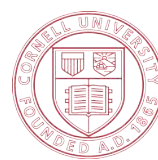


# Technical Manual for SRI in West Africa

## *Improving and Scaling up of the System of Rice Intensification in West Africa*



August 2014  
Version 2



***'Improving and Scaling Up the System of Rice Intensification in West Africa'*** is a project of the West African Agricultural Productivity Program (WAAPP), with funding coming from the World Bank. This project is jointly coordinated by CNS-RIZ in Mali, and SRI-Rice at Cornell University, in the United States.

*This is a working document, and will be continuously revised with input from all stakeholders, including both those inside and outside of the project.  
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*For more information on this project visit [sriwestafrica.org/about](http://sriwestafrica.org/about), or contact Erika Styger ([eds8@cornell.edu](mailto:eds8@cornell.edu)) or Devon Jenkins ([dlj67@cornell.edu](mailto:dlj67@cornell.edu)). The most current version of this manual is available at [sriwestafrica.org/documents](http://sriwestafrica.org/documents).*

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# Part 1. Context

*Part 1 introduces SRI, its origins, principles and practices, and provides a basic context of West African rice production.*

## Section 1. Background

*After starting in Madagascar in the 1980's and 1990's, SRI has spread most rapidly in Asia. With this WAAPP project SRI is poised to take center stage across West Africa.*

### 1.1 Introduction

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The System of Rice Intensification, or SRI, is an agro-ecological and climate-smart rice production methodology that allows farmers to produce more grain using less seed and water, and fewer purchased inputs. Unlike other agriculture strategies, SRI does not rely on infrastructural projects, new varieties or fertilizers, herbicides or pesticides to raise yields. Instead, SRI is a knowledge-based crop management approach that leads to the improvement of plant growth and productivity. This is achieved by advancing the expression of rice plants' genetic potential for increased productivity.

As part of the West Africa Agricultural Productivity Program's<sup>1</sup> (WAAPP) project *Improving and Scaling up the System of Rice Intensification in West Africa*,<sup>2</sup> this technical manual is designed to assist technical trainers in the 13 participating countries as they develop their farmer training programs. This is a living document, and will change and be adapted according to feedback from trainings, trials and field results. For those using this, we welcome your feedback to make this document as useful as possible to as broad an audience as possible across West Africa.

### 1.2 Origins and Evolution of SRI

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SRI's origin dates back to the early 1980's, after Fr. Henri de Laulanié, a French Jesuit priest and agronomist living in Madagascar, experimented over many years with various components of the rice system, including reduced irrigation water application, planting single and young seedlings with wider spacing, among others. Laulanié created a local non-profit organization called Tefy Saina, dedicated to aiding rural Malagasy communities, which collaborated in the mid 1990's, with a project of Cornell University's International Institute for Food, Agriculture and Development (CIIFAD). After learning about SRI, Cornell's project evaluated SRI's efficacy and after three years of trials became convinced of its utility. Since 1997, a small group at Cornell began sharing experimental and farmer-based results internationally. A large international network of SRI practitioners and researchers has developed since then, adapting SRI methods to a variety of rice growing systems around the world. In 2010, the SRI International Network and Resources Center (SRI-Rice) was established at Cornell University to improve the advancement and sharing of scientific and practical knowledge about SRI, and to support global networking of SRI practitioners and researchers. As of January 2014 SRI has been validated in more than 50 countries in Africa, Asia, the Middle East, Central and South America, and the Caribbean, with an estimated 8-10 million farmers applying and benefiting from the SRI methodology.

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<sup>1</sup> More information about the West Africa Agricultural Productivity Program (WAAPP) can be found at [www.waapp-ppao.org](http://www.waapp-ppao.org)

<sup>2</sup> More information on this project can be found at [www.sriwestafrica.org/about](http://www.sriwestafrica.org/about)

As SRI spread to new regions of the world, farmers began using the principles of SRI with other crops, learning that the 'SRI effect' works for a wide variety of crops, such as sugarcane in Cuba; wheat in India, Mali, Nepal, Afghanistan, and Ethiopia; and barley, finger millet, mustard, tef, vegetables, beans, turmeric and other crops in India and Ethiopia. When used for crops other than rice, SRI is often referred to as SCI, the System of *Crop* Intensification.<sup>3</sup>

### 1.3 SRI in West Africa

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West Africa is the largest rice producing, consuming and importing region in Africa, and for several decades production has stayed below demand, resulting in continuously growing rice imports. The trade imbalances can hurt local economies, and cause problems for national governments. In response, countries across the region are looking for ways to increase domestic rice production.

As a result, SRI has in recent years generated a lot of interest as an option to boost yields without relying on large and expensive infrastructural projects or increased reliance on imported synthetic inputs. From small trial plots to regional trainings and initiatives, farmers from Mali to Benin, Senegal, Nigeria and Sierra Leone, among others, have laid a beginning foundation for regional adoption of SRI, and the WAAPP project seeks to build off these initial developments in a collaborative and coordinated fashion.

Despite this enthusiasm, spreading SRI across West Africa will still take hard work, creativity, and collaboration. Unlike South and Southeast Asia, where wide expanses of irrigated rice fields predominate, West Africa consists of a broad array of different rice production systems, the largest of which is rainfed upland. To date SRI has grown more quickly around the world in areas of irrigated rice production, as it requires less adaptation and can be more quickly and seamlessly adopted by farmers, who then spread it to neighbors with little need for readapting the methods. Despite the differences in West Africa, trials have already demonstrated that SRI can and does work well here, across many different rice production systems. The key to our success then will be experimentation, and sharing adaptations across geographic boundaries and political borders, allowing farmers to learn from the adaptations of their counterparts facing similar conditions.

With the WAAPP, we are doing just this.

## Section 2. Rice Production Systems in West Africa

*West Africa is the rice basket of Africa, with a large diversity of production systems.*

In West Africa, rice is grown in a variety of settings and cropping systems, reflecting a large diversity of farming conditions. The two broadest categories of rice cropping systems are irrigated and rainfed systems.

### 2.1 Irrigated systems

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Irrigated systems account for an estimated 12% of the rice production area in West Africa, yet due to their higher productivity than other systems, make up 28% of the region's rice production.<sup>4</sup> These systems occur throughout the region, but thanks to abundant sunshine, are

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<sup>3</sup> For more information on SCI, visit:

[http://sri.ciifad.cornell.edu/aboutsri/othercrops/SCImonograph\\_SRIrice2014.pdf](http://sri.ciifad.cornell.edu/aboutsri/othercrops/SCImonograph_SRIrice2014.pdf)

<sup>4</sup> WARDA. 1997. Annual Report 1997. Bouaké, Côte d'Ivoire, WARDA (The Africa Rice Center).

most productive in the Sahel (notable Mali and Senegal), accounting for 22% of regional production.<sup>5</sup> Irrigated systems can be separated into two groups:

- Irrigated wet season systems: Irrigation water is added to a rice field as a *supplement to rainfall* – especially early in the season, and during any midseason dry periods
- Irrigated dry season systems: Irrigation is essential for growing a rice crop, as rainfall is very low or even non-existent

## 2.2 Rainfed systems

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Rainfed systems account for an estimated 75% of all rice production area in West Africa, yet due to their lower productivity compared to the irrigated systems, they make up approximately 61% of total production<sup>1</sup>. Rainfed systems can be separated into two main groups:

- Rainfed upland systems: Covering 44% of rice production area, upland systems are the most predominant, despite having the lowest productivity of all systems—contributing just 25% to regional production. They are of particular importance in Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Togo and Nigeria, where enough rainfall occurs to support the crop.<sup>5,6</sup> Rainfall is the only water source. These systems are mostly located on leveled surface areas in low-lying valleys or on slopes, with high water run-off and with lateral water movement. Soils are mostly freely draining and aerobic, and are therefore under non-flooded conditions. Soils vary in texture, water holding capacity and nutrient status. Rice is direct seeded on plowed dry soil or dibbled in wet, non-puddled soil. Rice is also planted in slash-and-burn systems or permanent, mixed cropping systems.
- Rainfed lowland systems: Responsible for 31% of the rice producing area in the region, these systems have higher yields than for upland rice systems—accounting for 36% of regional production. They are found throughout the region but are particularly prominent in Ghana, Burkina Faso, Nigeria, Benin and Togo.<sup>2,3</sup> In these systems rice fields are flooded non-continuously, often in the second half of the growing season of variable depth and duration. Soil conditions vary between aerobic and anaerobic conditions. Flooding occurs directly from rainfall, and from runoff of above-stream locations.

Under rainfed systems, water control is limited. Nevertheless, there are many different methods for managing water in these systems! An effective method is, for instance, bunding of fields for rainwater retention, to protect fields from floodwaters, or to drain water if possible and necessary. Bunding is described in more detail in Part 3, sections 1.2 and 7.1.

We can differentiate among 4 different situations in rainfed systems:

- Favorable systems  
In most years a stable yield is guaranteed. Characteristics of these systems are:
  1. Mid-slope (intermediary position in the toposequence), benefiting from both rainfall and a high water table that can help plants bridge dry spells
  2. Locations with well distributed and reliable rainfall
  3. Good soil structure with good water holding capacity
- Drought-prone systems  
Factors that contribute for a system to become drought-prone are:

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<sup>5</sup> Defoer, T., Wopereis, M. C. S., Jones, M. P., Lançon, F., Erenstein, O., & Guei, R. G. 2004. Rice-based production systems for food security and poverty alleviation in sub-Saharan Africa. *Int. Rice Commission Newsl*, 53, 85-96.

<sup>6</sup> Center, A. R. (2008). *Africa rice trends 2007. Africa Rice Center, Cotonou, Benin.*



1. A position higher up the slope, where access to the water table is not guaranteed
  2. Locations with lower or inconsistent rainfall during the growing season
  3. Light soils with little water holding capacity, and/or characterized by high water loss through run-off or evapotranspiration
- Flood-prone systems  
These systems occur in low-lying areas, where uncontrolled flooding can occur. This can be flooding for more than 10 consecutive days, or flooding with depths that exceed 50 cm, and where drainage is not possible. These systems occur in areas with high rainfall and/or with heavy soils.
  - Drought and flood-prone systems  
These systems can be found in locations with highly variable climate and rainfall, and in mid-slope locations. In seasons of heavy rainfall and high water tables, fields can get flooded. In seasons with low rainfall, plant roots may not reach the water table, and inconsistent rain can lead to drought conditions.

