain plants or minerals have the ability to grow back or eliminate parasites thanks to the natural molecules they have. Producers may use them to prepare solutions called "bio-pesticides."

These bio-pesticides present advantages in comparison with artificial chemicals.

Indeed, the industrial active ingredients used to produce phytosanitary products are often harmful for the environment and for Man, since they are toxic and degrade with difficulty.

Moreover, the cost involved in using these artificial products may significantly reduce crop profitability. Often, producers cannot protect their crops due to a lack of financial resources.

Effects:

Soil	Water	**Plant**	Landscape

Objectives:

- Limiting parasite attacks on crops
- Reducing the costs of artificial chemical inputs
- Limiting risks to the environment and Man
- Preserving natural balances between populations (pests and their enemies)

Conditions for implementation:

- Knowing how to identify pests and diseases
- Familiarity with plants and minerals, their effects, and means of use
- Availability of equipment (container, mortar and pestle, knife, sprayer…)

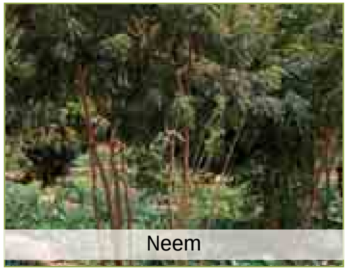
Principle

Natural phytosanitary treatments involve active ingredients obtained from **plant-based preparations** or other minerals such as cupric or sulphur products (Bordeaux mixture), ash… These preparations may act in different ways:

- **repulsion**: by the order or the presence of products establishing a barrier that repels parasites, e.g.: insect control solution, spreading ashes…;
- **inhibiting reproduction**: certain active ingredients act on parasite reproduction, preventing their invasion, e.g.: pheromones (traps), clove extract (direct reproduction inhibitor), neem oil (development and growth inhibitor for certain insects);
- **eradication:** the solution kills the parasites, e.g.: fungicide, insecticide… solution;
- **bio-fumigator emission** (volatile organic acids) resulting from the decomposition of organic matter, e.g.: moringa leaves, farm manure…


Chromoleana


Papaya


Neem


Lemongrass, basil


Hot pepper

Examples of plants and their natural treatment uses

Plants	Part used	Pests and diseases	Effect	Preparation	Application
Papaya	Leaf	Powdery mildew Rust	Fungicide	→ Finely rush 1 kg of fresh leaves → Mix in 10 litres of water → Add clay in the solution to reduce unpleasant odours → Place the mixture in a container and close it leaving an opening to allow air to enter → Stir every day → After 15 days fermenting, filter and use directly without diluting	**Prevention:** → Apply ever 15 days at a rate of 1 litre for 10 m^2 **Cure:** → Apply as soon as symptoms appear → Apply ever week at a rate of 2 litres for 10 m^2
Hot pepper	Fruit	Aphids or plant lice	Insecticide	→ Dry and crush when the fruit is completely dry → Soak 2 spoonfuls of power in 10 litres of water for 12 hours → Take 2 litres of mixture and add 4 litres of previously prepared soapy water	**Prevention:** → Apply 1 month before the insect's expected proliferation → Repeat the treatment every 10 days → Apply at a rate of 0.6 litres for 10 m^2 **Cure**: → Apply at a rate of 1.2 litres for 10 m^2 → Repeat periodically until the insect disappear
Tobacco	Leaf, stem	Plant lice, caterpillars, acarids Sweet pepper leaf curl virus	Insect control Insecticide Fungicide Acaricide	→ Crumble 1 kg of dry leaves and enclose the resulting power in a tissue → Soak the bundle in 9 litres of water, close the container and let marinate 24 hours → Crush a piece of soap and soak 2 pinches (3 fingers) in 1 litre of water, stir well → After 24 hours, stir, squeeze the bundle over the container → Remove the bundle and filter the juice containing the decoction → Add the litre of soapy water to the filtrate	→ Apply the solution with a sprayer or using a rake → Treat crops with the resulting solution (0.1 litre for 10 m^2) → For better effectiveness, the treatment should be periodically repeated (effective duration: 5 days)
Rice	Bran	Gourd family powdery mildew	Fungicide	→ Take 1/3 of a litre of fine rice bran → Mix with 10 litre of water → Let soak for 6 hours → Filter and use directly without diluting	**Prevention:** → Apply twice a week at a rate of 1 litre for 10 m^2
Basil	Leaf and stem	Insects and fungi in general	Insecticide Fungicide	→ Soak 200 g of leaves in 1 litre of water for one night, crush the leaves and filter → Add 1 ml of previously prepared liquid soap and mix	**Prevention:** → Spray the macerated mixtures + soapy water at a rate of 3 litres for 10 m^2
Moringa oleifera	Leaf	Fungi (nursery damping off)	Fungicide	→ Plough the fresh leaves into the bunches or nursery beds	**Prevention:** → Plough in 1 kg / m^2 of nursery bed

Plants	Part used	Pests and diseases	Effect	Preparation	Application
Garlic	Bulb	Aphids or plant lice	Insect control	→ Dry and crush the cloves when the garlic is very dry → Soak 2 spoonfuls of power in 10 litres of water for 12 hours → Mix 2 litres of preparation with 4 litres of previously prepared soapy water	**Prevention:** → Apply 1 month before the insect's expected proliferation → Repeat the treatment every 10 days → Apply to a plot at a rate of 0.6 litres per 10 m² **Cure:** → Apply at a rate of 1.2 litres for 10 m² → Repeat periodically until the insects disappear
Chromoleana	Entire plant	Soil nematodes	Nematocide	→ Chop the leaves and roots and incorporate them in the solid compost → Chop the roots and incorporate them in the liquid compost	See Compost leaflet p 81
Lemongrass	Entire plant	Bacteria in general	Preventive bactericide	→ Crush about 50 g of lemongrass leaves, let it soak for a few minutes in 2 litres of warm water → Filter	**Prevention:** → Spray the macerated mixtures + soapy water at a rate of 3 litres for 10 m²
Neem	Leaf	Various harmful insects: very effective against caterpillars and beetle larva (agrotis) leaf-miner flies, crickets, and leafhoppers.	Insecticide	→ Crush 3 kg of leaves with a mortar → Soak in 10 litres of water for 6 to 12 hours until the water turns greenish → Filter and press → Add soapy water to make 30 litres of mixture	**Prevention:** 2 means of combating insect infestations in the soil with unmacerated neem leaves: → use as a coverage fertilizer incorporating the leaves in the soil or under the nursery beds; → use as green matter incorporating the leaves into the compost. **Cure:** → Spray the macerated neem mixture + soapy water at a rate of 3 litres for 10 m²; persistent for 6 to 10 days
Neem	Fruit	Various harmful insects: very effective against caterpillars and beetle larva (agrotis) leaf-miner flies, crickets, and leafhoppers.	Insecticide	→ Lightly crush the fresh fruit to remove the peel and dry in the sun a few days → Remove the remaining peel and crush the stones to make a powder → Use in powdered form or continue preparing → Soak 1/3 litre powder in 10 litres water for 12 hours → Filter	**As powder:** → Mix 1 measure of powder with 4 measures of fine wood ash → Sprinkle over plants using morning dew to fix the powder → Apply the preparation to 1 are **As liquid:** → Spray at a rate of 1 litre for 10 m²
Palm	Male inflorescence	Spider mites	Acaricide	→ Incinerate male palm inflorescence	**As a cure**: → Sprinkle in cases of spider mite infestation

Advantages and Drawbacks

Technical

- ↗ Represent effective solutions for preventive and curative treatment depending on the plants and minerals used for the preparations
- ↗ Easily obtainable with local resources
- ↗ Offer numerous treatment possibilities
- ↘ Require knowledge of plants and minerals and their virtues
- ↘ Generally require numerous successive applications
- ↘ Sometimes less effective that artificial phytosanitary treatments

Economical

- ↗ Represent low cost (ingredients available locally)

Environmental

- ↗ Little harmful effect on the environment
- ↗ Maintain balances between antagonistic and destructive populations
- ↘ Represent a pollution risk due to the toxicity of certain active ingredients (nicotine in tobacco)

POINTS TO REMEMBER

Natural phytosanitary treatments generally use low-toxicity active ingredients. They often require several applications to control a parasitic invasion without devastating the natural fauna as a whole.

Their effectiveness is proven and they are more affordable for producers who can consider solutions with ingredients that exist locally.

They offer an interesting alternative to the difficulty obtaining artificial chemical input supplies and provide for significantly decreasing operating expenses.

These practices preserve the environment and human health.

Although the products are natural, bio-pesticide application must be subject to the same precautions as artificial chemical pesticides.

TAKING IT FURTHER

Leaflet: Integrated pest management (p. 123)


Neem treatment preparation


Neem treatment preparation


Jar containing bio-pesticides


Red acarid attacks on eggplant


Good quality beets


Good quality lettuces

Potted tree nursery

Producing healthy, robust fruit trees is the key first stage for a successful orchard.

Mastering the pot nursery is interesting for all producers who wish to produce their own trees to be planted or graft-bearers to be used.

It also provides for conducting the paid activity of a nursery tender which may or may not be paired with another farming activity.

This pot nursery activity has been implemented in Agrisud's programs, more particularly in Niger, Madagascar, and Cambodia.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Producing healthy, vigorous fruit trees for planting orchards or hedging farming plots
- Developing a nursery tender activity where appropriate

Conditions for implementation:

- Availability of a protected site with access to water
- Availability of sand, compost or recycled manure and quality seeds ready for sowing (producing "sound" stalks and graft bearers) or scions (grafted plant production)
- Availability of the tools necessary to set-up the nursery (pots, watering can, wheelbarrow, shovel, sieve)
- Availability of protective materials for young plants (fence…)

Principle

The pot nursery consists of fruit plants in plastic bags to facilitate tending, transportation and planting the young plants. These plants will be used directly ("sound" stalks) or after grafting.

Method

1-Nursery location selection

Nursery location is strategic; its choice should fulfil a majority of the following criteria:

Selection criteria	Justification
Proximity to a water source	→ Facilitate irrigation
Flat land not subject to flooding	→ Facilitate spatial management → Avoid flood-related losses
Proximity to domestic habitat	→ Facilitate nursery surveillance and tending
Accessibility	→ Facilitate earth, sand, compost… supplies for the nursery → Facilitate production removal
Protection against the sum	→ Avoid drying, excess water consumption and water-stress for plants

2-Site preparation

- **Clean:** weed and flatten the land
- **Protect:** ensure the site is protected against animals and wind (fence, live hedge, palisade)
- **Protect from strong insolation** natural cover (shade trees) or artificial (shade house)

Plant production in Niger

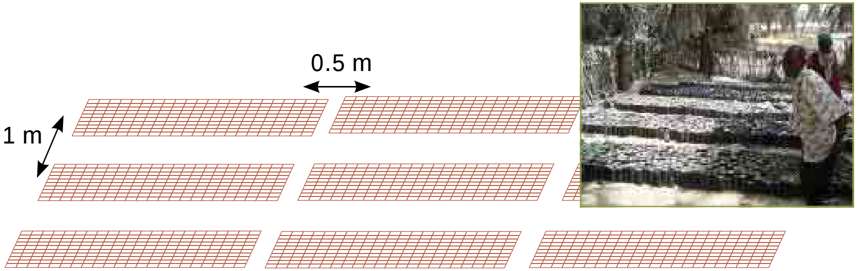
Plant production in Niger

3-Bed set-up

Nursery beds must be created as follows:

- 1 m wide and 3 to 6 m long to facilitate tending;
- slightly dug out (5 to 10 cm) to retain moisture and pot stability to favour good plant development;
- laid-out such that the bed width faces the dominant wind to prevent plant drying.

To facilitate access to the plants, leave 50 cm to 1 m alleys between the beds:



It is possible to mulch the bottom and side of the bed to protect the pots as well as the alleys to prevent weeds from growing.

4-Substrate preparation

The substrate must be **uniform** (well mixed) and **finely composed**.

Component	Proportion	Properties
Local sand well strained	2/3 of the substrate	Loose substrate structure Water draining
Recycled manure or well decomposed compost	1/3 of the substrate	Retaining moisture and nutritional elements

Leave the substrate in the shade 2 to 3 days and moisten periodically until the pots are filled.

5-Filling pots

The pots must be:

- **opaque** to protect the roots from the sun;
- **drilled on the bottom** (6 to 8 holes) in order to prevent excess water retention;
- **suitable** for the type of plants to be grown (size and shape).

To ensure good pot behaviour and limit damage during transportation before planting:

- fill the pots **to the edge** one by one;
- **avoid folds** in the plastic
- **pack** from time to time during filling for uniformity throughout the pot.

6-Layout

To optimize the use of space and facilitate composting, a bed generally contains 500 to 1000 erected pots, pressed against each other and in straight lines.

7-Watering

Water the pots until sowing, the soil should be moist but not dripping.

Citrus nursery under shade

8-Sowing

Before sowing, the nursery tender should have good quality seeds ready to germinate.

Sowing depth is determined by grain size:

Seed type	Technical	Examples
Small seeds (diameter less than 0.5 cm)	3 to 4 seeds per pot 1 cm deep in the centre of the pot	Guava, pomegranate, citrus
Large grains (diameter greater than 0.5 cm)	1 grain per pot (vertically, indent towards to bottom) 3 cm deep	Mango, safou, avocado

After sowing, **refill** the bunches and **water abundantly** with **a sprinkler water can**.

NOTE

Avoid sowing during the cold season, cool temperatures limit good development and growth for young plants.

Mango tree germinator technique:

For some **hard-shell seeds** such as mangos, whose conservation capacity is low (the kernel quickly deteriorates due to oxidation), the germinator technique provides for conserving the seeds and having young shoots even after the mango period.

The germinator is a small board from 1 to 2 m^2, 10 to 15 cm in depth and placed in the shade.

After depulping, the kernels are placed (vertically, indent towards the bottom) in thin layers, then covered with a 3 cm layer of white sand. As for the rest of the nursery, the germinators must be periodically watered to maintain their moisture.

When the plants have 1 to 2 cm shoots, **transplant to pots**. It is also possible to let them grow a little more and transplant in the soil at the "brown stage" (golden-brown leaf colour – 40 days).

9-Nursery tending

- **Watering:** twice a day (morning and evening) at a rate of 2 7-litre watering cans for a hundred pots. To prevent plant damage, use a watering can with small-perforation spray head
- **Mulching:** mulch the pots before growth (maintain moisture and protect young shoots). Remove the mulch when the plant comes out by 1 cm
- **Weeding:** weed the pots and alleys to prevent invasion by weeds
- **Singling:** remove excess plants and only retain one vigorous plant in the centre of the pot. In certain cases, singled plants may be moved to pots where germination did not occur
- **Hoeing:** as necessary scrape the soil surface in the pots to avoid forming an impenetrable crust and allow water to seep in
- **Undercutting:** lift the pots every 15 days (as soon as roots come out of the pot) to prevent them from taking root in the soil. If roots have pushed through the plastic, cut with a very shard blade
- **Pruning:** prune the plants that have grown excess branches
- **Group** plants by size and vigour to prevent puny plants from having the development hindered by competition for light with more vigorous plants.

NOTE

Potted nurseries may also be used for producing plants from cuttings. The plants may be used directly (e.g. pink pepper trees cuttings , photos below) or grafted (e.g. vines)

10-Grafting

Grafting allows a tree to benefit from the different qualities of two specific varieties in the same family. this technique is generally used to bring together resistance and productivity from two individuals:

- **the subject:** robust, resistant variety adapted to the environment, it will receive the graft It measures at least 50 mm (diameter of a pencil) and is aged 7 to 8 months;
- **the scion:** young part (branch, bud) of a tree recognized for the quality and size of its fruit. It is generally taken from a previous grafted tree call a "graft bearer."

Example of mango grafting

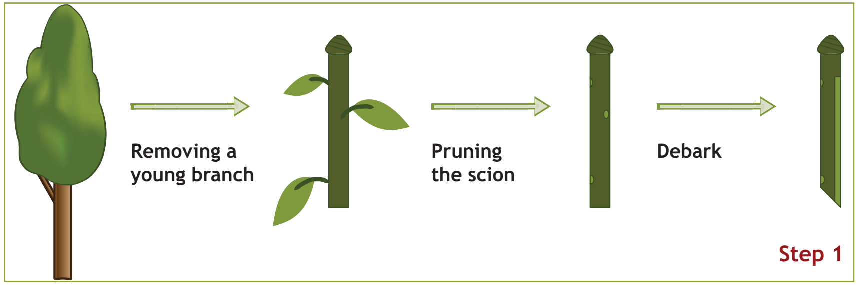
Step 1: Taking the scion
The scion is the end of a branch with the most mature terminal bud possible before the growth stage. This scion is removed from the graft source (grafted mango) and its is 10 cm to 12 cm in size. remove the petioles from the fragment.