The distinction between the systems is not always clear and systems could change depending on the season, and on farmers' management practices. Also, within a given landscape there is most likely more than one rice system present, and farmers often use different locations along the toposequence and work simultaneously in different systems with different cropping practices and varieties.

## 2.3 Other systems

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Other systems occur in West Africa, not described here but included in our project are: mangrove systems, deep-water rice systems, recession rice systems, and more. While not regionally significant, they are locally important in Guinea, Sierra Leone, and in parts of other countries like Nigeria. We will be describing these systems in more detail as the project moves forward, and work on adapting SRI practices to these systems.

## Section 3. Developing a Common Understanding of SRI

*SRI needs to be adapted to different local conditions, but while the specific practices used will vary, the underlying principles will always stay the same.*

As we start this West Africa SRI project, it is important to work and communicate with a common understanding about SRI to avoid confusion and to make fast and solid progress. Speaking the same language will allow interacting easily across climate zones, national boundaries and rice cropping systems.

To achieve this, we propose a conceptual framework that is clear and easy to use, yet one that can embrace and integrate the complexities and variability that will arise from working with different rice systems in West Africa (and beyond).

### 3.1 SRI Conceptual Framework

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The conceptual framework establishes a hierarchy of categories, important to maintain and apply: **methodology – principles – practices**. An introduction is given in the text and figure below.

SRI is an agro-ecological **methodology** that is composed of four core **principles**. For these principles to be implemented, farmers follow various crop, water, soil and nutrient management **practices** that can differ according to local conditions.

The principles of SRI stay the same no matter where and how farmers grow rice, and other crops when implementing SRI - but the practices to implement the principles can vary.

As farmers learn about SRI and start implementing the methodology, their main task is to adjust the cropping practices in such a way that they strive towards the optimal implementation of the SRI principles.

Applying the SRI methodology is therefore a work in progress for farmers and technicians, as they develop and fine-tune SRI practices for the local conditions. Thus, SRI is not a fixed package of practices, but is open and calls for innovations at the local level. The challenge lies in capturing innovations and adaptations of SRI practices that work for farmers in a given condition and location, evaluate them and disseminate the knowledge to other farmers in similar locations, so they can benefit from what was learned elsewhere.

Practices for SRI have been developed and are under development for many rice-cropping systems in over 50 countries worldwide. As our SRI West Africa project advances, we will document the SRI practices developed for the different rice systems in West Africa and improve upon the technical recommendations. We will improve and amend this manual as results are coming in from the field. The conceptual framework will allow us to do this in a structured way where innovative practices can easily be integrated.

### ***Four principles of SRI***

The four SRI principles interact with each other to create a synergistic change in how rice plants grow.

1. Favor early and healthy plant establishment
2. Minimize plant competition
3. Build fertile soils rich in organic matter and soil biota
4. Manage water carefully, avoid flooding and water stress, for ideal plant development

These four principles are elaborated below:

#### **1. Favor early and healthy plant establishment**

Careful and early plant establishment maximizes the plant's potential for shoot and root development, largely by minimizing early stress from both excessive competition among plants in the nursery and from transplanting. The earlier plants can be established in a rich soil, with plenty of space, the sooner they can develop roots and start tillering, and the healthier and more resilient towards stress they become. Most commonly, this translates in transplanting much younger seedlings, and if further pushed back can also include direct seeding.

*A multitude of practices including, among others: i) seed selection and seed treatment, ii) raised bed nurseries with non-dense sowing of seeds, iii) well leveled organic matter enriched soils, iv) careful and shallow transplanting at a young age, and v) direct seeding with seed pretreatment and shallow planting of 1-2 seeds/hill only.*

#### **2. Minimize plant competition**

Minimizing competition for resources—such as nutrients, water, sunlight and soil volume—helps plants grow quickly and healthy, and become more productive with better



panicle and grain development. This principle is highly interactive and dependent on Principle 1 and 3, *early and healthy plant establishment* and *building fertile soils*, respectively.

Under SRI management competition is minimized by reducing the density of the plant population, by both i) increased spacing between plants, and ii) planting only 1 plant/hill instead of 3-5 plants/hill.

### **3. Build fertile soils rich in organic matter and soil biota**

This principle strives to create a healthy soil that supports and provides a number of functions and benefits, among others: i) a good substrate for roots and for microbial life to develop and support plant growth, ii) improve nutrient and water holding capacity of the soil, iii) improve fertilizer use efficiency, iv) create favorable aerobic soil conditions, and iv) protects and buffers against conditions created by climate change, be it variable rainfall patterns, increased temperature, pest and disease pressure.

Improving soils with organic matter is the only viable solution in the long run to create productive and healthy soils. Integration of conservation agriculture principles and practices will be critical to reach the objectives of this principle.

### **4. Manage water carefully, avoid flooding and water stress, for ideal plant development**

This principle will not apply to the same extent to the various rice systems, most importantly to the irrigated system, rainfed lowland and rainfed upland systems. The take home message is that while rice plants can survive in flooded soils, they don't thrive.

Under non-flooded and aerobic soil conditions, roots grow more proliferous and deeper, aerobic soil microbes support healthy plant development, and the plants tiller more and better, which all translates into better panicle development and grain filling.

Aerobic soils are also greatly enhanced by organic matter additions, and in turn aerobic soil conditions increase mineralization of nutrients found in organic matter, making them better accessible to both soil microbes and plant roots. With aerobic soil management, methane emissions—a potent greenhouse gas—from rice fields are drastically cut and arsenic uptake in rice grain is also reduced.

For irrigated and rainfed lowland systems it is important to apply practices that reduce flooded and anaerobic soil conditions. From worldwide experience with SRI, irrigation water application can be easily reduced by 30-50%, when alternate wetting and drying irrigation is applied.

For upland rice systems keeping soils moist and retaining water throughout the rainy season, including through potential dry spells is the objective for water management. Practices to achieve this include, among others, bunding of fields to store rainwater within the plot, organic matter application and surface mulching to store and maintain soil moisture, create wells/ponds etc for assuring additional irrigation if necessary.

This principle is highly location specific and adaptation practices can vary greatly from one location to another.

### ***SRI practices***

SRI was originally developed for irrigated rice, and much of the adoption to date has taken place in Asia, where irrigated rice systems tend to dominate. A wealth of good practices have

developed and proven efficient for using SRI with irrigated rice production. The six most widespread and most often cited practices are:

1. Transplant early, at the 2-leaf stage (about 8-12 days after germination)
2. Plant only one seedling per hill
3. Adopt wide spacing (25cm x 25cm, or more), in a square grid
4. Fertilize with organic matter, and add chemical fertilizer only as needed
5. Apply alternate wetting and drying irrigation during the vegetative growth phase; and
6. Use a mechanical weeder

There are a number of other practices that have become established in many locations where SRI is implemented— for instance in regards to soil preparation or nursery management - that further reinforce the four SRI principles and contribute to improved and healthier plant phenotypes. We will discuss and summarize some of the main practices in Part II and III of this manual.

For rainfed rice—whether upland or lowland—and for other systems, such a mangrove rice systems, some of the SRI practices will change quite a bit, while other practices can still be implemented as they are with irrigated SRI. The planting patterns are easier to implement for instance (first three practices mentioned above) compared to the more environmentally dependent practices as water, nutrient and weed management.

Through this project, our goal is to develop best practices for each of the rice cropping systems across West Africa, and you will play an important role in making this happen!

Conditions across West Africa are not always ideal, and might not lend themselves to implement the four principles perfectly. But with an understanding of the SRI principles and synergies created by the SRI methodology, crop management can be modified striving towards more optimal conditions. By identifying constraints we can assist farmers in developing innovations and adaptations to overcome these. If this work results in a more productive and sustainable agricultural system and improves farmers' lives, our main goal working with the SRI methodology is achieved.

Agronomy is never a finished job, and is always evolving, especially at the system's level. There is not one SRI, and SRI is not fixed, but is an agro-ecological approach that helps create a healthier and better environment for plants to thrive in and produce.

### 3.2 Steps for implementing the SRI methodology

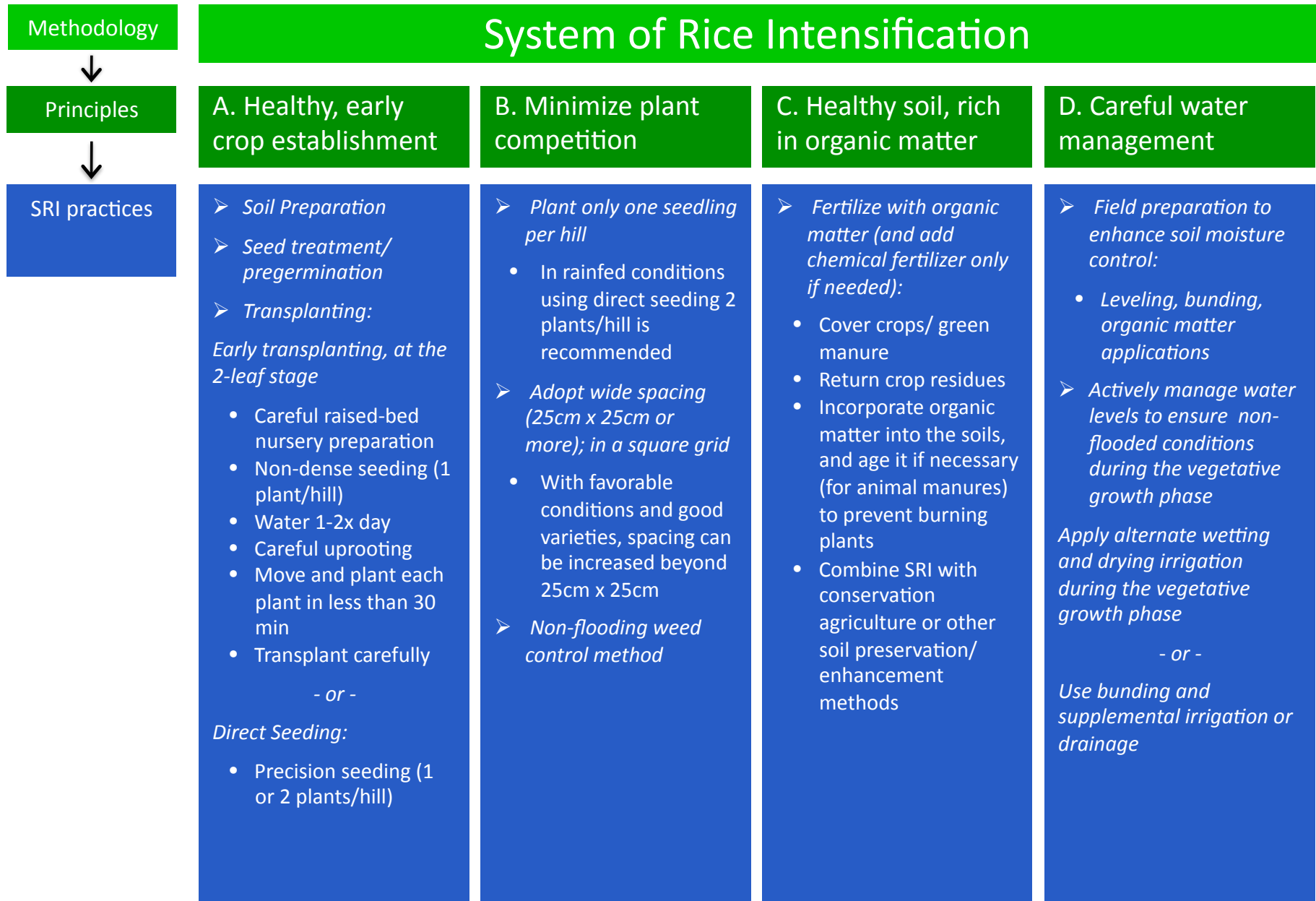
Changing over from the current rice production practices to adopting the SRI methodology is not a straightforward process. We propose hereby a number of steps that can assist in making this transition successful. Being systematic and staying creative are our two main recommendations when working through this process!

1. Understand the concept and principles of SRI  
Identify the main elements and practices that people have implemented successfully elsewhere. Understand the key drivers behind the improved performance of SRI plants.
2. Analyze the current rice production system  
Carry out a thorough, step-by-step analysis throughout the crop growing season, and detail the various current practices
3. Compare your current rice production system to SRI recommendations  
Conduct a step-by-step comparison of how the practices in your specific rice system

would need to be changed and adapted in order to follow the SRI principles, and by using SRI best practices developed by others

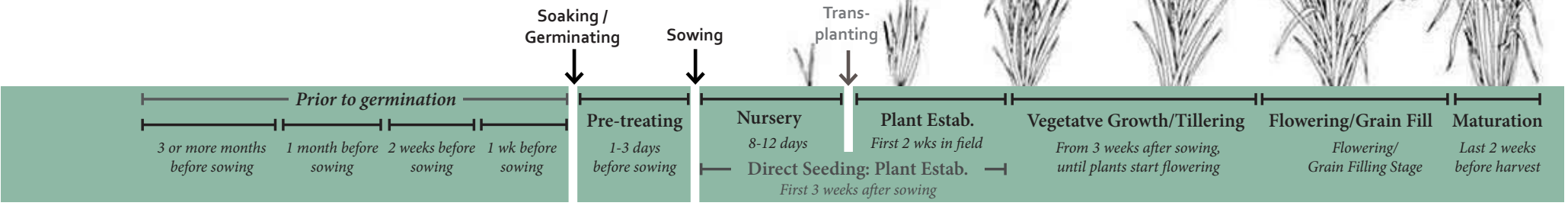
4. Come up with a plan of changed practices  
Identify constraints and propose how to address them
5. Follow an iterative approach  
Repetition is important for testing the new set of practices you adopt, evaluating them, and then either recommending them for further testing and adoption and/or continue developing new innovations. Repeat this cycle, and document through data collection, photos, videos and other communications
6. Share your findings  
Whether something works or doesn't, share these results. Innovations can help other farmers throughout the region, and accelerate the SRI adoption process

# Conceptual Framework



# SRI Planning and Field Preparation Timeline:

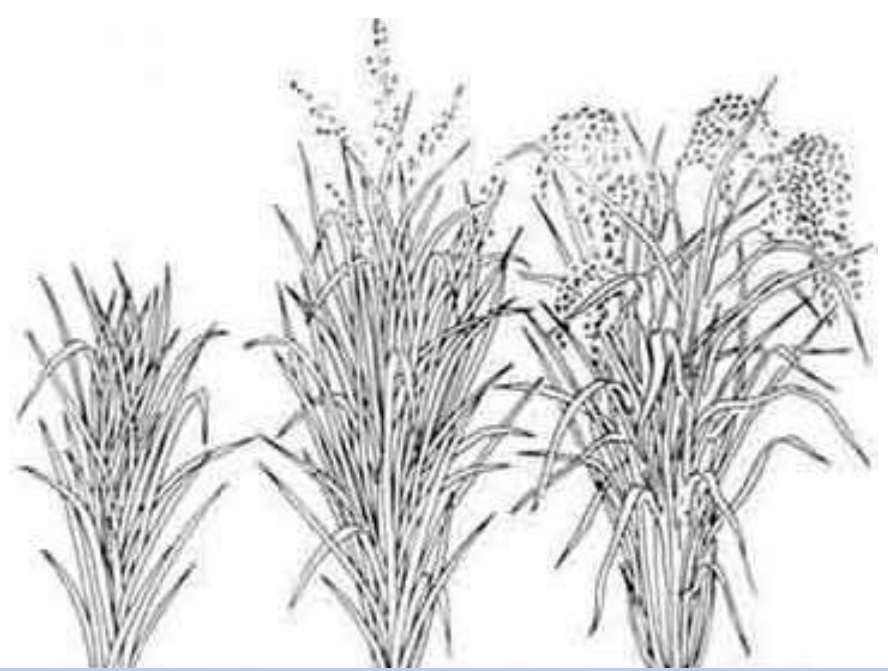
Use the calendar below as a guide to help you structure planning your SRI trial. Note: some activities aren't applicable to all situations.



<b>Planning</b>	Select site	Decide on plot size, variety, spacing, transplanting strategy, etc.							Plan harvest strategy and yield data to collect, train farmers/technicians
<b>Community Engagement</b>	Work with the community to identify and train farmers		Invite area farmers and local officials to view the plots, and participate in transplanting, watering, weeding, etc.					Harvest festival	
<b>Field &amp; Nursery Preparation</b>	Source/age compost or manure	Prepare the field - depending on the local agroecosystem, this could include leveling, bunding, and paddy/mudding							
	Incorporate manure/compost into field	Prepare nursery bed	Flood and weed the field	Prep seeds					
<b>Equipment &amp; Materials</b>	Source/build mechanical weeders (optional)								
	Source or build a spacing marker (for direct seeding or transplanting)								
	Source seeds								

# SRI Crop Management Timeline: *Irrigated Rice*

Use the calendar below as a guide to help determine when to fertilize, water and weed for irrigated rice fields. *For field and soil preparations see the Planning and Field Preparation Timeline.*



Soaking /  
Germinating

Sowing

Trans-  
planting

**Pre-Soaking Stage**  
1-3 days before sowing

**Nursery Stage**  
First 8-12 days after sowing (2 leaf stage)

**Plant Establishment**  
First 2 weeks after transplanting

**Vegetative Growth/  
Tillering Stage**  
From 2 weeks after transplanting, until plants start flowering

**Flowering/  
Grain Filling Stage**  
Flowering/  
Grain Filling Stage

**Maturation Stage**  
Last 2 weeks before harvest

## Fertilization

Apply aged compost at least 2-3 weeks before planting

Apply more compost or N-fertilizers at tillering stage, after weeding— about 24-30 days after planting

2<sup>nd</sup> N-fertilizer at internode elongation/panicle initiation, about 60 days before harvest

## Watering

Water 1-2 times per day

Keep soil moist

Keep soil aerobic & moist, using alternate wetting and drying (AWD) (Allow 7-10 days between waterings for the soil to dry)