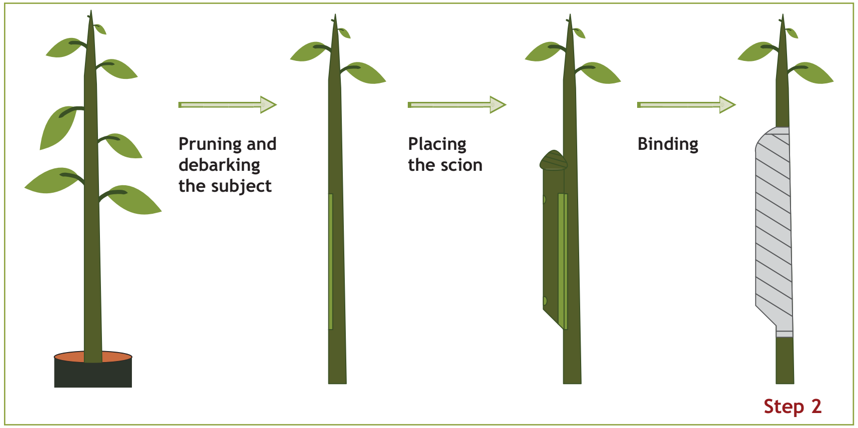
Step 2: Grafting
This technique is called "simple plaster grafting:" subject and scion are spliced together and bound.

- **Debark the subject and scion:** remove the bark from about 10 cm along the place where the two woods will be put into contact (be careful not to dig into the wood)
- Prune the lower part of the scion and **fit it into the lower part of the subject's debarked area** finish with a tab (top portion of the detached bark)
- **Push the two debarked areas** against each other, edge in the tab and buds towards the top
- **completely close the graft** using tight plastic tape, air must not penetrate
- **Water** abundantly each day


Debarking


Binding the scion





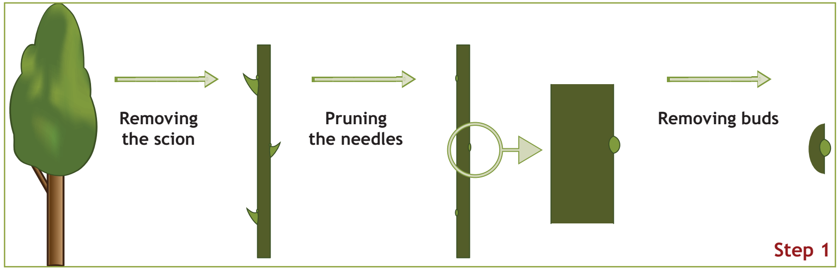
Interview:

- 15 days after grafting: remove the plastic from just the bud to allow the scion to grow, re-attach below
- At 20 days: if the scion develops, grafting is successful
- After scion growth: prune the "scion-holder" subject above the scion to allow it to grow

Example of citrus grafting

Step 1: Taking the scion

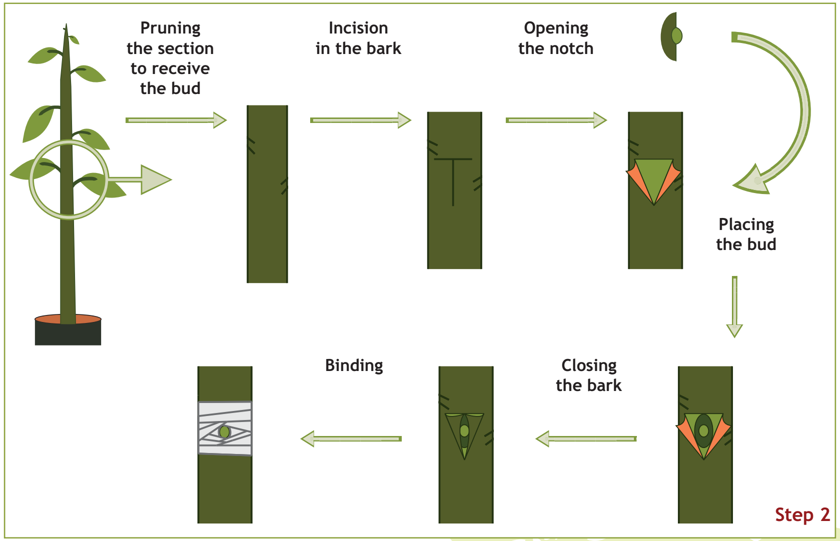
Remove a shoot (mature terminal branch) with several eyes or buds. Remove the leaves and end section. From this shoot, each bud will be removed to make a graft.



Step 2: Grafting

Grafting is called "budding:" subject and bud are spliced together and bound.

- **Prune the subject** 30 cm from the ground
- **Split the bark in a T** on the top third
- Pull back the bark to make two tabs on the upper part of the T
- **Place the bud** against the wood between the two tabs
- **Bind the tabs** to hold the bud leaving an opening for it to grow
- **Attach the graft** using plastic film starting above then below, the eye should not be fully attached
- **Water** abundantly each day



Tending:

- **Prune the tree** so that just the scion develops
- **10 days after grafting:** if the bud develops, grafting is successful

NOTE

Producers must know the production mode for the selected fruit trees. Safou trees, avocados, pomegranate trees, and guava are "sound" stalk trees: the plants are the result of sowing and not grafted as are mango, citrus, and apple trees

Advantages and Drawbacks

Technical

- ↗ Producing "sound" easy to control stalks
- ↘ Requires adjustments
- ↘ Grafting techniques are more difficult to master

Economical

- ↗ Requires little investment if site choice respects the selection criteria
- ↗ May be a source of additional income (nursery activity paired with fruit production)
- ↗ May be implemented on a small scale (secondary activity) or large-scale (primary activity)
- ↗ Represents significant profit with the sale of fruit trees, especially if they are grafted
- ↘ Requires investment if the site selection criteria are not met
- ↘ Requires investing money or time to building a fence

Environmental

- ↗ Provides for reforesting, creating orchards, recreating plant cover, hedges…

NOTE

Potted nurseries may also be used for producing forest plants. Plants may be used for hedging sites or re-foresting cleared areas.


Pink pepper trees cuttings in the nursery


Fruit tree nursery

POINTS TO REMEMBER

Compliance with selected criteria for setting-up the nursery is fundamental and must not be neglected. Spatial organization provides for correctly operation and optimizing work times.

Correctly preparing the substrate and filling the pots will allow the producer to produce robust, healthy plants.

Once sown, regular tending will allow the producer to produce good quality plants and fill orders.

Undercutting is required to prevent the plants from taking rood (which would wound them just before planting, compromising the plant's recovery).

Grafting provides for obtaining trees whit quality production corresponding to consumer expectations (correct variety selection).

TAKING IT FURTHER

Leaflet: Swath composting (p. 81)
Leaflet: Manure recycling (p. 77)
Leaflet: Hedging vegetable crops sites (p. 93)
Leaflet: Hedging food crop sites (p. 145)

Planting fruit trees

Fruit tree farming is an economic opportunity for producers. It may be conducted alone or in association with irrigated or rainfed crops.

In either case, the planting stage is primordial for successful crops. It is a question of guarantying the young plants develop well and ensuring quick, quality production.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Obtain robust, resistant trees
- Ensure good fruit production and underlying crops where appropriate
- Limits the use of phytosanitary treatments
- Contribute to landscape management

Conditions for implementation:

- Ownership of land with sufficient surface area to allow for planting (compliance with densities)
- Availability of a water resource
- Availability of suitable plants for the soil type
- Availability of the required equipment (shovel, pickaxe, spade, watering can)
- Availability of compost or recycle manure and mulch
- Provide protection for the young plants against wandering animals
- Provide, where appropriate, protection for the trees against the wind (windbreak hedge)

Principle

Planting fruit trees fulfils a certain number of criteria to ensure technical success and optimal use of the space. Producer should pay special attention to the following steps: site choice and preparation, densities, hole digging, and planting the young fruit trees.

Method

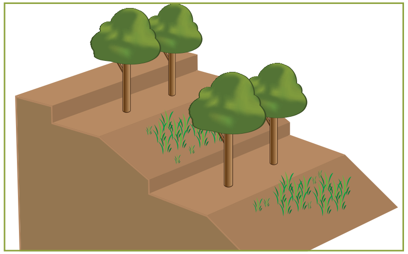
1-Site choice and preparation

Fruit trees may be cultivated on **flat areas** or **low grades** (<10%). The soil must be **fertile, permeable** and well **drained** to avoid extended waterlogging.

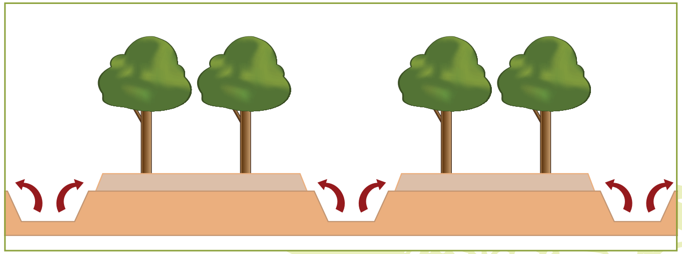
Before planting, you must:

- clear the site as much as possible, taking care to preserve the topsoil and any rare plant species that do not compete with the fruit trees;
- fit-out the site according to its characteristics: in flood zones or hydromorphic soils, create mounds and sufficiently deep draining channels to drain a sufficient soil layer (the earth removed from the channels may serve as fill for creating the mounts); on high grades, create terraces (see diagrams below);
- install windbreaks around the orchard if necessary

Development on steep slopes



Development in floodable zones or on hydromorphic soils



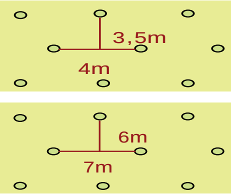
NOTE

It is imperative to have sufficient **water resources** to satisfy the water needs for fruit trees during the first 2 years after planting.

In general the young fruit trees are planted at the beginning of the rainy season so they benefit from the precipitation during the recovery phase.

2-Densities

Density depends on species and **varieties farmed** and the **farming systems** selected. If there are no crops under the orchard, the fruit trees may be relatively closer:



- small size trees (citrus, guava, soursop, pomegranate trees): 4 m along the row x 3.5 m between rows;
- big size trees (mango, litchi, avocado, safou): 7 m along the row x 6 m between rows.

Staggered planting optimizes space utilisation.

REMARKS:

For orchards in association with low crops, use larger spacing, at least 1.5 times the spacing for orchards without underlying crops. This will facilitate tending and favour crop insolation. East-west orientation for planting rows is also recommended to preserve sufficient insolation for low crops.

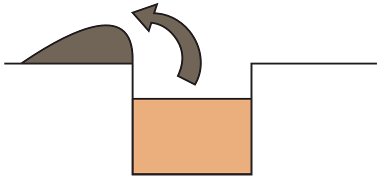
3-Hole digging

Holes must be dug, in compliance with densities, at least one month before planting (see diagram facing). Hole dimension depend on species and **varieties farmed**:

- 0.8 m x 0.8 m x 0.8 m = **0.5 m³** for **small size trees** ;
- 1 m x 1 m x 1 m = **1 m³** for **big size trees**.

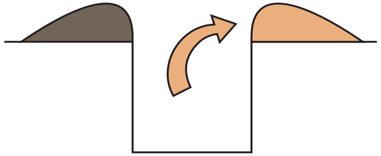
Planting peach and plum trees in Southern Morocco

Hole digging steps:

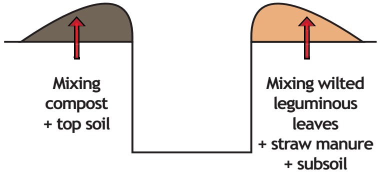


Step 1: Dig the topsoil and set aside the soil (1/3 of the height).

Step 2: Dig the lower part and set aside the soil (remaining 2/3).



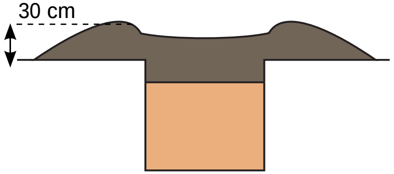
Leave the hole exposed to the sun for 7 to 10 days



Step 3: Fertilize the soil surface, enrich the undersoil.

- Small holes (0.5 m x 0.5 m x 0.5 m): 5 kg of compost and 2.5 kg of manure;
- Large holes (0.8 m x 0.8 m x 0.8 m): 15 kg of compost and 7.5 kg of manure.

If there is a significant termite presence, include neem leaves, crushed neem fruit, ashes... In the various mixture layers.



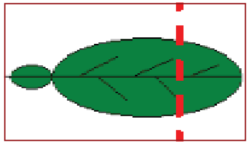
Step 4: Fill the hole putting the topsoil on last and creating a 25 cm to 30 cm high mount and a planting recess.

Step 5: Water abundantly and mulch the mound.

Wait 2 to 3 weeks before planting to all the fertilizing elements to decompose without endangering the young plant (manure heating phenomenon). Regularly water during this period if rain is rare.

4-Planting

Step 1: Reduce the plant's foliar surface by cutting the top third of fully developed leaves on the bottom of the plant to decrease transpiration (drying) while the plant develops its root system.



Step 2: Separate the mulch and dig a **hole at the centre of the mound** about 10 to 15 cm deep.

Step 3:

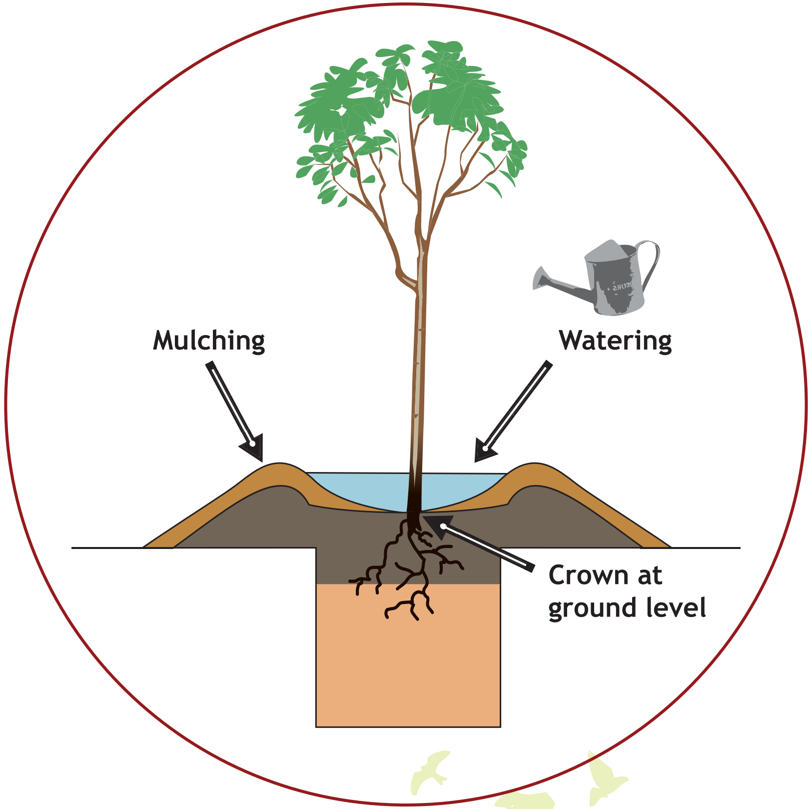
- **Cut the plastic pot** with a sharp blade holding the clod of earth at the root level;
- **Place the plant in the soil** up to the crown (for grafted trees, ensure that the graft is outside the soil).

Step 4: Pack the soil and **reform the mound and watering bowl**.

Step 5: Protect the plant:

- **Mulch** the recess to limit evaporation (at least 8 cm thick);
- **Stake** as necessary to protect from the wind;
- If the orchard is not fenced, protect to prevent damage caused by wandering animals (thatched basket, thorny branches…).

Step 6: Water abundantly, filling the bowl



NOTE

Preferably, plant during the rainy season during cooler hours, at the end of the day.

NOTE

After planting, don't abandon the plastic bags on the plot.

Advantages and Drawbacks

Technical

- ↗ Favours good fruit tree development
- ↗ Allows for early fruit bearing (good planting leads to a gain of at least one year for the first fruit)
- ↗ Observes density standards creating a healthy environment (reducing parasitic pressure) and offers the possibility of farming underlying crops
- ↘ Requires adjustment of significant grades and drainage in hydropmorphic or floodable areas

Economical

- ↗ Guarantees earliness and production quality
- ↘ Requires significant quantities of organic matter
- ↘ Labour-intensive hole digging

Environmental

- ↗ Develops the space and available resources by associating fruit / low-crop farming
- ↗ Provides for re-foresting and developing hedged landscapes

Planting citrus and vegetable crops, Madagascar

Setting-up an orchard, Madagascar

POINTS TO REMEMBER

Preparing the soil and regularly maintaining young plants allows producers to obtain well-developed trees and, consequently, quick, good quality production.

Similarly, water resources must be managed efficiently: fruit trees need water during dry periods, particularly during the first years, but are sensitive to extended flooding and waterlogged soils.

TAKING IT FURTHER

Leaflet: Swath composting (p. 81) / Crib composting (p. 89)

Leaflet: Mulching (p. 121)

Leaflet: Hedging vegetable crops sites (p. 93) / Hedging food crop sites (p. 145)

Leaflet: Potted tree nursery (p. 131)

Tending an orchard

Successful fruit planting is hallmark for good production and orchard longevity.

Orchard tending must be suited to the season and tree growth stage for sustainable fruit production in quantity, quality, and regularity.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Guarantying good tree growth and consequently regular fruit production in quantity and quality
- Guarantying orchard longevity
- Limiting phytosanitary pressure
- Limiting operating expenses related to using phytosanitary treatments

Conditions for implementation:

- Availability of the tools required to perform tending work (shears, hand saw, ladder, hoe, pull-hoe, sprayer)
- Availability of mulch, compost, and recycle manure
- Availability of putty to treat pruning wounds

Principle

Through tending, orchard trees develop well with good growth and are robust. They are less sensitive to parasitic pressure and disease and have better fruit production.

There are four types of tending: weeding, irrigation, fertilisation, and pruning.