Keep soil moist for maximum grain fill

Leave field dry

## Weeding

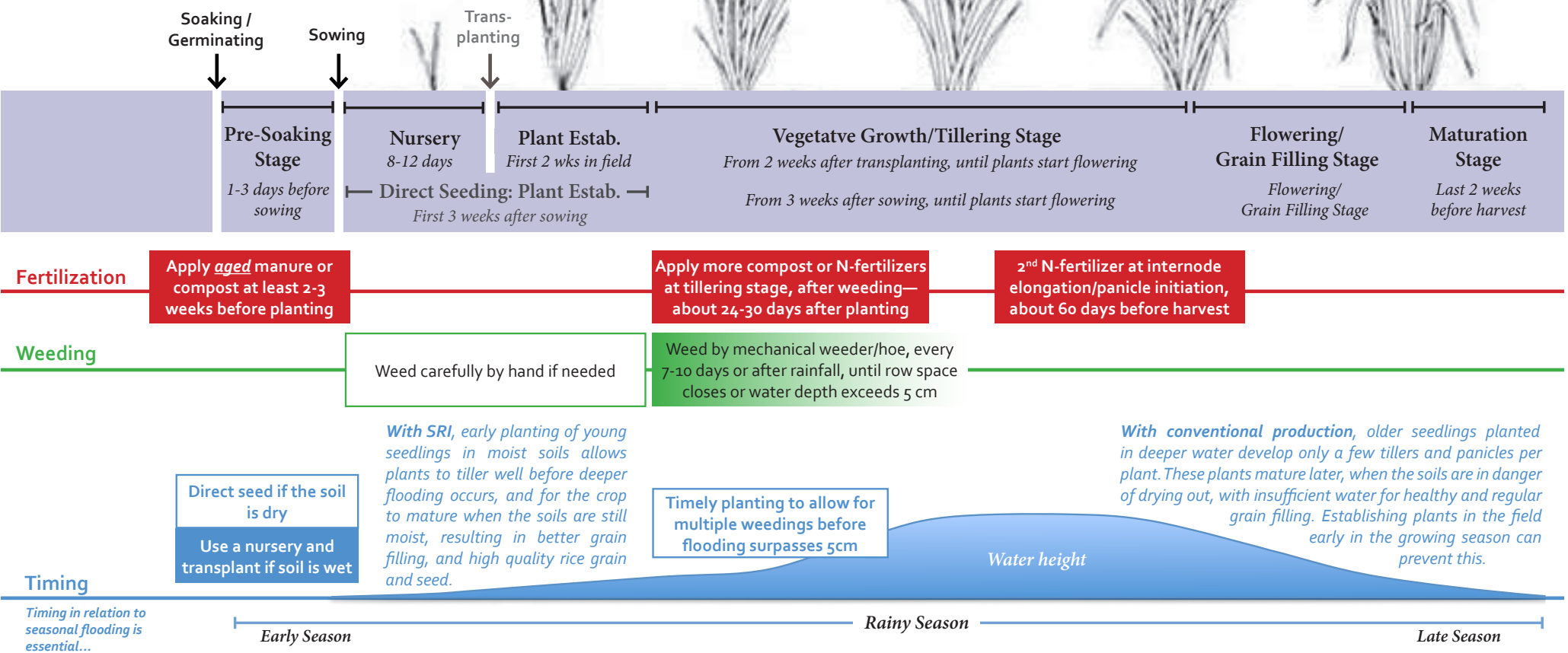
Weed carefully by hand if needed

Weed by mechanical weeder or hoe, every 7-10 days or after each rainfall, until row space closes



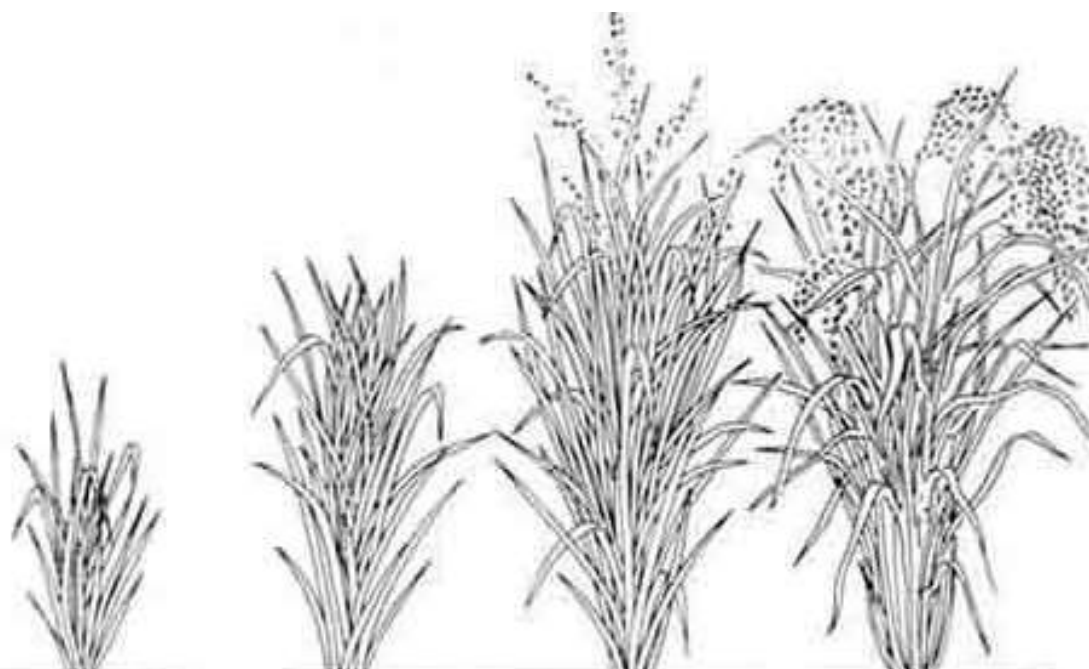
# SRI Crop Management Timeline: Rainfed Lowland Rice

Use the calendar below as a guide to help determine when to fertilize, water and weed for rainfed lowland rice fields. For field and soil preparations see the Planning and Field Preparation Timeline.



# SRI Crop Management Timeline: Upland Rainfed Rice

Use the calendar below as a guide to help you determine when to fertilize, water and weed for rainfed upland rice fields. Water management is most difficult for rainfed upland, but leveling, bunding, mulching, organic matter applications, supplemental irrigation and drainage can be used to achieve good soil conditions. For field and soil preparations see the Planning and Field Preparation Timeline.



Soaking /  
Germinating

Sowing

Pre-Soaking  
Stage

1-3 days before  
sowing

Plant Establishment  
Stage

First 3 weeks after sowing

Vegetative Growth/  
Tillering Stage

From 3 weeks after sowing,  
until plants start flowering

Flowering/  
Grain Filling Stage

Flowering/  
Grain Filling Stage

Maturation  
Stage

Last 2 weeks  
before harvest

Fertilization

Apply aged  
compost at least 2-3  
weeks before planting

Apply more compost or N-fertilizers  
at tillering stage, after weeding—  
about 24-30 days after planting

2<sup>nd</sup> N-fertilizer at internode  
elongation/panicle initiation,  
about 60 days before harvest

Watering

Keep the soil moist  
(bunding, mulching, supplemental  
irrigation, drainage, etc.)

Keep soil aerobic and/or moist  
Manage the soil for a good moisture/oxygen balance  
(bunding, mulching, supplemental irrigation, drainage, etc.)

Keep soils moist  
(bunding, mulching,  
supplemental irrigation, etc.)

Leave field  
dry

Weeding

Weed carefully by hand if needed

Weed by mechanical weeder or hoe,  
every 7-10 days or after each rainfall,  
until row space closes

# Part 2. Planning for an SRI Trial

*Part 2 will help you get started planning an SRI comparison trial, and give you perspective on how to introduce and scale up SRI in an area.*

## Section 1. From Introduction to Scaling Up of SRI

*When introducing SRI to a region, develop an implementation plan that includes scaling-up*

### 1.1 Introductory Phase

When introducing SRI to a new region or village, it's recommended to set up a comparison trial that shows the SRI system alongside the traditional or conventional system, which follows the methodology that farmers in the area already use. This allows farmers to easily compare the two systems side-by-side at any given moment throughout the cropping season.

Comparison trials are usually done for 1-2 seasons, until farmers are able to develop a good technical understanding of the SRI system. Once farmers are confident with using the new methodology and are ready to start expanding their area under SRI, the comparison trials won't be necessary anymore.

#### ***Adaptation Phase: Transition Phase from smaller to larger SRI plots***

Once farmers are ready to expand the area under SRI, they are encouraged to freely make their own decisions on how to proceed with their SRI plots. This marks an important transition period, where farmers often plant some parts of their field under SRI, and some parts under the conventional system, and changing fully to the SRI system might take a few years as farmers become more comfortable and confident with their SRI experiences. Technical assistance is very important during this transition, as it will help ensure sustainability, and assure that most technical questions and issues can be addressed in a way that successfully enables farmers to fully adopt SRI.

During this transition period, the focus will primarily be on:

- Fine-tuning and adapting SRI practices to local conditions while continuing to implement the four principles of SRI (as described in Part 1)
- Trying to find solutions to certain bottlenecks that prevent farmers from adopting SRI
- Working with the farming community to resolve organizational issues, such as changes in irrigation management, soil preparation, labor organization for transplanting, etc.

#### ***Continuous experimentation***

The transition phase is a period of adaptation. The technicians should encourage farmers to further experiment in order to see what works best under their conditions. A few rows or a small subplot in the larger rice field can be used, for instance, to test the number of applications (once, twice, three times) of the mechanical weeder and its impact on weed growth and yield. Or a small experiment can be undertaken testing different plant spacing for the different varieties farmers work with. It is important to instill a culture or a habit of experimentation by the farmers. Monitoring and reporting the results from these farmer-led trials is important to maximize the learning on SRI in the area. Ideally, farmers are meeting and discussing their trials, observations

and identify what works well for them and their environment. The technician should take note, and integrate the findings into their technical recommendations and manuals.

In summary:

- When introducing SRI to a new area, start with side-by-side comparison trials;
- Once farmers master the practices, comparison trials are not necessary anymore, and their attention can turn to better adapting SRI to their local conditions;
- Farmers should be encouraged to experiment and undertake trials in small subplots of their fields, in order to develop SRI practices that work well, are sustainable and provide optimal benefits.
- Data collection, however, should still be undertaken for the SRI fields and the non-SRI fields in order to monitor the strengths and weaknesses of the new system, new ideas and modified practices, and provide further technical advice if opportunities arise.

*To be successful with introducing SRI to a new location, the following section details how to setup a comparison trial.*

## Section 2. Planning a Comparison Trial

*Comparison trials that include the community are important for allowing farmers to form their own opinions of SRI, and should be planned well, in advance.*

### 2.1 Timing

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Begin planning the comparison trial at least a few months before planting in order to:

- Discuss the SRI trial with the village community and farmers at least a few times, well before the season, always giving farmers enough time for their decision-making process. If possible it can help to visit with the farming community several times, on a weekly basis, in order to gain community buy-in and support.
- Find a source of organic matter (manure, green manure, compost, crop residue, etc.). For a first trial, this might be organized in a more improvised manner, but on a longer-term basis one should think about the sustainability of organic matter applications, and identify opportunities for producing organic matter within the farming system.
- Age manure or compost if necessary to avoid burning the plants.
- Decide on a suitable location (see below on the criteria).
- Determine what variety to use and secure seeds if necessary (see below).
- Ensure that water will be available and reliable throughout the season.
- Interact with and fully train farmers who will be participating; make sure they understand the SRI principles and synergies created under SRI, which is more than just knowing what the recommended practices are.
- Publicize your trial with local officials, media and farmers, and make public events out of important parts of the trial process (beginning, transplanting, weeding, harvesting, etc)

*See the charts following this section for timelines that will help with planning and managing SRI trials.*

### 2.2 Site Location

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A number of criteria should be respected to find an optimal location for your SRI trial:

### *Accessibility*

- The site should be easily accessible throughout the entire cropping season
- Make sure access roads/paths will not be flooded during the rainy season, etc.

### *Visibility*

- Place the trial in an area where people pass by daily or very often. This can be close to the village, adjacent to a road, or on the way to the fields. The more visible the trials are the more closely farmers can observe how the crop is developing—ideally on a daily basis—and the more conversation and interest they will generate

### *Resources*

- Make sure that resources—such as irrigation water, organic matter and labor—are available when needed
- For irrigated rice the watering cycle will change from the conventional irrigation patterns. Depending on how water is distributed in the irrigation scheme that could cause difficulties. If SRI plots are next to the main irrigation channel, water can be accessed at any time.

### *Representativeness*

- The trial site should be representative of the general farmer conditions in the area; if the trial is under completely different conditions, farmers will not believe that they are capable of achieving the same results

## 2.3 Plot Size

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Start small, and as confidence and experience increase, try larger plots. Too much change at once can be overwhelming, and can cause farmers to have a negative experience, and not want to do SRI in the future. If they have a positive experience, even if it's small, they'll be enthusiastic about trying it again next year, and will convince other farmers to do the same.

- Let farmers choose the size, but aim for 100 m<sup>2</sup> (10 m x 10m) or 200 m<sup>2</sup> (10 m x 20m)
  - Smaller than 100 m<sup>2</sup> isn't statistically valid
  - Larger than 200 m<sup>2</sup> can be a lot of work for a first trial
  - Increase in size as you increase in experience
- The SRI and control plots should ideally be the same size
- Measure with a tape measure, rope, or by counting out steps—just be consistent; a tape measure will be important for calculating yields at the end of the trial

## 2.4 Selecting and Working with Farmers

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The first season of trials will heavily influence how farmers in the region will view SRI; take the extra work to make a good first impression.

- Engage with the farming community as a whole, well ahead of the field trial, and discuss the trials with them. Ideally have the farming community select the farmers who participate in a trial; they'll have a stake in the trial as a community, and selected farmers will be representing the community in the trials
- Incorporate women and young farmers in trials to bring their perspectives in, and generate interest among these groups for conducting their own SRI trials
- If the selection process cannot go through the community, work with volunteer farmers who are interested and invested in innovations
- Create a real interest and buy-in from the farmers, ideally without needing to compensate them. This creates real participation, and a commitment on their part. They

will participate with their land, labor and inputs, you will participate by providing the technical knowledge, and a promise to show up during the important tasks and work together with the farmers. You will need to hold up your promise, so make sure you are reliable and present throughout the trial!

- Visit the fields on a regular basis. Farmers will have questions, and may be tempted to simply treat the SRI plots like their traditional plots. By maintaining a stable presence in the fields, farmers will be able to get questions answered, and you will be able to identify potential problems right away. Setup a regular time to visit the fields, such as the same day(s) every week, and make sure the farmers are prepared in advance for each new step.
- Work with farmers who are available to interact with technicians, and who will be present in the village during the entire cropping season
- Work with farmers who are well respected in the community and are ready to pass on new knowledge to other community members
- Ideally work with 3-5 farmers in one location or village. This encourages farmer-to-farmer exchange, and enables them to observe and learn from differences in crop management that typically occur among a group of farmers

## 2.5 Choosing Varieties

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Applying the SRI methods is not dependent on using a certain variety to increase yields, although some varieties respond better than others.

How should you choose the variety for your trials? Here are some tips:

- Encourage farmers to choose a variety they know well and use regularly
  - The purpose is to try a new methodology, not a new seed
  - Unfamiliar varieties may fail, hurting the trial and the perception of SRI
  - Farmers may be more likely to trust the outcome of the trials if they are already familiar with the variety that was used
- If several farmers from one village participate in the evaluation, a discussion among the farmers should be sought about which variety to use. Ideally, the choice should be representative of the varieties used in the village—this can be improved, local or traditional varieties, etc.
- Use the same variety and same seed source for both SRI and control plots—this allows for a full comparison between the planting treatments
- Once farmers are familiar with SRI and have done one or several seasons of trials, encourage them to experiment with other or new varieties to see which ones respond best to SRI under their conditions

## 2.6 Planning Ahead

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Many parts when applying the SRI methodology are time sensitive, so make sure you are prepared for each step ahead of time. Something as simple as weeding late can dramatically hurt a trial and give farmers a negative impression of SRI that can be difficult to change later on.

- Transplanting must be done at the two-leaf stage—generally 8-12 days after germination. Assure that materials (markers, ropes etc), people and supplies are ready in advance, that a good plan is set up and that everyone understands their role
- Make sure that weeding tools will be available when needed. Weeders don't work well once weeds have become too tall, so don't miss opportunities to weed early!



- Make sure farmers and/or trained labor will be available during the entire growing season, and not leave for seasonal migration or other reasons

## 2.7 Collecting, Recording and Sharing Data

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Data is important to SRI for three reasons:

1. Adaptation - To adapt SRI to local conditions it is important to monitor what changes in practices worked well and what didn't work well. Without data from the step-by-step adaptation process extended over several seasons, it's impossible to know which of practices and factors contribute to changes in plant growth and yield
2. Experiences are best shared - West Africa has a broad diversity of rice production systems. Often several rice systems in different agro-ecological zones can be found in one country, thus comparison of a specific system might make more sense across countries within the same agro-ecological zone. Sharing successes, failures, challenges—and photos—of what happened will help others learn from our experiences, and in turn help each of us learn from the experiences of others
3. Replicability - Whether a trial works well or poorly, knowing exactly what was done will help repeat successes or avoid mistakes the following year.

How to go about data collection:

- Keep track of every detail in a journal; write down your observations after each field visit
- Use the data collection sheets in the M&E Manual (these are available from your SRI National Facilitator or from [sriwestafrica.org/documents](http://sriwestafrica.org/documents)) to plan, record and share data:
  - Farmer backgrounds
  - Rice farming practices for SRI and conventional plots
  - Labor costs
  - Input costs

The data you collect will help you:

- Calculate the profitability of SRI plots compared to conventional plots
- Calculate the change in yield attributable to SRI
- Assess the effect of SRI on plant growth and shape (morphology)
- Develop new ideas for adapting SRI practices in future tests and trials
- Keep track of SRI adoption and adaptation across farmers in different villages or regions

# Part 3. SRI Implementation Guide

*This part will walk you through the technical steps of conducting an SRI trial and harvesting your plots in a scientifically appropriate manner. A comprehensive list of resources is presented in Section 11 at the end of this part.*

## Section 1. Field Preparation

*Proper field preparation helps unlock the potential of SRI, so allow plenty of time for this step. In this section we will discuss organic matter application and soil preparation. More information on fertilization can be found in Section 8, below.*

*Manuals and guides for producing compost and working with manure are listed in the resources found in Section 11, below.*

### 1.1 Organic Matter Application

Improving soils through additions of organic matter (OM) is one of the four principles of SRI, and represents the basis for SRI fertilization, in addition to providing other important benefits, such as: increased soil water retention, enhanced soil microbial life, and improved soil structure. Depending on the specific rice system, objectives and circumstances, organic matter fertilization can be complemented with chemical fertilizer if appropriate and needed.

Organic matter is ideally added before the field is prepared and plowed, in order to incorporate the OM into the soil, though if the OM is well decomposed it can be applied during soil preparation. If working with poorly decomposed OM it should either be composted (see below) or be plowed under a few months before planting—for instance, by incorporating the fallow vegetation or crop residues left over from the previous harvest. In areas with a long dry season, plowing under rice straw or other residues right after harvest is an efficient strategy for maintaining the biomass produced on location, which is often otherwise removed from the field or burned. Even in a dryer climate, if the rice straw is incorporated into the soil after harvest, residual soil moisture will allow it to decompose slowly until the next rice crop is planted. If OM is applied just before the cropping season, a light incorporation is recommended through superficial plowing or harrowing.

In production systems that apply minimum or zero-tillage, OM can also be applied to the surface in the form of mulch. Keeping OM on the soil surface has many soil conservation advantages, and if you are able to apply these practices with SRI they can greatly enhance the sustainability of the cropping system. For more on minimum-tillage strategies and Conservation Agriculture (CA), see Box 1 further on in this section.

#### ***Types of organic matter***

There are many options for choosing an organic matter source; the type of organic matter used will depend on local availability of compost, plant biomass or manure; agricultural practices; and the location, climate and soil type. Semiarid/agropastoral regions like the Sahel may have poor access to plant biomass, but better access to animal manure. More humid regions may have better access to compost, plant biomass or green manure, but less access to animal manure. Common types of organic matter include:

- Compost: all available biomass (plant matter, food scraps, and animal waste) can be converted into compost instead of being burned or wasted. Even in dry areas,

substantial biomass is produced during the short rainy season within the farming system. Harvesting this biomass and producing compost on location immediately next to the rice field is a good way to store nutrients that can be used for the next rice crop.