Method

1-Weeding

Weeds compete with plants for water and nutritional elements and provide suitable shelter for pests to proliferate. They may provoke decreased yield and lower product quality.

Regular weeding must be performed:

- under trees: mulch the mounds and eliminate weeds that come through the mulch;
- between trees (if no underlying crops): manually or mechanically mow without up-rooting (keep-up a well-maintained cover).

Weeding under olive and date trees, Southern Morocco

NOTE

Weeding waste matter may be used for mulching the trees, associated crops, or for composting.
If you chose to keep the orchard grassy, prefer cover crops that are useful for maintaining soil fertility and creating mulch (*Arachis pintoi*, Stylosanthes, Brachiaria, Alfalfa...)

2-Irrigation

Fruit trees have significant water requirements when young and during prolonged dry periods. In order to fulfil these needs, without wasting the resource:

- **weed and hoe** to improve water seepage into the soil (unless permanent cover crops have been planted);
- **mulch** at the foot of the trees to maintain soil humidity;
- **regularly plough in** organic matter (compost or recycled manure) for better water retention in the soil.

Watering frequency for young plants varies by season:

- in the dry season, irrigation is periodic, twice a week, but reduced to once a week if the producer implements the various practices listed above;
- during the rainy season, irrigation acts as a supplement if the rains are late.

In all cases, you must ensure there is **no extended water stagnation** (more than 3 hours) at the foot of the trees to prevent the crown and roots from rotting and limiting roots system development. To this end, the mound maintenance is recommended: mulching, creation of a recess…

For orchards in areas that may be temporarily flooded or are hydromorphic, plant the young fruit trees on high mounds (40 to 50 cm) to keep them out of the water.

NOTE

Associating vegetable / fruit tree farming ensure the availability of water and fertilizers added for vegetable farming to the trees.


Lemon grass under litchis

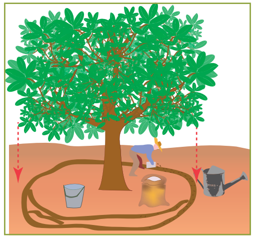

Zucchini under citrus

3-Organic fertilization for maintenance

Maintenance fertilization is added at three different periods: 2 months before flowering, 15 days after flowering, and 75 days after flowering.

Various supplements based on tree age:

- **for young trees**, add compost, nitrogen and potassium supplements;
- **for older trees**, add composts and phosphor-potassium supplements.



In all cases:

- **place the compost** on the ground in a circle whose diameter is the same as the aerial part of the tree;
- **Hoe** to incorporate the compost in the soil and break up the topsoil under the tree.

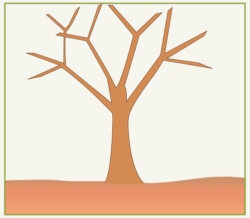
It is possible to associate the use of liquid compost to water the mulch at the foot of the trees.

4-Tree pruning

A tree's carriage determines its production. Pruning, which determines the carriage, is therefore a required operation. It is advisable to give a tree an **aerated** and **spread-out carriage** rather than dense and high. As a general rule:

- **lighten trees** to allow light to penetrate into the heart of the boughs;
- **remove parasite-infected branches**;
- **remove excess branches and rejects** to limit the unproductive consumption of nutritional elements and save them for fruit production;
- **control the tree's aerial growth** to facilitate fruit harvesting.

Pruning young, non-wire trained trees (1 to 3 years)



- Keep 3 to 4 branches 60 to 80 cm from the ground, select branches extending outwards (future "primary branches")
- Systematically remove shoots that are too low as well as those turned towards the inside of the foliage
- If the plant is in the form of a single stem (scion), it must be encouraged to grow secondary branches by pollarding the 2nd year after planting

Various types of pruning exist depending on fruit tree development:

- **Shape pruning** applies to young trees and consist of shaping their appearance; it differs depending on whether the producer wants a standard tree (free form), goblet-shaped, bush, wire-trained…
- **Maintenance pruning** provides for retaining the benefits from shape pruning, while continuing to grow the tree towards its final shape; it simply consists of removing diseased, dead, and broken branches in order to limit parasitic pressure.
- **Fruit-formation pruning** favours fruit production and consequently plays a significant role in fruit tree development and in production control; such pruning must only be performed on adult trees and not on young trees; it is not automatic, particularly for large-growth trees (called standard).
- **Regeneration pruning** is performed when trees or orchards have been untended for several years; this type of “severe” pruning consists of eliminating all diseased branches and lightening the tree by eliminating excess or poorly placed branches. Alongside regenerative pruning, the soil should be worked at the foot of the trees and significant manuring added.


Regenerative pruning, Morocco

REMARKS:

When pruning, you must protect the largest wounds by applying protective putty. Each wound is a potential entry point for disease that may endanger the entire plant.

Pruning performed during non-growing periods (e.g. in winter in Morocco) cause wounds that take longer to scar. Therefore they must be puttied.


Fruit production pruning


Grafting wax application

NOTE

In a fruit tree production dynamic, thinning fruit is an important practice to guarantee regular harvests, producing health, large-sized fruits. It provides for avoiding over-producing small-sized fruits, limits the number of branches breaking under the weight of the fruit, and prevents illness and pests on the fruit.

Advantages and Drawbacks

Technical

- ↗ Guarantees better orchard production
- ↗ Limits pressure from pests and disease
- ↗ Favours humidity retention, increases the value of added fertilizers (recycling leached elements by fruit trees) and maintaining the orchard by associating low crop / fruit trees
- ↘ Requires sufficient know-how, particularly for pruning

Economical

- ↗ Guarantees better production
- ↗ Reduces phytosanitary costs
- ↘ Requires a significant addition of organic matter

Environmental

- ↗ Ensures orchard continuity and consequently, maintains the tree's role in the landscape on the long term
- ↗ Limits soil deterioration (erosion, destructuring, leaching) with continuous cover (orchards on grassy or cultivated soil)

Orchards and crops, India

Almond trees, Southern Morocco

POINTS TO REMEMBER

After planting, regular plant tending provides for optimizing tree development and, consequently obtaining good quality production.

Correct pruning (well-spaced foliage, eliminating parasite-infected or dead branches…) limits the risk of disease and pests. It plays a decisive role in orchard health as well as future production (earliness, quality, and quantity).

It is also important to maintain continuous cover for the soil under orchards: periodically mown grass, association of low crops or cover crops.

TAKING IT FURTHER

Leaflet: Liquid compost (p. 91)
Leaflet: Mulching (p. 121)
Leaflet: Planting fruit trees (p. 137)

Hedging food crop sites

Hedging is an agroforestry technique consisting of planting shrubs and trees around and in cultivated plots to create a hedging effect. Depending on their density, layout, and type, they limit insolation and wind, thereby favouring soil water retention and creating a micro-climate favourable to crops.

The root system of these plants allows the absorption and recycling of mineral elements that have migrated into deep soil layers. Biomass produced may also be used as organic fertilizer and mulch.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting damage from wind and / or caused by animal pasturing
- Creating an environment (hedged landscape) favourable to crops (humidity, shade, diversity)
- Recycling leached mineral elements
- Availability of usable biomass source on the farm
- Creating ecological habitats conducive to maintaining agroecological balances

Conditions for implementation:

- Ownership of land with a nearby water source
- Available of plants, cuttings, or seeds favouring local, high-quality varieties
- Availability of tools (shovel or hoe, watering equipment) and protective equipment for young plants

Principle

Planting shrubs and trees as living hedges, or sparsely, allows creating hedged farmland favourable to crop growth.

Living hedges and trees have an effect that is both:

- **protective**: they protect crops from damage caused by the wind and / or wandering animals
- **regulating**: with their shade and windbreak effect, they participate in maintaining humidity in the soil and improve hygrometry in the dry season and during the rainy season; their deep root system allows underground water ascent;
- **improving**: by producing biomass, trees – more particularly leguminous (nitrogen contribution) – participate in the organic matter cycle directly (mulch decomposition) or indirectly (composting); moreover, their root system allows soil airing (structural properties of trees such as acacias) and recycling of minerals in deeper soil layers;
- **economical**: whether from forest or fruit tree products and sub-products may be used or sold on the market (fruit, firewood, wood for construction...).

Hedging provides for significantly increasing cultivated land productivity (number of production cycles per year, crop diversity and association) and authorizes sustainable intensification of farming systems without endangering the natural resources used.

Hedged farmland, Sri Lanka

Zones	Examples of usable species
Dry	*Acacia senegal* (rubber plant), *Prosopis africana*, *Parkinsonia aculeata*, *Calotropis procera* (euphorbia), *Agave sisalana* (sisal), *Azadirachta indica* (Neem), *Jatropha curcas*
Wet	*Crotalaria grahamiana*, *Cajanus cajan*, *Acacia dealbata*, *Dodonaea madagascariensis*, *gliricidia sepium*, *Leucaena leucocephala*, *Sesbania rostrata*, *Tephrosia candida*, *Flemingia congesta*, *Acacia mangium* and *auriculiformis*

Method

Hedges are rows of shrubs or trees around plots or partitioning large-sized plots.

1-Various hedge types

- **A windbreak hedge** is perpendicular to the dominant wind; it "breaks" the dominant wind to protect crops.

  Sample species: Jatropha, Acacia, Azadirachta (Neem), Parkinsonia, Tephrosia… to be planted in association.

A windbreak protects crops over a distance behind the hedge of about 10 to 20 times its height (i.e. 20 to 40 m for a 2 m high hedge).

- **Protective hedges** are often planted in addition to fences (barbed wire, mesh); they may be composed of thorny species or species that are not palatable to wandering animals ; they serve to prevent cattle from entering plots.

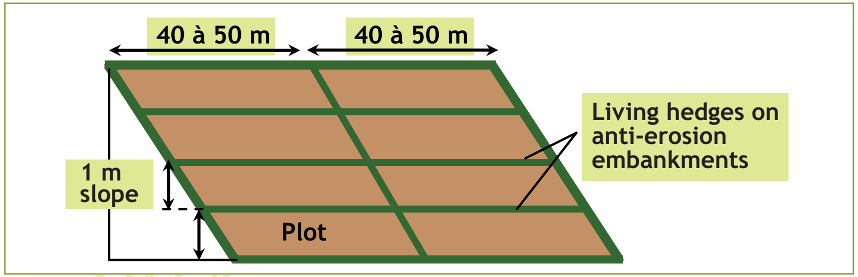
  Sample species: Euphorbia, Rubber plant, Prosopis, Ziziphus, Cactus, Sisal…

- **Biomass production hedges** are generally planted near parcels; they are periodically pruned and prunings serve to produce compost or as mulch.

  Sample species: Acacia mangium and auriculiformis, Tephrosia, Leucaena, Flemingia…

- **Anti-erosion hedges** are planted on embankments, dykes, and levees; they help fix the works, retain soil, and favour water seepage.

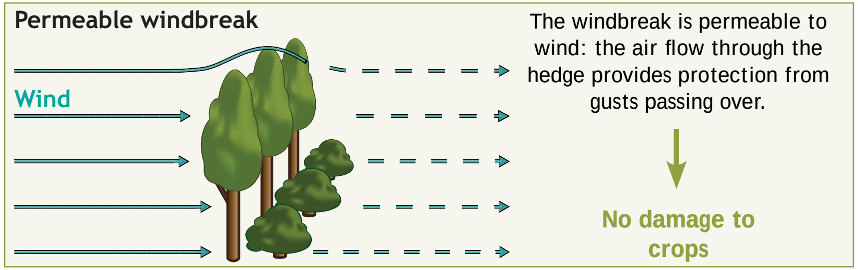
Example of hedging on sloped plots:

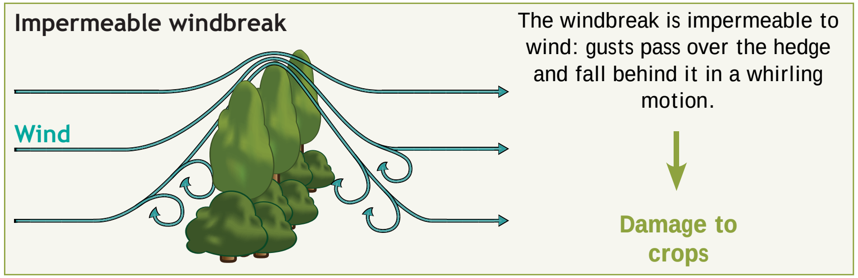


NOTE

An overly dense, and therefore impervious, windbreak causes damage to the crops (creating wind eddies).

Windbreak hedge





Each hedge type present different function that may be complementary. Producers may associate various hedge types and create a mixed, multi-function hedge.

2-Sizing

The number of plants depends on the type of tree, their purpose, and tree pruning.

SOME REFERENCE DATA

→ Protective hedges are planted around plots. Biomass production hedges are planted along crop plots. They must be dense: 2 to 3 plants per linear m. Plant the young trees at a rate of 1 plant every meter in 2 staggered rows. These two rows are separated by 0.8 m.

→ Windbreaks are planted in single lines or double rows. Tree spacing is generally higher than for protective hedges (1 plant per m^2). For double rows, plant staggered rows spaced 1.5 m apart.

3-Installing hedges and windbreaks

Hedges may be installed:

- by direct sowing (bunches spaced 50 cm to 1 m based on hedge purpose). E.g.: moringa, *acacia mangium* and *auriculiformis*, leucaena;
- by cuttings (e.g.: gliricidia);
- by planting in clumps.

Hedges are planted at the beginning of the rainy season (right after a good rain), in order to allow the plant to recover before the dry season. For planting in clumps:

- **Make a trough** about 30 cm x 30 cm x 30 cm (based on future plant growth);
- **Plant the plant** maintaining the crown at ground level. In dry areas, leave a sunken area to collect rain water and keep the soil humid. In humid areas, plant on mounds. (sunken area at the top of the mound) ;
- **Watering** if there is low rainfall, must be done at least once a week (twice during the first weeks). The plants will then be able to resist drought;
- **Protect the young plants** that are not sheltered from wandering animals (boughs, nets, baskets…).

4-Tending

- **Replenish** after a month or at the beginning of the following rainy season. Experience shows that a certain number of plants die during the first year, so replenishing is necessary.
- **Prune** the trees depending on the desired carriage:

Hedge type	Characteristic carriage	Pruning
Live protective hedge	Bush	Pollard regularly to 1.2 – 1.5 m
Windbreak	High	Cut excess branches to preserve 40% wind permeability (visual assessment)
Biomass production hedge	Bush	Pollard regularly to 1 – 1.2 m

Maintenance trimming (pruning) should generally be done at the beginning of the rainly season. However, for biomass production and site protection, pruning should be performed periodically based on hedge growth.

NOTE

As rainfed farming plots are not irrigated, fruit-bearing tree species suitable to the climate conditions must be selected (resistance to periods of drought).

5-Associations

Beyond simply planting hedges, **the producer may benefit from complementarities between crops and trees**. Tree planting density should not hinder crops.

The trees benefit from the fertilization of the underlying crops, constant humidity due to irrigation, periodic weeding and hoeing (tending). Underlying crops benefit from the trees' regulating and beneficial effects: shade, mulch, recycling water and leached elements.

- **Associating fruit-bearing tree farming and annual or semi-perennial crops:** fruit-bearing trees or rows of fruit bearing trees are planted with sufficiently wide spacing to allow intercalated crops cultivation. Suggested food and fruit crops include peanuts, sweet potatoes, bananas, pineapples…

  Rules for association:
  - Leave sufficient space between intercalated crops and tree rows
  - Plant tree rows from east to west (crop insolation)
  - Increase the space between tree rows with regards to a pure orchard if the association is to be extended on the long-term

- **Agroforestry:** generic term qualifying associations between trees, shrubs, and associated crops. Trees and shrubs may be planted around crop plots (hedging) or in lines while retaining crop corridors. On slopes, tree planting lines follow contour lines. The recommended crop corridor width is 10 meters.

  Rules for association:
  - Do not plant trees too densely and prefer species with pivoting root systems: acacia, leucaena…
  - Prune so as to avoid hindering crops (too much shade) or farming operations (roots and branches). Pruning waste may be used as firewood, garden stakes…
  - Plant tree rows from east to west (crop insolation)

Advantages and Drawbacks

Technical

- ↗ Conserves ground water and protects the plant (reducing evapotranspiration)
- ↗ Protects from wind and animals
- ↗ Improve vegetable matter disponibility for mulching and composting
- ↗ Creates a micro-climate conducive to crops
- ↗ Allows recycling leached minerals
- ↗ Favours soil aeration and improves the soil’s microbial life
- ↘ Requires a relatively long implanting period (1 to 2 season)
- ↘ Requires regular tending
- ↘ Space-intensive practice
- ↘ Requires land ownership

Economical

- ↗ Limits fencing repairs and deterioration by animals (living hedge protection)
- ↗ Provides a variety of resources (fruits, wood, bio-pesticides…)
- ↗ Allows extending farming periods and improves yields
- ↗ Allows saving on watering (by reducing evapotranspiration)
- ↘ Represents an expense if the plants must be purchased
- ↘ Labour-intensive (planting, water young plants, pruning)

Environmental

- ↗ Restores plant cover
- ↗ Protects against water and wind erosion
- ↗ Limits abusive tree cutting
- ↗ Improve biodiversity (fauna and flora)


Hedging at a pineapple farm, Sri Lanka


Alley-cropping, Gabon

POINTS TO REMEMBER

Hedging plots markedly improves farming conditions (improving soils, recycling water and mineral elements, favourable micro-climate) and provides for diversified products (wood, fruit…).

After planting protection and supplemental water allow young plants to quickly and sustainably get installed. These trees must be tended so they can play their role: protecting crops, providing biomass…

Fruit trees benefit from the producer tending underlying crops. However, the space must be organized in order to ensure that the trees do not provide too much competition for rainfed crops.

The association of rainfed and fruit crops provides better promotion of the plot.

TAKING IT FURTHER

Leaflet: Potted tree nursery (p. 131)

Leaflet: Planting fruit trees (p. 137)

Leaflet: Tending an orchard (p. 141)

Crops following contour lines

Erosion issues encountered on sloped land are primarily due to water flow over bare ground. By working the soil and planting crops in the direction of the slope, farmers amplify this phenomenon.

So, contour lines must be drawn in order to align on when sowing and planting on the low slope.

This practice limits erosion by distributing runoff, reducing its speed, and favouring seeping into the soil.

It has been primarily implemented as part of Agrisud's programs in Madagascar and the Democratic Republic of the Congo.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Combating erosion on slopes
- Improving water seepage in the soil and decreasing the speed of runoff
- Improving crop conditions and therefore yields

Conditions for implementation:

- Availability of a land with a grade not greater than 10%
- Availability of an A triangle and stakes
- Availability of seeds or cuttings ready for planting
- Availability of compost or recycled manure

Principle

In low-grade, less than 10%, areas, farming along the contour lines is recommended in order to **favour water seepage** into the soil and **limit the effects of runoff** (stripping the topsoil layer and carrying it to the shallows and valleys, creating ravines).

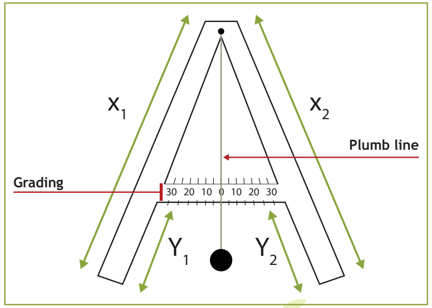
The practice consists of performing tillage and sowing along previously traced contour lines and not in the direction of the slope. On slopes greater than 10%, performing farm works according to contour lines must be combined with other measures (see Leaflet: Terraced Crops p 153).

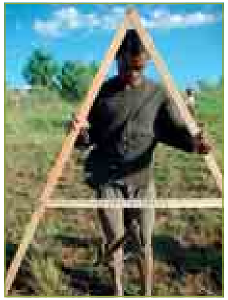
Method

Contour lines are imaginary or indicated lines following a constant altitude: they are horizontal. Tracing a contour line requires a tool called "level." Where it is not possible to bring in a topographer, an easy to make "A triangle" may be used.

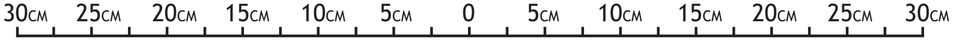
Overview of the "A triangle"

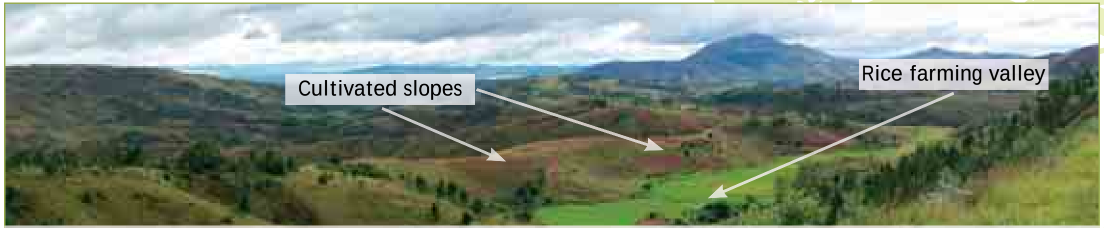
- The A is symmetrical
- X1 = X2 = 2 m
- Y1 = Y2 = 1 m
- The plum line indicates the slope between the A's two legs
- The grade must be gauged based on the spacing between the A's feet





Grade:



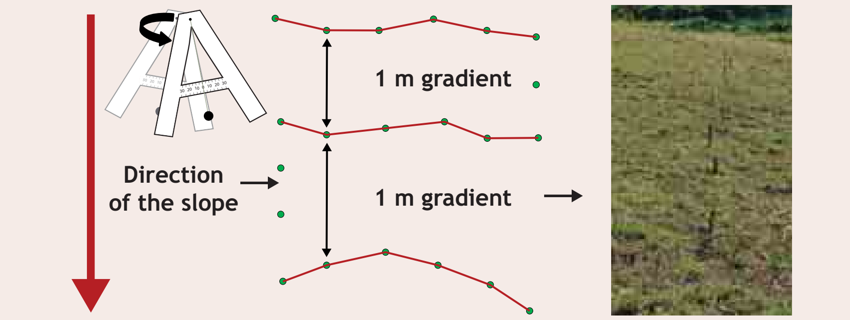


Crop areas, Madagascar

1-Tracing contour lines

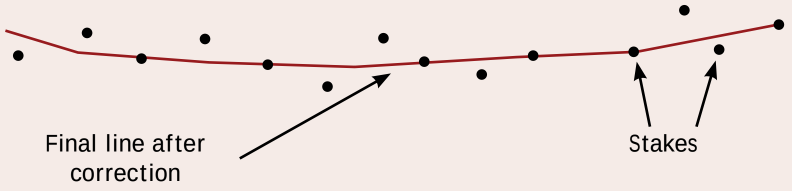
Before tracing the line, you must ensure that the land grade is less than 10%.

- **Clear** the plot to be fitted-out, taking care to preserve the topsoil and eventually any rare plant species
- At the top of the plot, **trace the first line** indicating the points on the same altitude with stakes (if the plot is large, mark only 1 of every 2 or 3 points). These points are obtained using a level, pivoting it successively from one leg to the other as seen in the schema below. The plumb line indicates the level's horizontal point
- Once the first line has been traced, **measure 1 m slope in the slope direction and begin tracing** contour lines every 1 m untill the bottom of the slope (if the plot is a low grade, <5%, indicate contour lines ever 0.5m of gradient)



NOTE

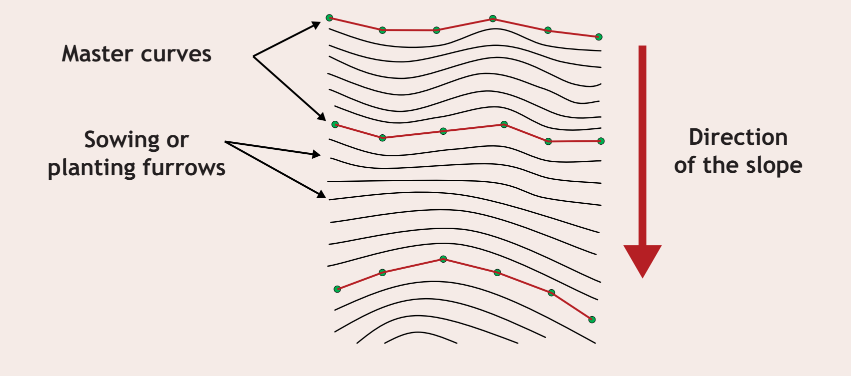
Land irregularity may cause to much irregularity in the contour line which must be rectified using its general shape. Without such rectification, farming operations will be more difficult and the water flow to be slowed-down by the anti-erosion works will be poorly distributed.



2-Planting crops according to contour lines

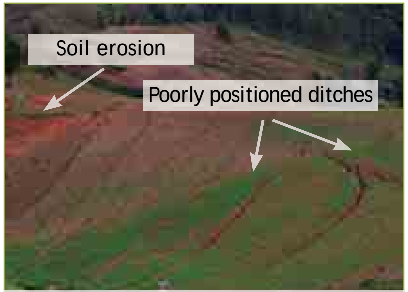
Once the contour levels are indicated perpendicularly to the slope:

- Go between two contour levels and **open furrows in parallel to the "master lines"** (they maintain alignment). Spacing between furrows fits with normal spacing between rows for sowing or planting on flat ground;
- **Sow in bunches** adding organic matter and laying out the bunches in a staggered arrangement maintaining the classic spacing between rows and between plants in the same row as for flat ground;
- **Or sow in line** after adding organic matter to the furrows;
- **When using cuttings** (cassava for example), comply with the spacing used for flat ground.



Illustrations of tracing contour lines, DR Congo

Illustrations of poor and best practices in Madagascar:



Crops in the direction of the slope

Crops following contour lines

Advantages and Drawbacks

Technical

- ↗ Simple to implement technique (easy to build and use an “A” level)
- ↘ Sometimes represents more binding work for producers who are not used to it
- ↘ Cannot be used for grades greater than 10%

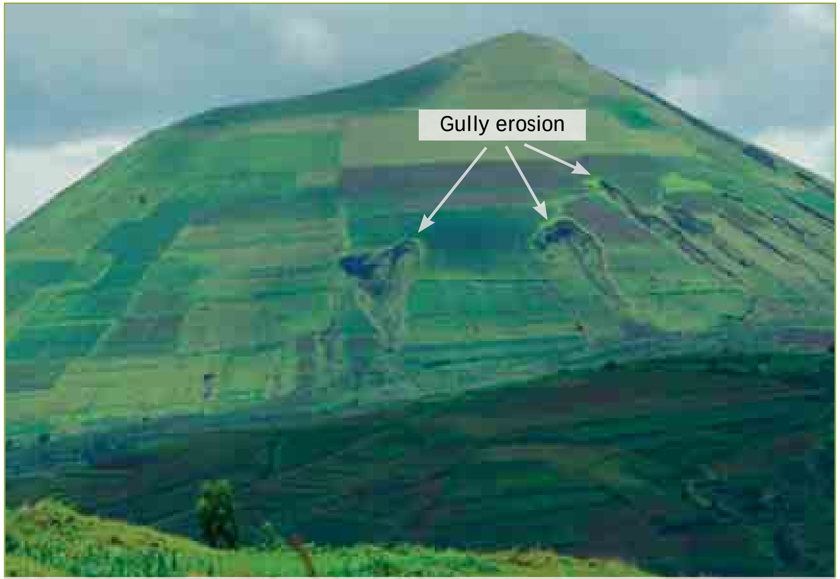
Economical

- ↗ Low implementation costs
- ↗ Maintains the soil’s productive potential

Environmental

- ↗ Combats low-grade plots soil erosion
- ↗ Contributes to long-term preservation of the “soil” resource
- ↗ Combats silting up in shallows

Crops following contour lines, DR Congo



Colonizing slopes without using best practices in Madagascar

POINTS TO REMEMBER

Producers tend to sow in the direction of the slope and create water evacuation channels parallel to the slope. These practices amplify erosion phenomena and threaten the land’s agricultural potential, even on low grades slopes.

To combat soil erosion on low grades slopes (<10%), it is important to plant crops perpendicularly to the slope direction in line with previously identified contour levels.

For higher grade land, contour lines will serve as the basis for creating crop terraces.

TAKING IT FURTHER

Leaflets: Swath composting (p. 81) / Crib composting (p. 89)

Leaflet: Manure recycling (p. 77)

Leaflet: Terraced crops (p. 153)

Leaflet: Hedging food crop sites (p. 145)

Terraced crops

When developing a sloped land, producers must ensure the activity's sustainability by taking into account soil erosion risks.

On high grades (>10% and <25%), these erosion issues are primarily due to water flow over the ground.

Developing farming plots as terraces limits erosion by distributing the running water, reducing its speed and favouring water seepage into the soil. This practice has primarily been implemented in Agrisud's programs in Madagascar, India, Sri Lanka, and DR Congo.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting the erosion of sloped plots
- Preserving soil quality
- Limiting crop destruction risks

Conditions for implementation:

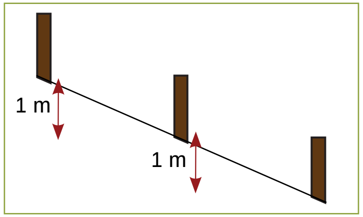
- Availability of land with a 10% to 25% grade
- Previously established contour lines every 1 m grade
- Availability of a plough or ploughing equipment
- Availability of soil-fixing plants ready for planting (pennisetum, vetiver, tephrosia, cassia…)

Principle

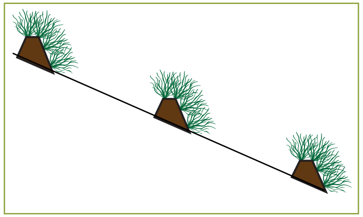
The practice consists of setting-up embankments along contour levels (see Leaflet: Crops following contour lines p. 149).

Progressive slope erosion, held by embankment systems, and their progressive establishment by working the soil should lead to terrace formation. Eventually, these terraces allows limiting soil erosion risks.

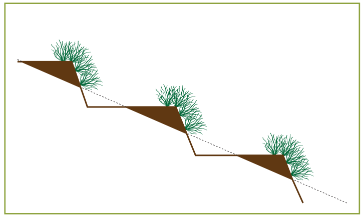
1. Tracing contour lines for every 1 m grade

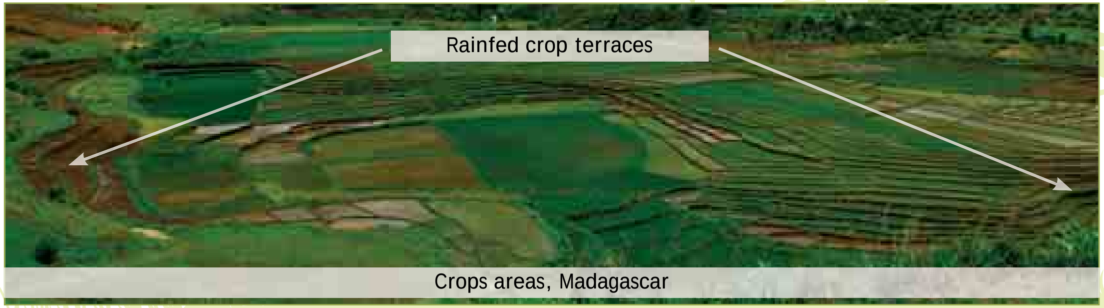


2. Establishing embankments and ridges and vegetating



3. Progressive grade decrease with adapted agricultural works





Crops areas, Madagascar

Method

1-Setting-up embankments

- **Create ploughing stop-lines** by making ridges following the contour lines identified by stakes. Establishing ridges takes place in 2 stages:
  - **rough ridge establishment** with a plough;
  - **manual finishing** being attentive to always bring up the earth from downstream to upstream (creating contour ridges).
- **Vegetate the embankment** using soil-fixing plants. The habitual plants are generally perennials, with rugged deep root systems (vetiver, brachiaria, pennisetum…) or very dense shrubs (tephrosia, flemingia, leucæna, cassia…):
  - **prepare the plant material** (break dormancy for seeds, trim the vetiver stems, prepare pennisetum cuttings…) ;
  - **plant the soil-fixing plants** on the ridges.

Tree species	Planting methods
Vetiver	20 cm x 20 cm staggered pattern
Brachiaria	Double line sowing: 20 cm interline spacing, 5 cm inter-plant spacing
Pennisetum	One line on either side of the ridge: spaced 50 cm on the line
Leguminous shrub	Sow in line on the ridge: 5 cm inter-plant

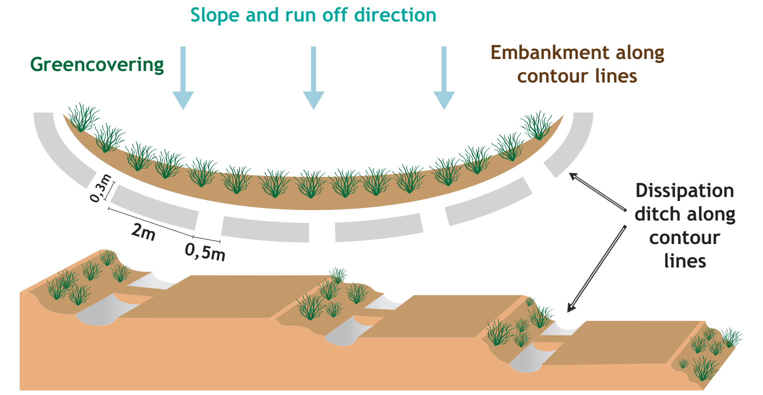

Vetiver plant


Potato farming – Northern Kivu

NOTE

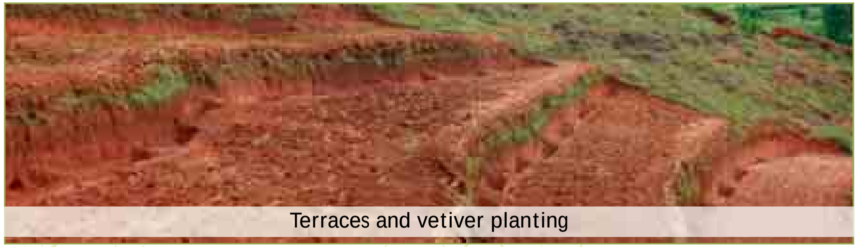
While soil-fixing plant growth does not provide effective embankment stabilization and good water draining, establishing **dissipation ditches downstream from the embankment** allows recovering the water and soil it carries as it runs off and redistributing it.

Establishing dissipation ditches: right at the foot of the embankment and following the contour line, dig a 50 cm wide x 30 cm deep dissipation ditch.