- **Animal manure:** Good manure comes from chicken and cows, but goat and sheep manure can be used as well. It is important to compost animal manure, otherwise it can burn the plants. Not all manures are the same:
  - Chicken/poultry manure is high in nitrogen and phosphorous, and therefore more likely to burn plants than other manures, and should not be applied directly to plants
  - Cow manure is lower in nitrogen—thus less likely to burn plants—is a good source of OM, and has few weed seeds
  - Sheep/goat manure is higher in nitrogen than cow manure, doesn't burn plants very easily, is easy to handle and has a low water content, making it lighter to transport. It decomposes more slowly than other manures.
- **Green manure:** Green-leaf manure trees such as *Gliricidia* sp., or other leguminous shrubs can be grown along field bunds and foliage can be cut and directly incorporated into the soil during soil preparation. In the Sahel, *Faidherbia albida* can work well as an overstory tree in upland rice areas, or alongside seasonal ponds and lowland areas, but grows slowly. Many other green manure species are used throughout West Africa.
- **Cover crops:** Cover crops grown in-situ can serve as an improved fallow between two rice cropping seasons. If perennial shrubs are used, the fallow period can be extended to 2-3 years if desired. Good candidates are annual legumes such as *Mucuna* sp., and Cowpea (*Vigna unguiculata*), which can be grown before or after the rice crop. Shrubby legumes, such as Pigeon Pea (*Cajanus cajan*), *Gliricidia sepium*, *Sesbania* sp., and *Crotalaria* sp., can be used for short term (0.5 to 1.5 years) or medium term fallows (2-3 years). The selection of the species depends on time available to grow the cover crop, adaptation of the species to soil and climate conditions, and seed availability. Cover crops can also be *intercropped*—planted together with rice; or *relay-cropped*—planted before the rice harvest. Inter-cropping and relay cropping are not very common with rice, but it should not stop you from experimenting with it. These systems can be very efficient in nutrient recycling and fertilization. When water is managed more carefully and soil conditions are kept aerobic it is easier to associate cover crops directly with rice; with conventional flooded rice production methods cover crops cannot be directly associated with rice.
- **Incorporation of crop residues:** Rice straw, bran, husk, stubble, or residues from another crop can be incorporated into the soil instead of being burning or otherwise removed. These can easily provide 20-25 kg/ha of nitrogen, improve soil organic matter and improve the physical, chemical and biological conditions of the soil. This solution is appropriate in all conditions, especially in locations where access to organic matter is difficult.
- Any combination of the above methods can work as well.

### **Composting animal manure**

- Animal manure must be composted or allowed to age before planting
  - Fresh manure, particularly from chickens/birds, can burn the rice plants and hurt plant performance
  - Composting helps to kill weed seeds and destroy pathogens

- Manure can be composted in a pile next to the animal enclosure or, ideally, can be mixed with other plant biomass or rice straw immediately next to the rice field, creating more balanced compost

### **Application rates**

- Many rice-cropping systems are normally *not* fertilized with organic matter, and the soils often show signs of depletion. It is important to discuss the natural fertility status of rice soils with farmers ahead of the trial
- How much organic matter to add depends on the fertility of the soil, which type of organic matter is available, and farmer preferences
- A general range is to apply 2-10 tons of organic matter per hectare. If the soils are fairly depleted, a larger dose is recommended; if soils are fertile a lower dose can suffice
- If a larger dose is applied, it might not be necessary to reapply every year. A longer-term strategy of fertilization with OM should be discussed with the farmers—for instance: applying smaller rates every year, or larger rates every two or three years
- Applying too much nitrogen-rich OM (for instance from manure) can cause the rice plants to lodge (fall over), hurting yields
- Traditional varieties respond well to organic fertilization and often remain dark green throughout the season until harvest solely from OM applications, whereas improved varieties might need some additional chemical fertilizer applications, most often for nitrogen in the form of urea

**Organic matter application rates per field size**

Field size	2 t/ha rate	5 t/ha rate	10 t/ha rate
100 m <sup>2</sup>	20kg	50kg	100kg
200 m <sup>2</sup>	40kg	100kg	200kg
250 m <sup>2</sup>	50kg	125kg	250kg
500 m <sup>2</sup>	100kg	250kg	500kg
0.1 ha (1,000 m <sup>2</sup> )	200kg	500kg	1t
0.125 ha	250kg	625kg	1.25t
0.165 ha	330kg	825kg	1.65t
0.25 ha	500kg	1.25t	2.5t
0.33 ha	660kg	1.66t	3.33t
0.5 ha	1t	2.5t	5t
1 ha	2t	5t	10t
1 acre	.8t	2t	4t

*1ha = 100m x 100m = 10,000m<sup>2</sup>; 1 acre = 209ft x 209ft = 43,560ft<sup>2</sup>;  
1 acre = 0.4 hectares; 1 hectare = 2.47 acres*

### **Experimenting with multiple organic matter application rates**

If it is possible to include a further degree of experimentation with the SRI trial, a trial can be planned that includes a few different levels of organic matter:

1. No organic matter added
2. Light organic matter added
3. Moderate or heavy organic matter added

Another trial could look at the application of different types of OM. Trials such as these can be very useful in:

- Determining the extent OM affects SRI
- Identifying ideal application rates under local conditions
- Identifying ideal combinations of different OM types

When doing this you will need to consider two points:

1. Use the same treatments for SRI plots and control plots—for this you will need to divide your trial into six separate plots: 3 different OM treatments using SRI, and the same three OM treatments using conventional rice production
2. Separate the three sub-treatments with a well constructed earthen bund, to avoid OM migrating from one sub-plot to another

### ***Proper application of organic matter***

Good field leveling and bunding can help keep OM in the field. Incorporating OM into the soil can keep it protected from desiccation by the sun/wind, and will maximize its positive effects on the soil.

When working with OM, particularly sources like fresh manure that are very high in nitrogen and phosphorous, proper handling is important to prevent environmental damage to nearby streams, rivers and lakes. If not well incorporated into the soil, heavy rains can wash these nutrients into nearby water sources, causing eutrophication. When composting make sure that nutrients don't wash off into water sources as well. Create small pits to catch any runoff, and cover the compost piles with banana leaves for protection.

## **1.2 Soil Preparation**

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### ***Plowing and puddling***

Soil preparation practices can vary greatly depending on local customs, soils, crop rotation, availability of tools, and the degree of mechanization in an area. It is fine to follow the common soil preparation practices when applying the SRI methodology, although as outlined further below, soil conservation practices that steer away from heavy soil preparation will result in better soil structure and health, and optimize the impacts of SRI.

Conventional preparation of irrigated rice soils involves heavy soil disturbance. It includes plowing when soil conditions are dry or wet (adding water to the field before or after plowing), breaking up large soil clumps, puddling, and then leveling the field before transplanting. This can take anywhere from a few days to a few weeks. Over time, these practices can degrade soils, resulting in soils that are harder, less workable, and lower in microbial life and organic matter. In many areas farmers are already encountering these problems, and often turn to larger machinery to prepare their soil, making the problem worse. In severe cases the soil is abandoned and farmers find new fields. For farmers that are facing this sort of problem, there are alternative methods that can help, such as Conservation Agriculture, which are compatible with SRI.

### ***Integrating Conservation Agriculture and SRI***

*Conservation Agriculture (CA)*—which is based on minimum soil disturbance, crop rotation, and improving soils with organic matter through surface mulching—is an ecological approach to soil management that reverses the problems associated with traditional soil preparation (see Box 1,

below). CA is quickly becoming common practice in large parts of Southern Africa, and is actively being adopted in parts of Central, East and West Africa as well.

- CA and SRI both focus on improving soil health (physically, chemically and biologically), and the methodologies are compatible with each other.
- Both systems strive for aerobic soil conditions, enhancing soil health, retention of soil organic matter and reversing soil degradation.
- Heavy soil preparation interventions, including soil puddling, might not be necessary in an SRI plot, and even works against the third and fourth principles of SRI—creating healthy, fertile and aerated soils. Puddling removes air channels in the soil, whereas under SRI improved air circulation within the soil is desirable. Changing soil preparation methods is no easy task and is a gradual process that might take a number of years. The pros and cons of puddling should be discussed in detail with farmers, and ideally some technical steps should be tested in association with your SRI trials that steer away from heavy soil preparation.
- Depending on farmers' preferences and needs, CA and SRI can either be introduced simultaneously, or if this is too much new information for farmers, we recommend to focus first on introducing the SRI methodology while maintaining the common soil preparation practices. Discussion on CA practices can be started and integrated step-by-step as farmers become more familiar with SRI.
- Rainfed upland and lowland systems lend themselves well to Conservation Agriculture, especially minimizing soil disturbance and mulching the soil surface with organic matter.

### Box 1. What is Conservation Agriculture?

*Adapted from <http://conservationagriculture.mannlib.cornell.edu/> and [www.fao.org/ag/ca](http://www.fao.org/ag/ca)*

Conservation Agriculture (CA) is a set of agroecological soil management practices that minimize the disruption of the soil's structure, composition and natural biodiversity. Despite high variability in the types of crops grown and specific management regimes, all forms of conservation agriculture share three core principles:

1. Permanent organic soil cover
2. Minimum mechanical soil disturbance through tillage
3. Regular crop rotations and/or diversification of crop associations

CA also uses or promotes additional management practices:

- Utilization of green manures/cover crops to produce an organic residue cover
- Not burning crop residues
- Integrated disease and pest management

*For more information on CA, see the resources in Section 11.*

When designing a comparison trial for SRI and a conventional field, there are two options for doing so:

1. Prepare the soils the same way in both treatments
2. Prepare the soils in the conventional manner for the control plot, and change the soil preparation methods for the SRI plot(s) by applying some CA practices, such as minimum soil disturbance. If this option is chosen, the SRI plot should ideally be split in two, following the same practices as under the control plot in the first SRI sub-plot and applying the CA practices in the second SRI sub-plot



### **Field leveling**

Whether using conventional soil preparation or Conservation Agriculture, carefully leveling the plot or field is very important when using SRI, especially under irrigated conditions. Depending on the current practices, this may or may not present a challenge for the farmers.

- All soil preparation interventions (plowing, harrowing, etc.) should automatically strive for good field leveling.
- Leveling can be done with a leveling board attached to a tractor, a hand tractor, or to a pair of oxen; or with a wooden board that is pushed or pulled across the paddy by people.
- In areas with slopes, plots may need to be divided into separately leveled sub-plots. Each sub-plot should be surrounded with earthen bunds to help prevent surface runoff and erosion.

Well-leveled fields have a series of advantages; for **irrigated rice** these include:

- Water distribution is more even across the field
- Less water is needed to irrigate the field (!)
- Small seedlings require a well-leveled field, so as to not drown or remain dry during irrigation or heavy rainfall
- Less potential for seeds to get moved (when direct seeded) due to channeling or surface water flow
- Crop stands develop more evenly, increasing yields and making harvest easier
- If fertilizer is applied, distribution across the field is more even
- If fields are uneven, surface-applied fertilizers tend to accumulate in lower lying areas of the field, and plant development becomes uneven, favoring plants in lower lying areas

Well-leveled fields also have advantages for **rainfed systems**, with similar benefits as mentioned under irrigated systems. Under rainfed conditions, a big challenge can be water management, with either too much or too little water available during the cropping season.