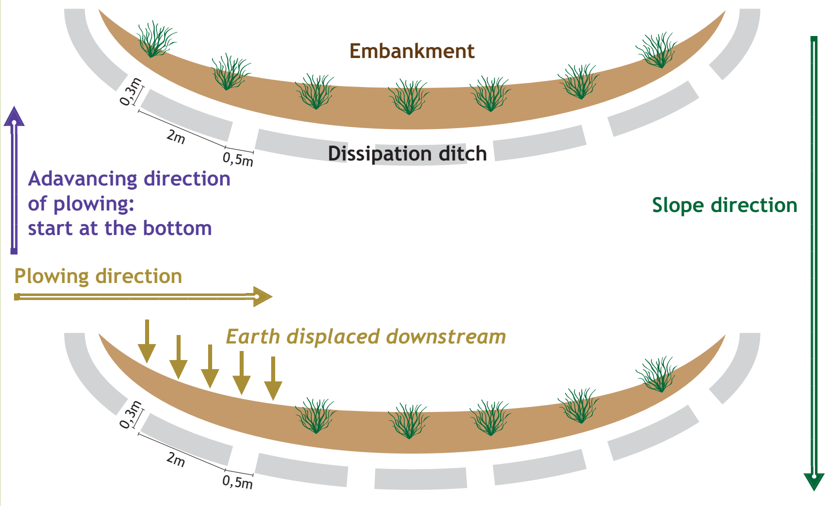


2-Terrace establishment

- **Plough («flat» ploughing)** just before the rainy season and following contour lines
- **Turn the soil over towards the downstream direction** such that the grade is progressively lessened with each ploughing. To do so, it is easier if a reversible plough is available
- **Stop ploughing 20 cm from the dissipation ditch of the upstream embankment**


Terraces and vetiver planting

Diagrammatic representation of plowing sloped land:



NOTE

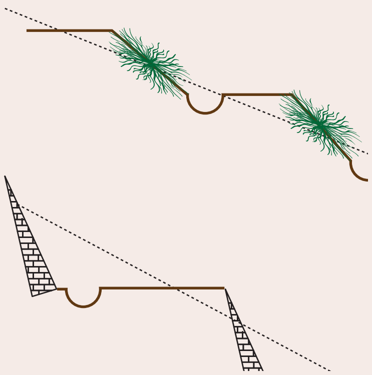
Installation according to grade

For 10% to 15% grades, **grassy terraces** may be considered.

For steep slopes (>15%), the method is the same but **flat terraces** where:

- embankments then terraces are solidly stabilized by riprapling dry stone or by fascines and planting shrubs;
- the grade requires that terraces be immediately levelled with spoil and backfill.

This highly sloped land development technique is labour-intensive.



Advantages and Drawbacks

Technical

- ↗ Simple to implement technique
- ↗ Achievable with locally available materials
- ↘ Requires time (progressive terrace construction)

Economical

- ↗ Maintaining crops in sloped areas on the long-term
- ↘ Mobilizing significant labour to trace contour lines and establish embankments

Environmental

- ↗ Reducing erosion for highly sloped plots
- ↗ Improving water infiltration into the soil (recharging the water table)

POINTS TO REMEMBER

Establishing embankments and terraces limits soil erosion on slopes. Fitting-out farming plots in highly sloped areas allows sustainably exploiting the available land.

In this practice, embankments must be stabilized with vegetation and work should be done parallel with contour lines.

Terrace farming, Madagascar

TAKING IT FURTHER

Leaflet: Crops following contour lines (p. 149)

Direct seeding Mulch-based Cropping system (DMC)

Direct seeding Mulch-based Cropping system (DMC) consist of reproducing forest ecosystems, where mulch production constantly protects and fertilizes the soil.

The humid tropical zone is primarily a fragile, quickly degrading environment if farming methods are not adapted; DMCs provide a concrete alternative to itinerant slash-and-burn farming.

This practice has been primarily implemented in Agrisud's programs in Gabon and, to a lesser extent, in Madagascar and Laos.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting erosion and protecting soil structure
- Favouring the soil's biological activity and recycling mineral elements
- Improving cropping conditions and therefore yields
- Controlling weeds in cultivated plots

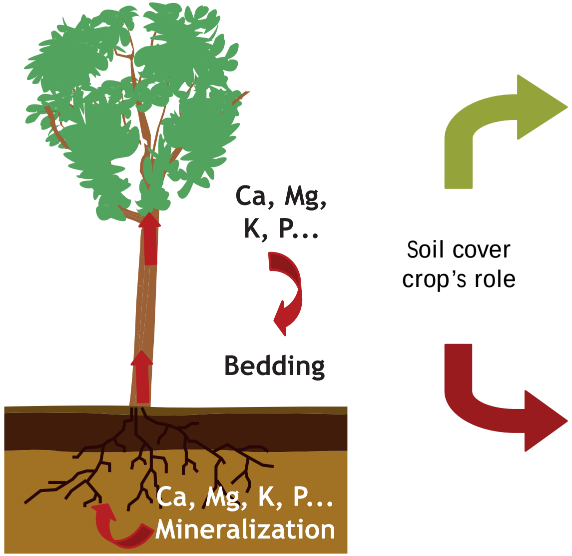
Conditions for implementation:

- Availability of significant cultivated and / or imported biomass: waste from weeding and other wild plants, cereal mulch, tree leaves…

  Examples of biomass producing plants:
  - Brachiaria, Mucuna, Stylosanthes, Pueraria
  - Leguminous plants

Principle

DMC group a set of farming systems based on the basic principle of continuous soil cover. This practice has a double goal of protecting and fertilizing.



Above the Soil
- Protecting against water and wind erosion
- Feeding crops through mineralization
- Controlling weeds
- Reducing evaporation and regulating heat

In the Soil
- Maintaining soil structure
- Developing biological life
- Recycling mineral elements
- Improving soil fertility by producing humus

Plant cover can be dead mulch (added or resulting from the destruction *on site* of a cover crop) or a living plant (cover crop) associated with the main crop.

Sweet pepper on mulch

Taro on dead cover

Banana trees on live Brachiaria cover

Method

DMC implementation varies based on **cropping systems** and the plant cover's origin and production period.

That said, in every case:

- the soil must always be covered;
- the soil must not be worked or ploughed; or a minima;
- sowing, replanting, or planting must occur directly through the cover, dead or alive.

Five systems can be identified:

- **DMC on harvest waste and weeds:** plant cover is only provided by harvest waste and weeds that grew during the intercropping period;
- **DMC with imported dead coverage:** the soil is covered by mulch from neighbouring plots;
- **DMC with dead coverage produced on-site:** the dead coverage is produced in succession before or after the main crop, for example, cultivating maize on Mucuna;
- **DMC with permanent cover in alternating strips:** on the same plot, alternating live and dead strips; the live strips are periodically mowed and the mulch is spread on the dead strips. For example, planting banana trees on dead strips with alternating live strips of Brachiaria;
- **DMC with permanent live cover:** the cover crop and main crop are grown in association on the same plot. For example, growing palm oil trees or rubber trees on Pueraria.

Cassava on Brachiaria

Groundnuts on Mucuna

Advantages and Drawbacks

Technical

- ↗ Protecting soils and limiting weeds propagation (decreasing the difficulty of labour)
- ↗ Maintains and improves soil fertility, stabilizing yields on the long-term
- ↗ Improves the plant's water feed system
- ↗ Provides flexibility for work schedules
- ↘ Presents a difficulty for mechanically controlling the plant cover over large surface areas in hot and humid areas

Economical

- ↗ Stabilizes and increases production
- ↗ Decreases production costs and sustainable increases economic profits
- ↘ Requires investment for setting up and, where required, mastering cover crops

Environmental

- ↗ Reduces soil erosion
- ↗ Favours carbon sequestration
- ↗ Reduces deforestation by limiting slash-and-burn practices
- ↘ Leads to a water and soil pollution risk if herbicides are used (the use of natural herbicides is currently being studied).

POINTS TO REMEMBER

DMCs allows maintaining and improving production while protecting the soil, but their implementation requires an additional investment in comparison with so-called "conventional" systems.

In these systems, significant biomass production is primordial. It is necessary to verify that the producer has an environment allowing it to produce.

TAKING IT FURTHER

Leaflet: Cover crops (p. 159)

Leaflet: DMC with dead cover (p. 169)

Leaflet: DMC with permanent cover in alternating strips (p. 165)

Leaflet: Mulching (p. 121)

Cover crops

Direct seeding Mulch-based Cropping system (DMC) are based on the basic principle of permanent soil cover. This coverage is provided by the Cover crops, used dead – mulch added or mulch from the on-site destruction of a cover crop – or alive, associated with the main crop.

Cover crop selection is sensible. The cover crops' main characteristics must be wellknown in order to master their implementation and management over time.

The characteristics of the plants presented in this leaflet are the result of data obtained in the framework of Agrisud's programs in Gabon, and to a lesser extent, Madagascar.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting erosion and protecting soil structure
- Favouring the soil's biological activity and recycling mineral elements
- Improving farming conditions and therefore yields
- Controlling plot weeds

Conditions for implementation:

- Availability of sufficiently sized land to implement DMC for periods of 2 to 3 years
- Prior land preparation (clearing, weeding)
- Knowledge of the main cover crop characteristics and crop association principles

Principle

Cover crops are plants that are capable of producing a significant quantity of biomass that have a root system capable of structuring the soil deep down. Depending on their specificities, cover crops may present various interests: provision of nitrogen, used as cattle feed…

Therefore cover crop selection is sensible.

Brachiaria, Stylosanthes, Mucuna and Pueraria are among the main cover crop used in DMC.

Method

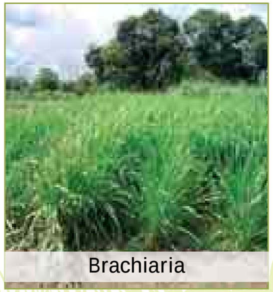
1-Cover crop selection

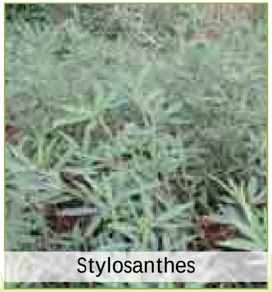
Cover crop selection must factor in the following crucial elements:

- **soil characteristics** (poor or rich, compacted or not);
- the **main crop's characteristics**: for example, its organic matter requirements (if the crop requires organic matter, a cover crop capable of quickly producing sufficient quantities of biomass should be selected);
- the **cover crop's characteristics**: annual or not, ability to reproduce on its own or assisted, seed production period, need to use herbicides to eliminate it or not, biomass decomposition velocity;
- the selected DMC.

NOTE

The soil must be cleared and manually weeded 2 days before sowing cover crops.


Brachiaria


Stylosanthes


Mucuna


Pueraria

2- *Brachiaria ruziziensis*

Brachiaria is a very leafy, stoloniferous, erect, perennial grass suitable for compact, poor, acidic soils. It is used as a middle- and long-term cover crop, as mulch, or cattle feed.

→ High-performance plant for restoring soil fertility and restructuring deteriorated soils.

Using the plant for a dead cover system produced on-site or a permanent cover system in alternating strips:

Advantages	Constraints
→ Quick growth (3 to 4 months) → Significant above- and underground biomass production (20 t of dry above material per ha per year) → Average nitrogen contribution for the main crop (50 to 80 kg per ha) → Powerful root system capable of restoring macroporosity, providing for recovering leached nutritional elements at great depth and recharging the soil's carbon stock → Highly capable of connecting to the fringe of deep capillary water during the dry season → Significantly limits soil erosion once the cover is fully installed (after 4 months) → Perennial plant facilitating managing farming and planting date → Easy intercropping with maize → Extended weeds control due to its slow decomposition rate → Controls Imperata and cyperaceae	→ Sometime difficult to reproduce seeds → Requires additional nitrogen provision at the beginning of the main crop cycle (high C/N ratio) → No symbiotic nitrogen fixation as with leguminous → Low germination rate (less than 30%) → Seeds must be treated → Total mechanical destruction difficult (herbicide use)  Manioc on dead Brachiaria cover

Cover scheduling

- **Cover alone:** starting after 30 to 40 mm of rain and as early as possible to achieve a 7 to 12 month cycle and benefit from significant biomass
- **Intercropping:** at the same time as sowing maize (low rainfall) or 30 days after (better rainfall), 60 days after sowing okra; sowing just after weeding

Seed and cutting treatment

- **Soak** the seeds in potassium nitrate (2% solution) for 24 hours then dry
- **Puddle** the cuttings with a mixture of clay and phosphorus (1.5% solution)

Planting the cover

Sowing:

- **Cover alone:** 40 cm x 40 cm spaced squares
- **Intercropping**: 2 lines (as for single-crop farming) between 2 crop rows

For 1 ha, 3 to 6 kg of seed are needed, at a rate of 8 to 15 seeds per bunch (depending on whether the seeds are treated or not), sowing depth: 1 to 2 cm. 10 days after sowing, sow the missing bunches again.

Using cuttings:

Identical spacing to sowing, 2 cuttings with 3 nodes per bunch (2 nodes buried) or 2 stem divisions with 2 slips per bunch; for 1 ha, you need 125,000 cuttings or slips. Gapfilling 15 to 20 days after planting.

Cover tending

Weeding is possible during the first month.

Maize on dead Brachiaria cover produced on-site

Hot pepper on permanent cover in alternating strips of Brachiaria

3-Stylosanthes

Stylosanthes is a perennial leguminous, erect or semi-creeping and lignified at the base, which adapts to difficult non-clay soils (compact, poor, and acidic). It is used as a middle- and long-term cover crop, as mulch, or cattle feed.

→ High-performance plant for restoring soil fertility and restructuring deteriorated soils.

Using the plant for a dead cover system produced on-site or a permanent cover system in alternating strips:

Advantages	Constraints
→ Planting as seeds or cuttings → Significant nitrogen contribution for the main crop (100 to 150 kg / ha) → Perennial plant facilitating managing farming and replanting dates → Powerful root system capable of restoring macroporosity, good for recovering leached nutritional elements at great depth and recharging the soil's carbon stock → Highly-suitable for tuber plants with its high macroporosity creating root system → Highly capable of connecting to the fringe of deep capillary water during the dry season → Tolerates drought, remains green during 4 month long dry seasons → Extended weeds control (slow decomposition rate) → Good erosion control once the cover is fully installed (after 4 months) → Destruction without herbicide by mowing to the soil	→ Difficult to install with slow early cycle growth (4 to 6 months for installation) → Significant weeding time during the installation phase → Low germination rate (< 30%) → Seeds must be treated → Seed conservation time limited to 1 year → Average above- and underground biomass production (10 t of dry abvoeground material per ha per year) → Sensitive to anthracnose, selection of resistant cultivars → Limited production in clayey soils → Average tolerance of humidity → In intensive mowing systems, stem lignification is intensified and the life expectance is limited to 3 to 4 years

Cover scheduling

- **Cover alone:** starting after 30 to 40 mm of rain, as early as possible to achieve a 7 to 12 month cycle and benefit from significant biomass
- **Intercropping:** at the same time as sowing the maize (low rainfall) or 30 days after (better rainfall), 60 days after sowing okra ; sow just after weeding

Seed and cutting treatment

- **Soak** the seeds 30 min. in 70°C water then drain and sow
- **Puddle** the cuttings with a mixture of clay and phosphorus (natural phosphorus, 1.5% solution)

Planting the cover

Sowing:

- **Cover alone**: 40 cm x 40 cm spaced squares
- **Intercropping**: 2 lines (as for single-crop farming) between 2 crop rows

For 1 ha, you need 1.5 to 3 kg of seed, at a rate of 5 to 10 seeds per bunch (depending on whether seeds are treated or not), sowing depth: 1 cm.
10 days after sowing, sow the missing bunches again.

Using cuttings:

Identical spacing as for sowing, 4 cuttings with 4 to 5 nodes per bunch (3 nodes buried). For 1 ha, you need 250,000 cuttings as a single-crop and 165,000 as intercrop. Gapfilling 15 to 20 days after planting.

Cover tending

Weeding 2 to 3 times during the initial installation phase.

Manioc on permanent cover in alternating strips of Stylosanthes

4- *Mucuna cochinchinensis*

Mucuna is a creeping, twining annual leguminous (6 to 7 month cycle) that requires average fertility, well-drained, loosely compacted soils. It is suggested as a short-term cover crop.

→ High-performance plant for maintaining fertility in the environment and restoring the fertility of "exhausted" soil.

Using the plant for a dead cover system produced on-site or a permanent cover system in alternating strips:

Advantages	Constraints
→ Significant nitrogen contribution for the main crop (150 to 200 kg / ha) → Good erosion control with quick soil cover → Annual crop that may be grown without intervention to create dead cover → Well suited to all DMC crops on dead cover → Significant and easy seed production → High germination power → No seed treatment before sowing → Good control of weeds when used and, if sufficient biomass, during the crucial crop start-up phase → Easy intercropping with maize → Control by mowing, low herbicide dose if necessary to stop the cycle → Nematode Trap → Combating Imperata	→ Climbing plant which may strangle crops without control → Low-growth in low-fertility, compact soil → 6-month cycle to produce significant biomass (5 to 7 t of dry matter per ha) → Sensitive to excess water → Requires at least 2 months of rainy season to be able to survive a 4-month dry season → Limited self-propagating plant control (30 to 45 days) due to rapid decomposition → Limited cyperaceae control → Cyperaceae and commelinaceae selection risk once fertility is restored and maintained → Shallow root system, limited recycling of leached elements → Seed conservation under normal conditions is limited to 6 months → Total mechanical destruction difficult (herbicide use)

Cover scheduling

- **Cover alone:** starting at 30 to 40 mm of rain, as early as possible to obtain a 150 to 180 days cycle depending on precipitation
- **As intercropping with maize:** 30 days after sowing the maize; sow just after weeding

Seed and cutting treatment: No treatment required.

Planting the cover

Sowing:

- **Cover alone**: 1 seed per 50 cm x 50 cm spaced bunch at a depth of 2 to 4 cm or 2 seeds per 50 cm x 100 cm spaced bunch at a depth of 2 to 4 cm
- **Intercropping**: 1 seed per 40 cm spaced bunch in 1 line between 2 rows of maize, at a depth of 2 to 4 cm

For 1 ha, you need 30 to 40 kg of seed. 2-seed sowing is more suitable for soils with low weed pressure.

Sow the missing bunches again 10 days later.

Cover tending: No tending required.

Mucuna recovery after growing maize

Okra on dead Mucuna cover

Groundnuts on dead Mucuna cover

5- *Pueraria phaseloides*

Pueraria is a perennial, twining leguminous which may grow in uncompacted, acid soils with low fertility. It is suggested as a middle- and long-term cover crop.

→ High-performance plant for restoring fertility, eliminating weeds, and limiting erosion risks.

Using the plant for a dead cover system produced on-site or a permanent cover system in alternating strips:

Advantages	Constraints
→ Good germination, growth rate, very significant biomass produced → Significant nitrogen contribution (100 to 150 kg / ha) → Perennial plant facilitating managing farming and replanting dates → Significant and easy seed production → If planting is early, it is possible to have seeds from the first year → Easy intercropping with maize → Good erosion control once fully installed (after 6 months) → Continuous recharge in nutritional elements for the soil by the continuously created mulch → Excellent control of weeds despite its poor control of weeds during the installation phase → No tending → Tolerates temporary hydromorphic conditions → Combats Imperata and controls Mimosa invisa	→ Climbing plant which may strangle crops without control → Slow growth at the beginning of the cycle → More than 6-month long cycle to produce significant biomass → Shallow root system, limited recycling of leached elements → Mediocre suitability for tuber plants due to its root system creating little macroporosity → Requires seeds to be treated before sowing → Requires at least 2 months of rainy seasons to pass 4 months of dry season → As a dead cover, control duration limited to 30 / 45 days due to its rapid decomposition → Total mechanical destruction difficult (herbicide use)

Cover scheduling

- **Cover alone:** starting after 30-40 mm of rain. With a short rainy season, sow early for a one-year cycle before planting long-cycle crops (flowering from the first year). Seed production: wait 18 months before planting crops (flowering during the second dry season)
- **Intercropping:** 5 to 7 days after sowing the maize to identify the sown lines. For short rainy seasons, sow early. For other short-cycle crops, expect 260 to 320 days of cover depending on cycle duration.

To avoid increasing the time allotted to the first maize weeding (30 days after sowing) due to the need to care for young Pueraria plantlets, it is possible to sow after the first weeding.

Seed and cutting treatment

- **Soak 1 hour** in 70°C water, drain and sow
- **or dip 20 min.** in concentrated sulphuric acid (1 volume of acid for 2 volumes of seed), rinse with water, drain, and sow

Planting the cover

Sowing:

- **Cover alone:** bunches arranged in 50 cm x 50 cm squares
- **Intercropping**: double row of 40 cm x 40 cm squares between two rows of maize

For 1 ha, 3 to 6 kg of seed are needed, at a rate of 4 to 8 seeds per bunch (depending on the selected treatment); sowing depth: 1 cm.

Sow the missing bunches again 10 days later.

Cover tending: No tending required.

Pueraria Cover

6-Plants used for biomass production

Examples of cover crops used for producing added mulch:

Cover crops	Advantages	Constraints
Panicum maximum	→ Present in significant quantities in fallow areas → Facilitates periodic supplements (recharges) → Slow decomposition → Complementarity with livestock for fodder	→ Risk of plant proliferation (if using mulch with numerous seeds) → Limited suitability for high-density crops → Required nitrogen supplement at the beginning of the cycle to compensate the effect of nitrogen immobilization by bacteria ensuring decomposition
Pennisetum purpureum	→ Significant presence around plots → Facilitates periodic supplements (recharges) → Complementarity with livestock for fodder	→ Stinging, cutting mulch → Difficult to replant → Requires using young parts to avoid internode root revival → Rapid decomposition, limiting the fight against weeds and requiring additional mulch for long-cycle crops → Impossibility of farming high-density crops → Required nitrogen supplement at the beginning of the cycle to compensate the effect of nitrogen immobilization by bacteria ensuring decomposition
Brachiaria decumbens	→ Slow decomposition → Complementarity with livestock for fodder	→ Requires managing a production plot (planting cuttings, fertilization) → Difficult to make periodic supplements to the plot → Impossibility of farming high-density crops → Required nitrogen supplement at the beginning of the cycle to compensate the effect of nitrogen immobilization by bacteria ensuring decomposition

Advantages and Drawbacks

Technical

- ↗ May be implemented with a wide range of plants
- ↗ Presents multiple interests (multi-function cover crops): soil protection, fodder plants, coverage fertilizer...
- ↗ Reduces work time (weeding and tending)
- ↘ Requires technical mastery to avoid competition between cover crops and main crop

Economical

- ↗ Uses locally available plants
- ↗ Provides crop / livestock synergy
- ↗ Limits expenses by reducing organic manure and mineral supplements
- ↗ Maintains and improves yields and economic margins
- ↘ Represents an investment for planting the cover

Environmental

- ↗ Reduces soil erosion
- ↗ Provides additional nitrogen depending on the plant used
- ↘ Leads to a water and soil pollution risk if herbicides are used (the use of natural herbicides is currently being studied)

POINTS TO REMEMBER

The choice of cover crop is based on the area's status (soil structure, acidity, waterlogging, fertility, rainfall, etc.), qualities of the various cover crops, the selected DMC and the farmer's investment capacities. The difficulty lies in controlling the plant cover. Mechanical control methods should be favoured and herbicides should only be used as a last resort to limit water and soil pollution.

TAKING IT FURTHER

Leaflet: Direct seeding Mulch-based Cropping system (DMC) (p. 157)
Leaflet: DMC with permanent cover in alternating strips (p. 165)
Leaflet: DMC with dead cover (p. 169)
Leaflet: Mulching (p. 121)

DMC with permanent cover in alternating strips

The DMC with permanent cover in alternating strips system consists of alternating dead strips with live strips of a cover crop.

The main crop is planted on the dead strips. The live strips are periodically mowed and the mulch serves as cover for the dead strips.

This practice has been primarily implemented in Agrisud’s programs in Gabon and, to a lesser extent, in Madagascar

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting erosion and protecting soil structure
- Favouring the soil’s biological activity and recycling mineral elements
- Improving farming conditions and therefore yields
- Controlling weeds in cultivated plots

Conditions for implementation:

- Availability of a land with sufficient surface area to dedicate a part of the land to the cover crop
- Availability of Brachiaria, Stylosanthes, or other suitable cover crops

Principle

In a DMC with permanent cover in alternating strips, the land covered by a cover crop is separated into strips. Every other strip (the live strip) provides the biomass for mulching the dead strips. On the dead strips, weeds are controlled by adding biomass and mechanical action. The main crop is planted on the dead strips. The live strip for the previous crop becomes the dead strip for the crop being planted.

Diagram 1: cassava is associated by biomass producing strips (cover crops).

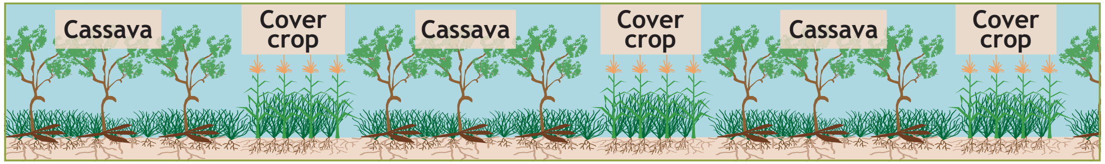
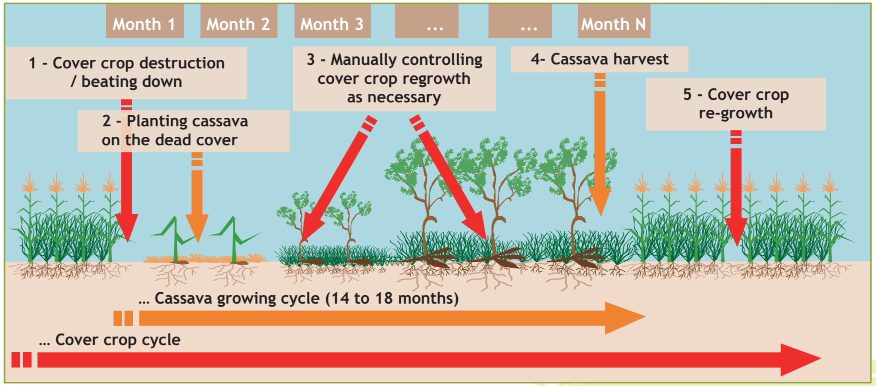


Diagram 2: cassava completes its cycle (14 to 18 months) taking advantage of soil improvements contributed by the cassava cover crop.

The cover crop is redeployed or another is planted.




Alternating strips of cassava on Brachiaria


Okra in alternating strips on Stylosanthes

Method

1-Permanent cover in alternating strips system

Planting the cover crop (Brachiaria or Stylosanthes)

Two options are possible:

- at the **beginning of the rainy season**, plant the cover **when starting** the system to quickly benefit from significant biomass;
- let the cover crop **grow for one year** before implementing DMC.

Tending

- **Mow regularly** on the live strip based on plant growth (between 20 cm and 50-60 cm in height for Stylosanthes; between 10 cm and 50-60 cm in height for Brachiaria). Let dry 2 days on the live strip before spreading the mulch on the dead strip
- During dry periods, **cut the Stylosanthes** fairly short (20 cm) or the **Brachiaria** to the ground (5 cm) to avoid competition for water with the main crop
- **Weed** if weeds grow uncontrolled by the mulch

The **crop manuring plan** on dead cover is the same as for crops on bare ground. However, 3 years after planting a continuous dead cover, manure supplements may be reduced by 20%.


1. Installing a banana tree / Brachiaria system


2. Brachiaria tending


3. System after 2 years

Example of implementing DMC with permanent cover in alternating strips (Gabon):

Crops	Implementation
Long-cycle crops: Cassava, taro	3-year rotation: during Year 1, long-cycle crop planted at the beginning of the rainy season and continuous cover crop, followed in Year 2 by a long cycle crop planted in the middle of the rainy season with a continuous cover crop. Between each crop cycle, 6 to 8 months of the cover crop alone.
Short-cycle crops: okra, hot pepper, eggplant	Medium-cycle crops planted at the beginning of the rainy season and continuous cover crop, followed by 6 to 7 months of the cover crop alone.
Banana tree	Banana trees cropping for 2 to 3 years with continuous cover crop followed by 1 year of the cover crop alone.

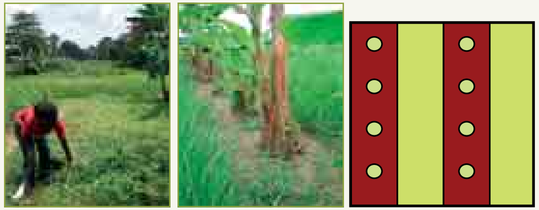
2-Example of planting banana trees on permanent cover in alternating strips of Brachiaria

1. Plant the cover or colonize the plot with an existing cover crop (1 year)

2. Mark out the plot in 2 m strips (staking and folding down by rolling with a barrel 1/3 full of water) and control coverage every other strip

3. Add basal manuring in the planting holes and plant the banana trees in a line at the centre of the dead strips (spacing between stumps: 2 m)

4. Banana trees conducted for 2 to 3 cycles (depending on yield), mowing the grassy strips to mulch the dead strips (once / month during the dry season, twice / month in the rainy season), and light weeding for live strips

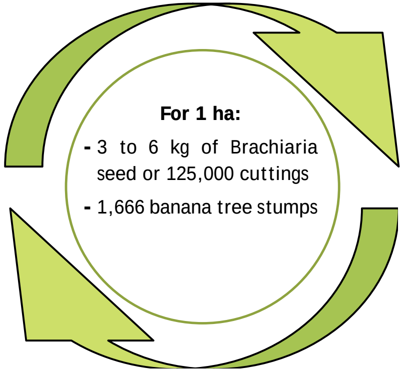


5. Dead strips overtaken by the plant cover (1 year), possible to replant cuttings or the plant's seeds

6. Roll and control the cover in the old grassy strips

7. Add basal manuring and migrate the banana trees by replanting the stumps on newly controlled strips

8. Banana trees conducted for 2 to 3 cycles (depending on yield), mowing the grassy strips to mulch the dead strips and lightly weed the live strips



For 1 ha:

- 3 to 6 kg of Brachiaria seed or 125,000 cuttings
- 1,666 banana tree stumps

🟩 **Live cover** 🟥 **Dead cover** ○ **Banana trees**

Certain practices consist of chemically killing the plant cover (using glyphosate-like herbicides).
These chemicals are dangerous if incorrectly used. There use must only be considered when no other remedy is possible.

Advantages and Drawbacks

Technical

- ↗ Protecting soils and limiting weeds propagation (decreasing the strenuousness of labour)
- ↗ Maintaining and improving soil fertility and stabilising yields on the long-term
- ↗ Favours the plant's water feed system
- ↗ Provides flexibility for work schedules
- ↗ Only requires the cover to be planted once
- ↗ Provides manual or mechanical control of the cover
- ↘ Presents a difficulty for mechanically controlling the plant cover over large surface areas in hot and humid areas
- ↘ Requires good technicity to balance dead and live strips
- ↘ Requires significant rigor in running the system
- ↘ Requires work time for live strip mowing

Economical

- ↗ Stabilizes and increases production
- ↗ Decreases production costs by reducing expenses related to soilwork
- ↘ Requires investment for planting the cover

Environmental

- ↗ Reduces soil erosion
- ↗ Favours carbon sequestration
- ↗ Reduces deforestation by limiting slash-and-burn practices
- ↘ Leads to water and soil pollution risks if herbicides are used


Taro in alternating strips of Brachiaria


System of banana trees in alternating strips of Brachiaria

POINTS TO REMEMBER

DMC with a permanent cover in alternating strips is effective, it provides for producing the crop and cover crop at the same time. In its implementation, the cover crops are primarily Stylosanthes and Brachiaria.

To control plant coverage, mechanical control methods should be favoured and herbicides should only be used as a last resort to limit water and soil pollution. Note that the use of natural herbicides is currently under study.

TAKING IT FURTHER

Leaflet: Direct seeding Mulch-based Cropping system (DMC) (p. 157)
Leaflet: Cover crops (p. 159)
Leaflet: DMC with dead cover (p. 169)
Leaflet: Mulching (p. 121)

DMC with dead cover

In DMC with dead cover, the cover crop is installed at the beginning of the main crop rotation.

The cover crop is destroyed and left on-site. The main crop is sown through the dead plant cover created.

This practice has been primarily implemented in Agrisud's programs in Gabon and, to a lesser extent, in Madagascar and Laos.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Limiting erosion and protecting soil structure
- Favouring the soil's biological activity and recycling mineral elements
- Improving farming conditions and therefore yields
- Controlling weeds in cultivated plots

Conditions for implementation:

- Availability of a land with sufficient surface area to allow for including a fallow period in the crop rotation
- Availability of cover crop seeds

Principle

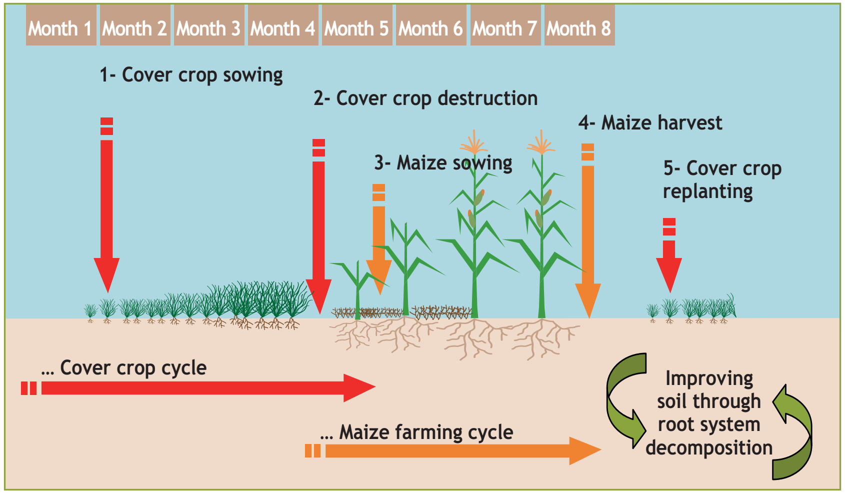
In this types of DMC, the land is entirely covered with the cover crop. After which, the cover is controlled to give way to the main crop. It is directly sown or planted through the dead cover.

Before harvesting a new plant cover may be planted as intercropping.

Illustration of a maize farming cycle under dead cover:

Cover crops grew during the first part of the farming cycle.

Maize farming settled after the destruction of the cover crop. It benefits from the improvements to the soil generated by this way: aeration by the roots, added organic matter...



At the end of the cycle, the roots remaining in the soil contribute, after decomposition and through the action of micro-organisms, to its improvment.