### **Earthen bunds**

Earthen bunds can play an important role for regulating water, maintaining soil fertility, and for land leveling purposes in both irrigated and rainfed systems.

- Bunds can help to keep water in or out of a plot, thus allow for irrigation or drainage of a plot, especially under rainfed conditions.
- Bunding also protects organic matter or fertilizer from being washed out of a plot, allowing for nutrients to be maintained on location.
- Water erosion can be reduced through bunding, helping to slow down water flow or direct water in a controlled manner across a larger area.
- In areas with slopes, bunding of fields help to create and maintain leveled subplots, without having to undertake large-scale field leveling, which is costly and not advisable, as large amounts of topsoil need to be moved.

## Section 2. Crop Establishment

*The first principle of SRI refers to early and healthy plant establishment. Many practices work together to achieve this principle, including soil preparation, seed selection, seed preparation, nursery preparation and management, and transplanting or direct seeding.*

*Soil preparation was discussed in Section 1, above.*

### 2.1 Nurseries or Direct Seeding

In irrigated systems, transplanting seedlings from a nursery is the norm; it helps farmers better ensure healthy plant establishment and achieve greater precision in spacing. However, in certain farming systems transplanting isn't possible or is uneconomical.

In some rainfed upland and lowland systems where rainfall is irregular, or is unreliable early in the season, direct seeding may be more appropriate. In these circumstances, nurseries may need to be restarted multiple times—a time consuming and frustrating experience. Direct seeding, on the other hand, can save time, labor and seed that might otherwise be lost. More recently some farmers have begun evaluating direct seeding for irrigated rice systems as well, especially as a means to save on labor for transplanting. If you are not sure what works best, undertake a trial comparing both. Depending on rainfall and climate, trials might need to be repeated more than once to obtain reliable conclusions. It is important to discuss the options with the farmers, and farmers can also start with whatever they are more familiar with (direct seeding or transplanting) for their first season trying SRI, and experiment with a comparison trial to evaluate the other crop establishment strategy the following season.

Recommendations for direct seeding are presented below in Section 3; recommendations for nursery establishment are presented in Section 4.

### 2.2 Calculating How Much Seed to Use

Regardless of what crop establishment method is chosen, SRI uses much less seed than with conventional production. For example, under irrigated systems in Mali, farmers only use 6 kg/ha of seeds for SRI, while conventionally they use 40-60 kg/ha—an 85-90% reduction in seeds.

#### **Seed usage for nurseries**

The table below shows how much seed to use for a given trial area when using a nursery and transplanting. The amount of seed recommended here is a bit higher than what is most likely needed, and will allow for some buffer. Use the column on the far right, 'SRI + reserve', to ensure plenty of extra seeds and seedlings for a first trial. Farmers will be tempted to use more seed than this, but it will not be necessary!

**Calculating Seed Requirements for a Nursery**

Field size	Nursery size	Nursery dimensions	SRI (8.5 kg/ha)	SRI + reserve (10 kg/ha)
100m <sup>2</sup> (.01ha)	1m <sup>2</sup>	1m x 1m	85g	100g
200m <sup>2</sup> (.02ha)	2m <sup>2</sup>	1m x 2m	170g	200g
250m <sup>2</sup> (.025ha)	2.5m <sup>2</sup>	1m x 2.5m	215g	250g
500m <sup>2</sup> (.05ha)	5m <sup>2</sup>	1m x 5m	425g	500g
0.1ha (1,000m <sup>2</sup> )	10m <sup>2</sup>	1m x 10m	.85kg	1kg
0.125ha (1,250m <sup>2</sup> )	12.5m <sup>2</sup>	1m x 12.5m	1.05kg	1.25kg
0.165ha (1,650m <sup>2</sup> )	16.5m <sup>2</sup>	1m x 16.5m	1.4kg	1.65kg

0.25ha (2,500m <sup>2</sup> )	25m <sup>2</sup>	1m x 25m	2.15kg	2.5kg
0.33ha (3,330m <sup>2</sup> )	33m <sup>2</sup>	1 m x 33m	2.85kg	3.3kg
0.5ha (5,000m <sup>2</sup> )	50m <sup>2</sup>	1 m x 50m	4.25kg	5kg
1ha (10,000m <sup>2</sup> )	100m <sup>2</sup>	1 m x 100m	8.5kg	10kg
1 acre	400 sq. feet	4' x 100'	3.16kg	3.72kg

1ha = 100m x 100m = 10,000m<sup>2</sup>; 1 acre = 209ft x 209ft = 43,560ft<sup>2</sup>;  
1 acre = 0.4 hectares; 1 hectare = 2.47 acres

### Seed usage for direct seeding

When direct seeding your field, we recommend using twice as much seed as is used for an SRI nursery. As with the recommendations for nurseries, above, even a low seeding rate of 17 kg/ha will most likely leave plenty of buffer (i.e., extra seeds), however, for a first trial an additional buffer can be used, which is presented in the far right column. More information on direct seeding can be found in Section 3, below.

#### Calculating Seed Requirements for a Direct Seeding

Field size	SRI (17 kg/ha)	SRI + reserve (20 kg/ha)
100m <sup>2</sup> (.01ha)	170g	200g
200m <sup>2</sup> (.02ha)	340g	400g
250m <sup>2</sup> (.025ha)	430g	500g
500m <sup>2</sup> (.05ha)	850g	1kg
0.1ha (1,000m <sup>2</sup> )	1.7kg	2kg
0.125ha (1,250m <sup>2</sup> )	2.1kg	2.5kg
0.165ha (1,650m <sup>2</sup> )	2.8kg	2.3kg
0.25ha (2,500m <sup>2</sup> )	4.3kg	5kg
0.33ha (3,330m <sup>2</sup> )	5.7kg	6.6kg
0.5ha (5,000m <sup>2</sup> )	8.5kg	10kg
1ha (10,000m <sup>2</sup> )	17kg	20kg
1 acre	6.32kg	7.44kg

1ha = 100m x 100m = 10,000m<sup>2</sup>; 1 acre = 209ft x 209ft = 43,560ft<sup>2</sup>;  
1 acre = 0.4 hectares; 1 hectare = 2.47 acres

## 2.3 Seed Preparation

Because SRI uses so much less seed than conventional rice production, each seed is responsible for a much larger percentage of the yield, so it is important to use the best seed possible and give it the best treatment possible.

### Seed collection and selection

SRI incentivizes farmers to be selective about the seed they use. Because so much less seed is used, farmers can benefit from selecting the best and fullest panicles *immediately before harvest* and saving them for planting the following season. This guarantees mature, healthy seeds, and helps ensure a homogenous seed supply (regardless of the variety used), which is particularly important in case the previous seed was contaminated with other varieties. In Cambodia, SRI farmers add another step by discarding the top and bottom spikelets of each panicle, keeping only the fully matured seeds from the middle part of the panicle as seed for next year.

### **Seed sorting**

For eliminating non-viable seeds (which will not germinate), a simple method can be used:

- Seeds are placed in a container of water: the seeds that are not fully mature (partially or fully unfilled) will be lighter and will float to the surface, while fully mature seeds will be heavier, and sink to the bottom. Fresh water works fine for this, and separates out a majority of non-viable seeds. To obtain even more accuracy, however, a salt water brine can be used:
  - Find a bowl or pot large enough to hold all the seeds and extra water
  - Add your seeds and cover with a 10-20 cm of water
  - Add one uncooked egg
  - Stir in salt until the egg floats to the surface (it takes quite a lot of salt)
  - Remove the egg, stir vigorously, and discard any seeds that are floating
  - Thoroughly rinse seeds to clean off all the salt
  - Proceed to seed soaking in fresh water

### **Soaking or pre-germinating the seeds**

Most farmers seed their conventional nurseries without soaking first the seeds. Seed soaking will help to initiate the germination process and obtain a more regular germination of the seed, and is highly recommended for the SRI method.

After separating out the viable seeds:

- Soak seeds in clean warm water for 24 hours to start the germination process
- Drain the water and either:
  - Sow seeds directly into the nursery; or
  - Dry them in a shady place and use dry seeds for direct-seeding into the field;
- For colder climates: proceed to pre-germination of seeds, where seeds are kept in a burlap sack in a warm place for an additional 24-48 hours. Special care has to be given not to damage the small roots and shoots when handling pre-germinated seeds. This step is recommended for colder climates only (where germination can be slow), but is not necessary in a warm and hot climate (where germination is typically fast).

***KEEP IN MIND: once the seed gets in contact with water, whether through soaking or sowing in the ground, the germination process starts. Theoretically, the trials start at this point. If you like and can be precise, you soak the seeds for SRI the same day as you sow the nursery or the field in the control plot.***

## **Section 3. SRI Direct Seeding**

*While starting seeds in a nursery is ideal for SRI, for some farmers this is either impractical, or not a viable option. Fortunately, SRI works with direct seeding. If you are not sure what seed establishment strategy to use, see Section 2.1, above.*

To pursue direct seeding with SRI methods, here are our recommendations:

- Create grid lines with a marker, a roller, or using a marked rope, as described in more detail in the next section

- If doing a side-by-side comparison trial, start the trial by *soaking* the SRI seeds and *seeding* the conventional plot the same day, which will ensure that they germinate at the same time and that the trials will be synchronized.
- For the SRI plot, sow two seeds per hill:
  - For hills where both seeds germinate, farmers can leave two plants per hill, or thin the hills to one plant per hill:
    - Thinning to one plant per hill is time consuming, can damage the plant roots for the seedlings which are not uprooted, and can be culturally unfamiliar, it might be most practical and economical to leave two plants/hill.
    - Farmers should feel free to experiment with both methods, to thin or not to thin, to see which provides the best yields and makes the best use of their time, energy and resources
  - For hills where no seeds germinate, seedlings from hills where both seeds germinated can be transplanted. This should not be a problem when seed selection and seed soaking is done as explained in Section 2.3.
  - It is important to explain to workers the importance of only sowing two seeds per hill; work side-by-side at first to make sure they understand, and then to make sure they continue to follow this practice
- The more precise you are from the start (soil preparation, leveling, number of seeds sown), the easier it will be for any further crop management
- Experimentation can help fine tune your direct seeding approach using SRI, just remember to take notes about each step

Once the field is sown, it will be important to carefully attend to the plants for the first three weeks during establishment. See more in Section 6 (Sections 4 and 5 below cover nurseries and transplanting).