Maize grown without weeding thanks to the dead Brachiaria coverage

Pueraria regrowth after harvesting the maize

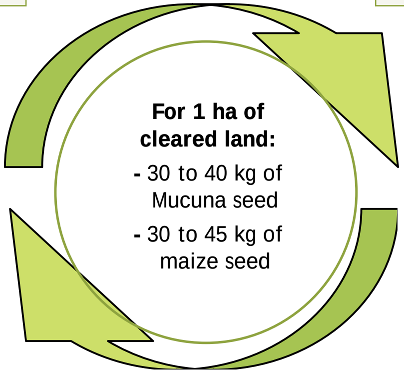
Method

In this DMC, cover crops regularly used include Stylosanthes, Brachiaria, Mucuna, and Pueraria.

1-Example of planting a maize crop on dead Mucuna cover (Gabon)

1. Planting a cover (Mucuna) or existing cover

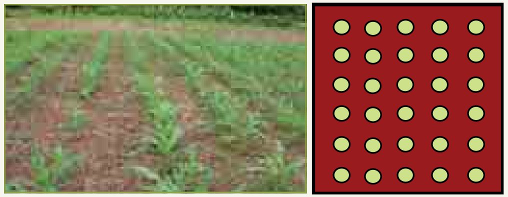
2. Control (mow) the plant cover



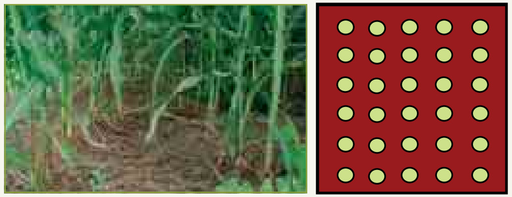
For 1 ha of cleared land:

- 30 to 40 kg of Mucuna seed
- 30 to 45 kg of maize seed

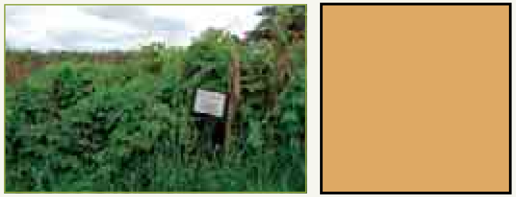
3. Sow, then 7 days later, the maize rises through the dead cover



4. Grow the maize without working the soil, light weeding as if necessary; recovery of the cover crop



5. After harvesting the plot, the cover crop takes over the plot and prepares a new cycle



🟩 **Live cover**

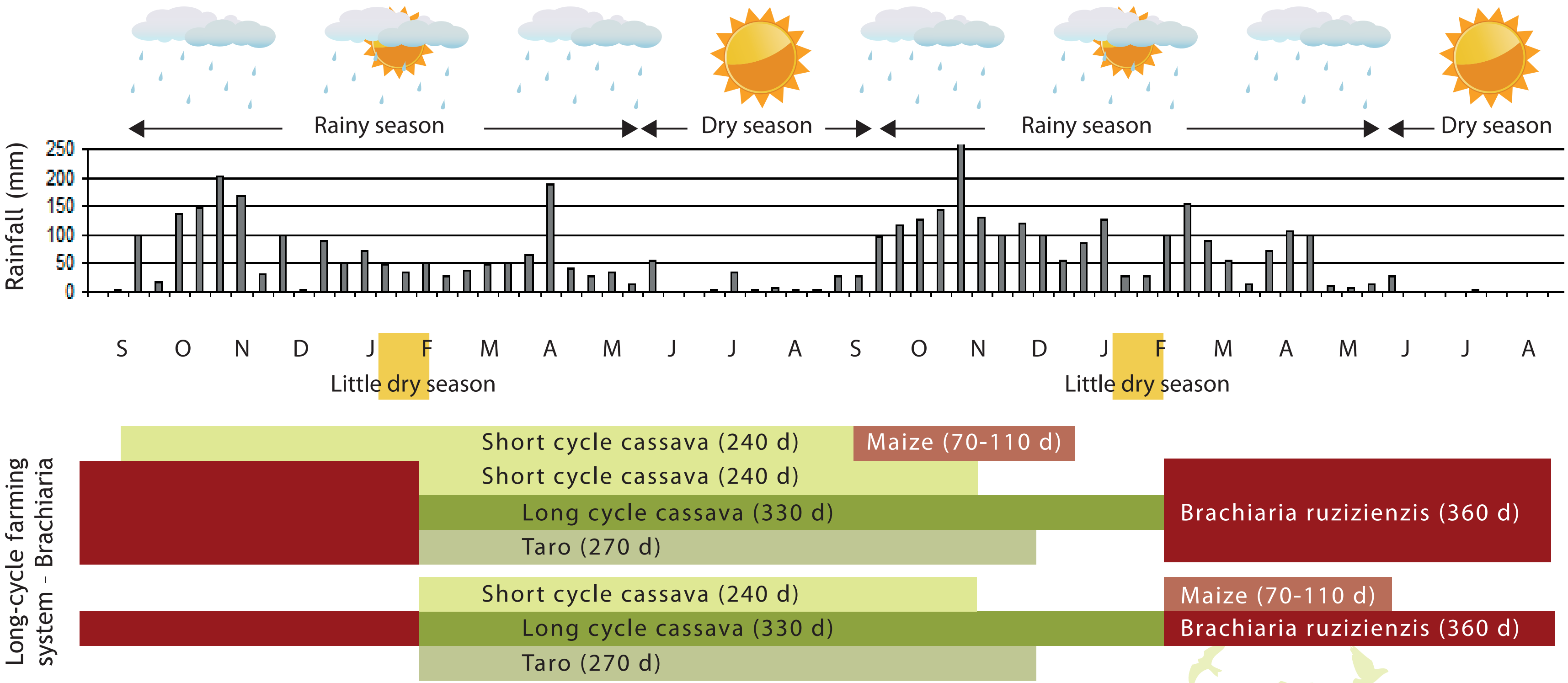
🟥 **Dead cover**

🟧 **New cover planted**

🟢 **Food crop**

In certain cases (large surface area, lack of labour...), the plant cover may be controlled by using herbicides. This must be limited and reasonable.

2-Example of a crop schedule associating Brachiaria and rainfed food crops (Gabon)



NOTE

For all crops:

- Favour repeated light weeding by avoiding heavy weeding of developed weeds. Weeding is performed by hand pulling (avoid the use of tools that risk opening the plant cover and leaving the way open to weeds propagation).
- Good dead cover guarantees limiting weeds propagation and reduces tending difficulty, especially in humid tropical areas.

Advantages and Drawbacks

Technical

- ↗ Protecting soils and limiting weeds propagation (decreasing the stremuousness of labour)
- ↗ Maintaining and improving soil fertility and stabilising yields on the long-term
- ↗ Favours the plant’s water feed system
- ↗ Does not require any particular technicity
- ↗ Suitable for all crops
- ↗ Provides flexibility for work schedules
- ↘ Mechanically controlling difficult plant coverage over large surface areas in hot and humid areas
- ↘ Requires immobilizing the land to produce the coverage
- ↘ In most cases, requires planting the coverage each year

Economical

- ↗ Stabilizes and increases production
- ↗ Decreases production costs by reducing expenses related to soilwork
- ↘ Requires investment for planting the cover

Environmental

- ↗ Reduces soil erosion
- ↗ Favours carbon sequestration
- ↗ Reduces deforestation by limiting slash-and-burn practices
- ↘ Leads to water and soil pollution risks if herbicides are used

TAKING IT FURTHER

Leaflet: Direct seeding Mulch-based Cropping system (DMC) (p. 157)

Leaflet: Cover crops (p. 159)

Leaflet: DMC with permanent cover in alternating strips (p. 165)

Leaflet: Mulching (p. 121)

Cassava on Brachiaria

Hot pepper on mulch

POINTS TO REMEMBER

Implementing DMCs with dead cover produced on site is simple. The applications are valid with low to medium landuse pressure. Usable cover crops are relatively diversified.

To control plant coverage, mechanical control methods should be favoured and herbicides should only be used as a last resort to limit water and soil pollution. Note that the use of natural herbicides is currently under study.

Intensive Rice-farming System - IRS

The Intensive Rice-farming System - IRS is a farming system developed in Madagascar by Father de Laulanie.

This method provides for significantly improving rice production, while ensuring good fertility management, without necessarily using high doses of mineral fertilizers.

The practice has been implemented as part of Agrisud's programs in Madagascar and, to a lesser extent, in Cambodia.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Improving small surface area plot valorization
- Increasing rice production
- Limiting the quantity of seed used

Conditions for implementation:

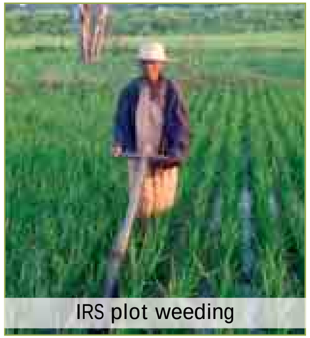
- Availability of a flat paddy field with very well controlled water: adding and removing water possible at any time
- Availability of rice plants to transplant
- Availability of sufficient quantities of compost: 20 tons / hectare on average, variable depending on the paddy field's initial fertility

Principle

IRS is distinguished from other rice-farming systems in the following ways:
- transplanting vigorous young plants during the 2-leaf stage;
- transplanting spaced by at least 25 cm;
- frequent weeding to control weeds;
- controlling water to favour tillering, i.e. the development of a number of strands per rice plant.

These technical characteristics are **interdependent** to increase tiller production (increasing the number of ears) and to have a developed root system allowing good filling of numerous grains.


Transplanting

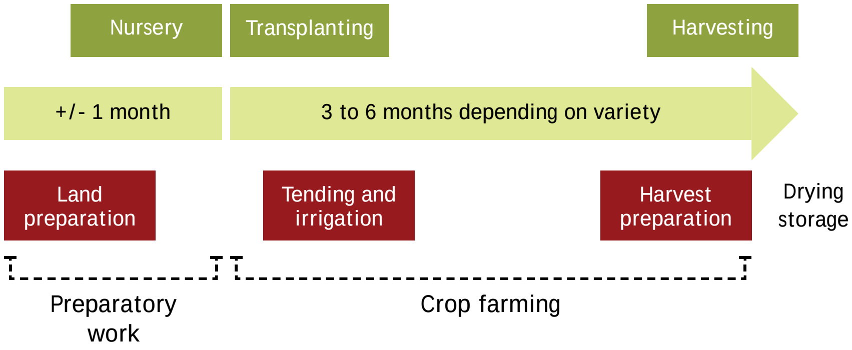

IRS plot weeding


IRS plot


Transporting rice bundles

Method

IRS general technical itinerary:



1-Preparation

Seed selection

Knowledge of variety characteristics in primordial in choosing the seeds to use: cycle length (short / long), photoperiodism (sensitivity to day length), disease tolerance / resistance, phenotype (straw lengths, number of tillers…).

Characterization of some of the commonly used varieties in Madagascar:

Name	Cycle length	Grain shape	Crop behaviour	Recommendation
Boeing	Variable	Long	Photoperiod sensitive, short straw	High season
X265	135 days	Oval	Good tillering, average straw	High season
X915	125 days	Oval	Fairly good tillering, average straw	Off-season and rich soil
Mailaka	115 days	Oval	Early rice, short straw	Off-season
FOFIFA 160	135 days	Oval	Long straw, hail tolerant	High season
China	125 days	Short	Short straw, very early	Off-season
Congo	125 days	Short	Short straw, very early	Off-season

Recommended crop planting figures:

Spacing (cm)	25 x 25	27.5 x 27.5	30 x 30
Number of plants / ha	160,000	132,231	111,111
Seeds kg / ha	6	5	4

Nursery

Successful IRS is depending on correctly scheduled work and more particularly by the switch from the nursery to the field (see Leaflet: Rice-farming nursery p 179).

Preparing the paddy field

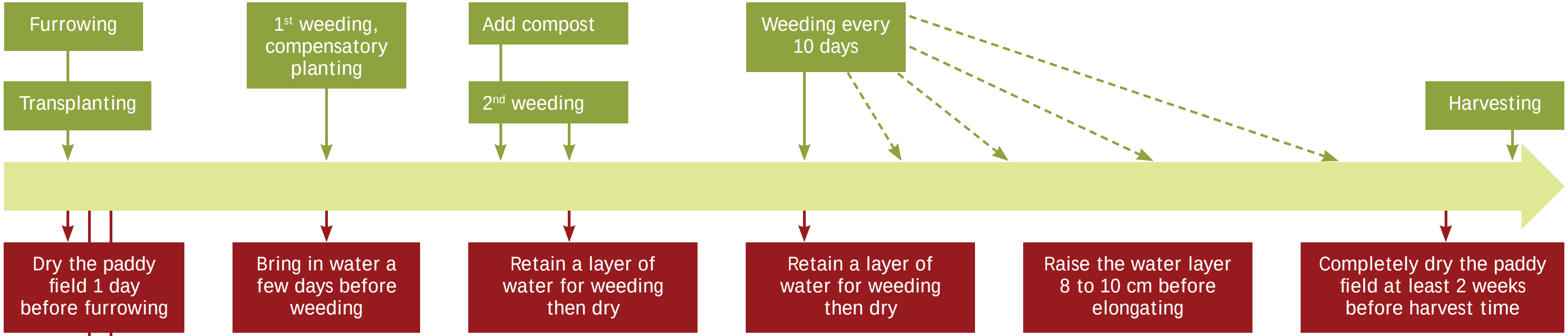
The paddy field must be ready before sowing or when preparing the nursery.

- **Spread the compost**: at least 10 t / ha
- **Deeply plough** to bring up leached fertilizing elements
- 7 days later, **harrow, weed, and break up clods**
- 7 to 15 days later, **plough again**
- 4 days later, **harrow again then puddle**
- **Flatten** to level the soil
- **Create a channel around the paddy field** to act as a buffer for incoming and outgoing water

☐ **REMARKS:**

- Implementing IRS requires significant added compost. Producers must ensure they have sufficient quantities otherwise paddy field fertility may decrease rapidly.
- Compost requirements are estimated at 20 t / ha on average, added in 2 batches: when preparing the paddy field (basal manuring) and during the second weeding (see paragraph 3, tending). The 2nd batch supplements the 1st: 10 t / 10 t ; 15 t / 5 t…
- For peat soils, add firm soil to solidify the ground and allow good anchorage of the plant; balance fertilizing elements by planting a vegetable cycle before establishment of IRS (vegetable crops consume the excess nitrogen and prevent the rice from producing too much floral glumes at the expense of the grain).

2-Crop farming



Furrowing

Transplanting

1st weeding, compensatory planting

Add compost

2nd weeding

Weeding every 10 days

Harvesting

Dry the paddy field 1 day before furrowing

Bring in water a few days before weeding

Retain a layer of water for weeding then dry

Retain a layer of water for weeding then dry

Raise the water layer 8 to 10 cm before elongating

Completely dry the paddy field at least 2 weeks before harvest time

Bring in water after completing transplanting

After eliminating the traces, dry until cracking

Although rice withstands flooding and requires a lot of water, it is not an aquatic plant.

Contrary to traditional practices where paddy fields are permanently flooded, IRS proposing regularly drying the paddy to favour the young plants' tillering. Increasing the water layer level acts to stop tillering in favour of grain development.

Rice plants in the tillering stage

Large-scale IRS

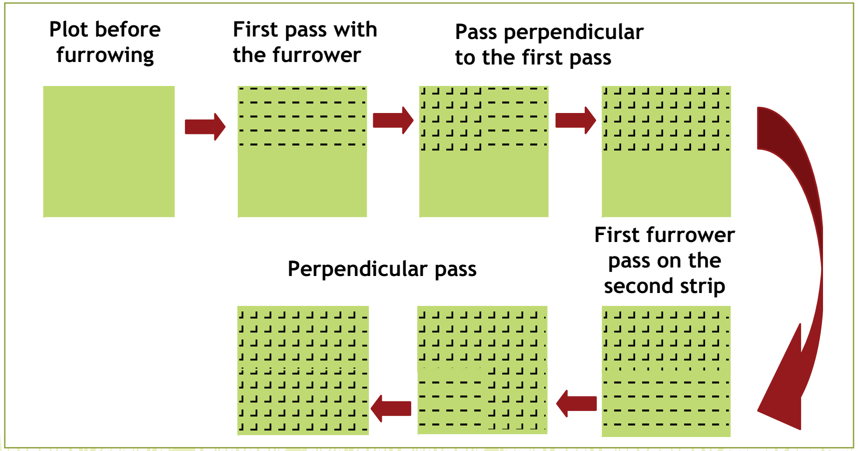
Furrowing

Before transplanting, use the furrower. This tool provides for **facilitating weeding and transplanting** (saving manpower and ensuring transplanter self-sufficiency):

- **Dry the soil** one day before transplanting (2 days before for peat soils)
- Use two ropes to indicate **the starting alignment along the plot**
- **Drag the furrower** along the rope just for the first tracing
- Go back and trace perpendicularly (obtaining a cross-hatch pattern)
- The cross-hatching serves as alignment for the rest of the furrowing
- Continue until the plot is fully cross-hatched

The intersection of two perpendicular lines indicates the transplanting point. It is preferable to transplant as the furrower advances.

Diagrammatic representation of rice-framing plot furrow marking



Transplanting (at the 2-leaf stage)

- **Remove the plants** from the nursery, retaining their mound of earth on the root and seed
- **Transplant one by one** sliding the plant in the furrower groove so as to not orient the roots towards the top
- **Place the plants** at the furrower crossing level
- After completely transplanting the plot, **bring in the water** to flatten the soil and favour the plants' regrowth

After the lines have disappeared, completely dry the paddy field to favour the young plants' root development and tillering.

Tending

Weeding

- **1st weeding** - 10 days after transplanting: bring in water a few days beforehand to soften the soil, use a weeder
- **2nd weeding** - 10 days after the first: retain a water layer for weeding, use the weeder then immediately by hand, then dry the paddy field to restart tillering
- **Following weeding** - every 10 days, as needed: retain a water layer for weeding with a weeder then dry the paddy field

Compensatory planting: during the 1st weeding, use nursery reserves.

Fertilization: add compost one day before or during the 2nd weeding.

Tillering control: before elongating, raise the water layer to 8-10 cm to stop tillering. Poor control of tillering could produce much more husk at the expense of the grain (numerous ears but poorly developed grains).

Weeding operation

3-Harvest and post-harvest operations

Harvesting

Dry the plot at least 2 weeks before harvest-time to obtain a uniformly mature harvest.

- When harvesting, **let the cut rice dry for 3 days** in the paddy field or carry the cut rice and lay out on a rick for the grains to mature
- **Thresh the rice** 3 days later
- **Do not burn the straw**, use it for mulch, composting, spread it on the paddy field, wet it down, and plough it under

Drying and conservation

- **After threshing**, dry the grains well to eliminate any excess humidity (traditionally, rub with the heel: if the grains are easily dissect without breaking, they are fully dry)
- **Once winnowed**, the rice must be kept in plastic bags or woven tissue on palettes in dry air and not too hot

Rice threshing

Advantages and Drawbacks

Technical

- ↗ Presents a high adoption rate by producers
- ↗ May be implemented less strictly (but less productively): ERS, Enhanced Rice-farming System, which requires less water control and older plants for transplanting (2 to 3 weeks)
- ↘ Requires significant soil fertility renewal
- ↘ Requires nearly total control of water on the plot
- ↘ Requires very precise farming activity planning

Economical

- ↗ Provides for increasing yields from 2 t / ha (traditional) to 6-8 t / ha
- ↗ Provides for better value from rice-farming plots

Environmental

- ↗ Allows continuous soil cover since increased production for a rice cycle makes producers more likely to diversify production for following cycles
- ↘ Presents a soil depletion risk if fertility is not renewed

POINTS TO REMEMBER

IRS technical itineraries allow producers to increase yield.

Even if labour times increase slightly, this increase benefits better labour distribution on the farm.

Conversely, the practice must be accompanied by a fertility renewal strategy in order to be practiced sustainably.

TAKING IT FURTHER

Leaflet: Rice nursery (p. 179)
Leaflets: Swath composting (p. 81) / Crib composting (p. 89)
Leaflet: Manure recycling (p. 77)

Rice nursery

For irrigated rice crops, producing quality plants is a decisive stage in successful farming.

The Rice nursery is consequently a delicate phase that producers must master if they want to start their technical itineraries on good terms.

The rice nursery has been primarily implemented in Intensive Rice-farming Systems (IRS) or Enhanced Rice-farming System (ERS) as part of Agrisud's programs in Madagascar.

Effects:

Soil	Water	Plant	Landscape

Objectives:

- Produce young plants of quality in quantity
- Optimize rice seeds purchased
- Ensure correct crop start-up

Conditions for implementation:

- Availability of rice seeds
- Availability of compost, mulch or green leaves
- Availability of the necessary equipment to form mounds (shovel, rake…) and planks of wood to create removable supports
- Availability of a protective net

Principle

Several factors must be taken into account before scheduling a nursery 's implementation:

- placement, which is not random;
- season, which influences nursery techniques;
- surface area to be planted and the availability of labour, which influences the size of the nursery and its staggering.

Method

1-Nursery location selection

Nursery location is **strategic** ; its choice should fulfil a majority of the following criteria:

Selection criteria	Justification
Proximity to a water source	Facilitate irrigation
Proximity to domestic habitat	Facilitate nursery surveillance and tending
Protection against wind and animals	Avoid losses due to wind gusts and / or wandering animals

To limit plant transportation, the nursery should preferably be located near the paddy field, but nursery surveillance will be more difficult than if the nursery is near the home.

Rice nursery on banana tree leaves, Madagascar

2- Seed preparation

- **Winnow** to remove bad seeds
- **Boil water** and let it cool to about 50°C
- **Let the seed soak** for at least 30 min. and up to 12 hours (totally cooled) in order to prevent disease and break dormancy
- **Remove the seeds from the water**, keep in a wet cloth and place it in the heat (near a fire, in compost…) until the seeds germinate (generally, for 24 hours)
- When the seeds are at the 1mm visible germ, **sow in nurseries**

3-Preparing and monitoring nurseries

For 1 ha of 25 cm x 25 cm transplanted paddy field you need 4 to 12 kg of seed depending on sowing density, sown on a 100 m² nursery.


Rice nursery on beds, Madagascar


Paddy fields after planting

REMARKS:

If the soil is clayey, it is preferable to mix it with fine sand to make it easier to separate the plants when transplanting.

Depending on season, rice nurseries are set-up differently.

During **the warm season** (rainly season in Madagascar) prepare the **beds with mounds** to favour drainage.

- Earth-up the nursery bed
- **Add a layer of compost** to the bed
- **Water** abundantly
- **Evenly broadcast sow** the pre-germinated seeds
- **Cover** with a thin layer of compost or fine soil
- **Mulch** to protect from birds and insolation
- From the 1st shoot, **lighten the mulch** and lift it up to avoid hindering the young growing plants
- **Remove the mulch** 2 days before the schedule transplanting

The period in the nursery is 8 to 15 days. Transplanting occurs when the plants are in the 2-leaf stage.


Plants ready for transplanting

During **the cold dry season**, plants must be protected from the cold, favouring germination. In this case, the nursery must create the heat by decomposing green leaves.

Two sowing techniques are possible.

Sheltered sowing technique:

- Cover the nursery with a woven canvas making a tunnel (protection against the cold)
- Dig the entire nursery surface (about 10 cm)
- Add a layer of easily decomposable green matter (e.g.: tephrosia, neem leaves...)
- Cover with earth soil (1/3 mixed, 1/3 with compost and 1/3 sand)
- Sow online or broadcast four days after the first heat release related to the degradation of green materials
- Water and wait for the 2-leaf stage to transplant

Table sowing technique:

- Prepare a aboveground nursery
- Add a layer of easily decomposable green matter to the bottom of the nursery
- Lay out a well-mixed substrate layer (1/3 compost, 1/3 soil and 1/3 fine sand) of about 5 cm on the vegetable-matter layer
- Sow in a line or broadcast
- Water and wait for the 2-leaf stage to transplant

In case of removable nursery, protect the bed from the cold in the evening and bring it out with the dew dissipates.


Rice nursery on table


Rice nursery under cover

The table sowing technique is only suitable for small paddy fields

Advantages and Drawbacks

Technical

- ↗ Simple to implement practice
- ↗ Allows easy tending
- ↗ Provides for robust plants
- ↘ Requires materials for building detachable supports and shelters
- ↘ Quantitatively limits plant production (if using the table sowing technique)

Economical

- ↗ Allows savings on seeds
- ↗ Guarantees good success rates in transplanting

Environmental

- ↗ Limiting phytosanitary risks due to more robust plants

POINTS TO REMEMBER

Establishment of nurseries guarantees robust plants and saves seeds.

Scheduling and successfull establishment of nurseries should help producers comply with the IRS work schedule (replanting at the 2-leaf stage).

TAKING IT FURTHER

Leaflet: Intensive Rice-farming System - IRS (p. 173)
Leaflets: Swath composting (p. 81) / Crib composting (p. 89)
Leaflet: Manure recycling (p. 77)

Lexicon

Absorption: elements fixed by a substrate (e.g. absorption of mineral elements in a clay-humus complex…).

Acaricide: active substance or preparation used to protect plants from acarids (microscopic insects from the arachnid - spider – family) aggression by killing them.

Aerobic: in the presence of oxygen.

Agroforestry: production method associating tree and shrub farming with underlying or intercalated crops (vegetable and fodder crops…); agroforestry favours biodiversity within agro-ecosystems and improves productivity while limiting soil deterioration.

Agro-system or agro-ecosystem: ecosystem in which man intervenes by implementing plant and animal production techniques.

Alluvial (or alluvionary) soil: soil composed of alluvia – generally fine deposits such as fine sand, silt, or clay, carried by running water and deposited by sedimentation.

Anaerobic: without the presence of oxygen.

Annual / biannual crop: crop planted for one or two annual cycles: vegetable crops, cassava, peanuts, maize…

Anti-erosion control: set of schemes providing for combating erosion.

Bacteriosis: illness caused by a bacteria.

Bench terrace: small terraces for crops.

Biodiversity: biodiversity or biological diversity evokes the natural diversity of living bodies, animals and plants, composing an ecosystem.

Biomass: all plant-originated organic matter (tree leaves, savannah grasses, crop residues…); biomass may be recycled to produce organic fertilizers (composting) or for covering soils.

Bolting: process during which a grass produces its seed (initial stage in going to seed).

Breaking up soil: action consisting of loosening the ground; the soil is broken up by working it (ploughing, harrowing, hoeing…) separating the earth and making the top layer more permeable to roots and supplements.

Canopy: forest trees foliage.

Capillary ascension: capillary rising groundwater through soil caused by evaporation.

Chaff: fine residual matter from threshing cereals (cob shards, glumes, and floral glumes).

Clay-humus complex: association of clay and humus in a complex bound by calcium ions or iron. Humus protects the clay from dispersion: it stabilizes the structure and forms a “cement” with the clay providing for the construction of solid aggregates resisting water deterioration (D. Soltner); also called “absorbent complex” it plays an essential role in storing water and nutritive elements and returning them to plants as needed.

Clod breaking: action consisting of breaking up clods of earth.

Colluvial (or colluvionary) soil: soil composed of colluvia – relatively large deposits resulting from wind and water erosion on a slope, called slope deposits; they are found at the foot of and on the slopes of hills and mountains.

Cupric compounds: compounds containing copper.

Coverage fertilizer: temporary crop intended to be ploughed into the soil to provide nutritive elements to the following crop.

Cracking: the appearance of cracks, slits.

Cryptogrammic disease: disease caused by a fungus.

Damping-off: plant illness caused by micro-organisms (Pythium genius among others) with the main symptom being rotting of the young shoots’ crown.

Drainage: action consisting of favouring the evacuation of excess water present in the soil.

Dredging: process consisting of extracting solid materials and debris naturally deposited at the bottom of a pit, canal, well…

Ecological habitat: site where animals and plants live

Ecological unit: area presenting groups of typical plant and animal species in interaction with their surroundings.

Ecosystem: all elements (fauna, flora, soil, water, climate…) composing a natural environment and interacting with each other.

Effluents: liquid or semi-liquid discharge sometimes susceptible of contaminating the areas where they are discharged; they may be organic or chemical.

Ending dormancy: dormancy is a biological mechanism in plants that, in nature, prevents the seed from germinating if climatic conditions are not favourable; ending dormancy consists of breaking this mechanism to make seeds germinate, after ensuring the conditions for growth.

Evapotranspiration: total quantity of water transferred from the soil and plants to the atmosphere by water evaporation in the soil and by water lost by plant transpiration.

Foliar fertilizer: liquid fertilizer sprayed on plant leaves.

Food crop: crop primarily intended for local food consumption.

Fungicide: active substance or preparation used to protect plants from illnesses caused by fungi.

Furrow irrigation: irrigation system consisting of bringing water to crops using a more or less dense network of small canals and ditches (furrows) dug in open fields.

Gap filling: action consisting of replacing dead or sickly plants in a cultivated plot.

Glumes and floral glumes: envelops seeds on grass ears.

Half-moon: embankment in the form of a semicircle in sloped areas used to collect runoff and ensure seepage and depositing the solid elements carried.

Harrowing: action consisting of working the top layer of the soil using a harrow (a tined frame).

Herbicide: active substance or preparation used to destroy grass species such as weeds.

Hoeing: action consisting of breaking the top crust of compacted soil with a ploughing instrument; hoeing limits capillary evaporation of the water from the soil, favours soil aeration and water seepage.

Humification: process of transforming fresh organic matter into humus through, among other things, micro-fauna and -flora activity in the soil.

Humus: in the soil, humus is produced by the decomposition of organic matter (plant and animal waste). It plays a decisive role in soil fertility.

Hydromorphic soil: waterlogged soil (permanently or temporarily).

Hygrometry: characterizes the air's humidity content.

Improvment: improving the soil's physical, chemical, and biological properties by supplementing with missing elements (limestone, organic matter...).

Insect control: active substance or preparation used to protect plants from insect attacks by repelling them.

Insecticide: active substance or preparation used to protect plants from insect attacks by killing them.

Lateritic soil: red soil, typical of intertropical regions, rich in alumina and iron oxides and hydroxides.

Leaching: loss of mineral and organic elements carried by percolating water; soil and manure may be subject to leaching.

Marling: farming technique consisting of enriching soil with limestone and clay (supplementing with crushed limestone, shale...).

Micro-climate: specific climate in a limited section of an area, distinct from the general climate in that area.

Mineralization: process during which humus in the soil is broken-down and frees its component minerals.

Natron: mineral composed, among other things, of sodium carbonate decahydrate.

Nematocide: active substance or preparation used to protect plants from nematode attacks by killing them.

Nematode: small earth worms (eelworms) which may be plant parasites.

Nematofuge: active substance or preparation used to protect plants from nematode attacks by repelling them.

Perennial crop: crop located in the same plot for several years (> 5 years): orchards, forestry plantations...

Phenotype: set of apparent characteristics of a living being; corresponding to the execution of the genotype (expression of the genes).

Phytosanitary compounds or pesticides: combinations of substances or preparations designed to protect crops against disease and parasites; they may be natural (bio-pesticides) or chemical.

Pollination: transporting pollen grains (male element) to the pistol (female element) in the flower to ensure fertilisation; this natural mechanism (often performed by insects) may be accomplished artificially.

Production crop: crop generally intended to be sold.

Pulverulent structure: typifies the structure of a soil composed of very fine particles, with low aggregation.

Rainfed crop: crop relying on natural water supplied by rain, without using an irrigation system.

Revegetating: action aimed at installing grass, shrub, or tree vegetation on a site.

Semi-perennial crop: crop located in the same plot for a few years (2 to 5 years): pineapple, bananas, papaya...

Shoal: low, often humid or hydromorphic, dominated by surrounding slopes from which it receives water and colluvia.

Singling: action consisting of removing excess plants after sowing in a nursery or on a farming plot, with the goal of favouring the development of the remaining plants.

Slash-and-burn: agricultural practice in which fields are cleared of trees, burned (branches, stumps, waste material...) and farmed discontinuously, involving fallow periods longer than cultivated farming periods.

Soil structure: more or less stable assembly of a soil's component elements (clay, sand, silt, humus, calcium, iron...) in variably-size aggregates, with open spaces forming porosity allowing for the passage of water, dissolved nutrients, and gases (oxygen, nitrogen).

Soil texture: defined by a relative proportion of a soil's various fractions (sand, silt, clay, limestone, organic matter); it determines the soil type: e.g.. clay soil, silt-clay soil...

Stomata: small openings located under the leaves through which transpiration and gas exchange occurs in plants.

Stone contour line: development consisting of stones laid-out along contour lines; its purpose is to combat water erosion by favouring water dispersion and seepage as well as depositing the solid elements transported upstream from the line.

Submersion irrigation: irrigation system consisting of flooding crop beds or pots.

Substrate: crop support.

Sump: broad, shallow well providing access to the surface water table.

Supplemental fertilizers: fertilizers provided when growing crops to supplement the initial contribution. Through regular addition, they cover crop needs based on their growth stage.

Underlying crop: crop planted under another crop (e.g. vegetable farming crops under orchards)

Vegetative bud: bud that will become stems or leaves.

Water erosion: designates erosion phenomena caused by water; precipitation and runoff cause soil particles to be detached and transported to deposit areas; this type of erosion is strongly related to site morphology, soil characteristics, and its vegetation coverage.

Water pumping: pumping underground or surface water; water pumping means include water extraction systems.

Waterlogging: water saturation of farming land due to the water table level, significant runoff, or excessive irrigation; waterlogging compacts the soil and deprives plant roots of oxygen.

Weeding: action consisting of cutting weeds in a crop with a hoe.

Weeds: synonym for self-propagating plants.

Wilting: drooping stems and leaves on a plant (loss of rigidity) possibly caused by illness or water stress.

Wind erosion: designates erosion phenomena caused by wind. Wind is a major erosion agent in areas where the soil is poorly structured, dry, bare, or sparsely covered with vegetation.

Winnowing: action consisting of cleaning seeds; winnowing may be performed using a basket like a strainer.

Graphic design and page setting:

iden studio
www.idenstudio.com

Translated from french by
« the word company »
www.word-company.co.uk

Printed according to environmentally-friendly processes by an IMPRIM'VERT certified printer

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This guide has been produced with the support of:

Caisse desDépôts

VEOLIA ENVIRONNEMENT

VEOLIA EAU

CLUB MÉDITERRANÉE

IMPRIM'VERT
Votre imprimeur agit pour l'environnement

ISBN: 978-2-9537817-1-7

€15 tax included

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