## Section 4. Nurseries

*Under most conditions, starting seeds in nurseries will give the best results for SRI.*

### 4.1 Nursery Timing

With SRI, plants don't spend a long time in the nursery, so it is recommended that farmers first finish their land preparation before sowing the nursery. This allows being in control of the timing for the nursery and transplanting. From experience, if nurseries are prepared before soil preparation is finished, two scenarios tend to occur: i) Soil preparation ends up being hasty/incomplete (not well leveled, too much water in the field, etc.) when farmers realize that the seedlings are ready for transplanting, or ii) Transplanting ends up being delayed beyond proper seedling age at the two-leaf stage. It is advisable to decide on the transplanting technique before the nursery is installed, so there is time to make, purchase or find the necessary tools needed for it (see Section 5).

## 4.2 Nursery Bed Preparation

### Site selection

- The site of the nursery should be as close to the field as possible, or even in a section of the field, as seedlings are ideally transplanted within 15-30 minutes after leaving the nursery to minimize transplanting shock
- Have a reliable source of water close by for frequent watering (1-2 times/day)
- Keep the nursery safe from predators (rats, birds, ants, etc.), and away from active ant colonies or debris piles that can harbor rats or mice. Wood ash can help protect against ants

### Nursery bed size

- SRI nurseries are 1% the size of the field
- Beds are ideally 1m wide. This width:
  - Allows easy access to the nursery bed from both sides
  - Prevents the need to step on the nursery bed
- The bed length depends on how large your nursery needs to be:
  - For larger nurseries, split into multiple beds, each 1m wide
  - E.g., a 10m<sup>2</sup> nursery can be 1m x 10m, or two beds each 1m x 5m
  - Always maintain the 1 m bed width, regardless of the length or number of beds
- Mark out the beds in a straight rectangle using twine and stakes

### Nursery bed size calculations

Field size	Nursery size	Nursery dimensions
100m <sup>2</sup> (.01ha)	1m <sup>2</sup>	1m x 1m
200m <sup>2</sup> (.02ha)	2m <sup>2</sup>	1m x 2m
250m <sup>2</sup> (.025ha)	2.5m <sup>2</sup>	1m x 2.5m
500m <sup>2</sup> (.05ha)	5m <sup>2</sup>	1m x 5m
0.1ha (1,000m <sup>2</sup> )	10m <sup>2</sup>	1m x 10m
0.125ha (1,250m <sup>2</sup> )	12.5m <sup>2</sup>	1m x 12.5m
0.165ha (1,650m <sup>2</sup> )	16.5m <sup>2</sup>	1m x 16.5m
0.25ha (2,500m <sup>2</sup> )	25m <sup>2</sup>	1m x 25m
0.33ha (3,330m <sup>2</sup> )	33m <sup>2</sup>	1 m x 33m
0.5ha (5,000m <sup>2</sup> )	50m <sup>2</sup>	1 m x 50m
1ha (10,000m <sup>2</sup> )	100m <sup>2</sup>	1 m x 100m
1 acre	400 sq. feet	4' x 100'

$1\text{ha} = 100\text{m} \times 100\text{m} = 10,000\text{m}^2$ ;  $1\text{ acre} = 209\text{ft} \times 209\text{ft} = 43,560\text{ft}^2$ ;

$1\text{ acre} = 0.4\text{ hectares}$ ;  $1\text{ hectare} = 2.47\text{ acres}$

### Nursery bed preparation

- Mix equal parts of soil, compost/well dried fine manure and sand to create a well-textured and fine soil. When seedlings are uprooted, soil should be loose enough that plants can be easily separated during transplanting, but not so loose that the soil falls off the roots
- Create a raised bed with mixed soil to a height of 10-15cm. At the time of transplanting (8-12 days of age) seedling roots will extend to about 10-15cm, so the nursery bed will

need to be sufficiently deep to allow for easy uprooting in a manner that doesn't damage the young seedlings' roots

- One option for easy uprooting is to cover the ground using plastic sheets or banana leaves, then add nursery soil on top. The disadvantage is that there is no free drainage through the soil in case of high rainfall events
- Rake surface soil to make it smooth and flat
- Pre-water the nursery 1-3 days ahead of sowing to create a consistent seed bed; the soil will settle and the seedbed will become denser and more regular, which will improve germination and seedling development

## 4.3 Nursery Management

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### ***Sowing seeds at a low density***

One of the secrets to a good SRI nursery is to sow seeds at a low density. The ratio between amount of seed and size of nursery bed is presented in Section 2.2, above. In a nutshell, 100 grams of seeds are used for each 1m<sup>2</sup> of nursery bed. To obtain a very regular sowing rate and consistent spacing, use the following steps:

1. Divide the seeds into 3 equal parts
2. Divide the nursery bed(s) into 2 equal parts
3. Evenly broadcast the 1st portion of seeds across the 1<sup>st</sup> half of the nursery
4. Evenly broadcast the 2nd portion of seeds across the 2<sup>nd</sup> half of the nursery
5. Use the 3<sup>rd</sup> portion of seeds to fill in any empty spaces across the entire nursery bed

*GUIDELINE: Avoid seeds overlapping or touching each other. SRI emphasizes reduced competition and individual plant health, and careful seedling handling is an important component of this. When each seed has its own space and radius it is allowed to grow without directly competing with other seedlings. This space is also very important for the transplanting process; at the two-leaf stage, if the nursery was not sown too densely, the seedlings and their roots will not be intertwined with each other, and it will be easy to separate seedlings from the nursery mat and from each other without the risk of tearing the roots.*

### ***Covering the seeds***

- Cover the seeds with a thin layer of fine soil to protect them from drying out, washing away, or being eaten by birds, insects or rodents. Tap the soil with your hands to eliminate any air space between seeds and soil, which will improve the germination process
- Cover with a thin layer of straw or palm fronds and water the nursery well

### ***Nursery management***

- Water nursery 1-2 times per day, preferably with a watering can to disperse the water and prevent channeling and erosion
- The speed of seedling development can be influenced by the watering frequency:
  - Watering twice per day speeds up the seedlings' growth
  - Watering once per day slows down the seedlings' growth a bit



- Thus, fine-tuning of seedling development is possible, in order to align the seedling stage with the optimal day for transplanting.
- Check the nursery regularly, and guard against pests like birds, rodents, and ants
- Once the rice shoots push through the soil (already at 2 days after sowing), remove the straw gradually.
- Surround with netting if birds tend to be a problem

## Section 5. Transplanting

*Seedlings are ready for transplanting at the 2-leaf stage, which is generally 8-12 days after germination. The range of days to reach the two-leaf stage depends on how quickly and well the seeds germinate and the seedlings grow. The variety used, seedbed quality, temperature, and watering all impact seedling development.*

### 5.1 Marking Strategies

SRI uses a precise grid for plant spacing, ensuring that each plant has plenty of space and that mechanical weeding is fast and efficient. To achieve this spacing, SRI practitioners use a system for marking where each plant goes. The three most common marking strategies are ropes, rakes, and rollers.

Many other methods exist, however, and there is much room for innovation. Pictures of different marking strategies are available at: <http://picasaweb.google.com/sri.cornell/SRIMarkers>

#### 5.1.1 Transplanting with Ropes

Ropes are most commonly used for planting crops in lines, and many technicians and farmers are already familiar with the technique. Nevertheless, there are some technical details that can make planting with ropes for the first time much easier and faster.

Transplanting can be done with one single rope, but using three separate marked ropes will make transplanting easier and faster.

##### **Preparing the ropes**

- Decide on spacing—25 cm is a good spacing to start for initial trials
- Measure three lengths of rope:
  - Two pieces long enough each to cover the *length* of the plot, with some extra length
  - One piece long enough to cover the *width* of each planting bed, with some extra length
- Every 25 cm (or whichever spacing you decide on) mark the rope by tying a piece of colored string or plastic into the rope (i.e., between the strands of the rope). To do this, the string can be laid on the floor with a measuring tape, and with a pen or marker the string gets marked exactly at 25 cm interval. Old cloth is ripped or colored string is cut



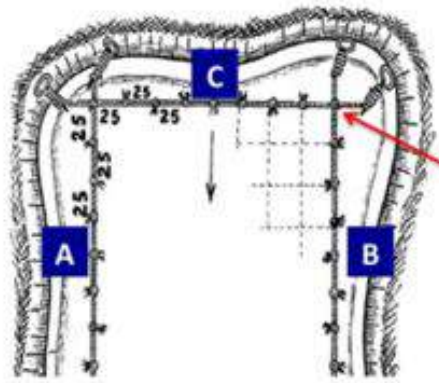
into long pieces that will then be tied *into* the rope. Below is an image of a marking rope using small sticks instead of cloth or string for the markings

### ***Things not to do***

- **Do not** tie a string or plastic piece *around* the rope: the string might slide along the rope and thus the spacing will not be correct anymore
- **Do not** mark the rope with a colored marker or with tar: once the rope is immersed into mud, the marks will not be visible anymore
- **Do not** tie knots with the rope itself—there are two problems with this: i) once the rope is immersed into mud, the marks will be difficult to see; ii) when tying a knot with the rope, precise spacing of 25 cm will be difficult to be maintained as the rope shortens with each knot. We have tried this out several ways, but at the end there has always been some irregularity with the spacing

### ***Marking the edges of the field (A and B)***

***Using three ropes:*** Two ropes are used to mark the two sides of the field (Rope A and B in the drawing below). They are put in place before transplanting and before seedlings are removed from the nursery. These two ropes stay in place during the entire transplanting process and



**Align marks of Rope C and B to obtain a perfect grid:**  
Be consistent to align the marks for each row always on the same side (Rope C and B) throughout the entire transplanting process.

are only removed when transplanting is done. Make sure they are **parallel** to each other and that the rope that will be used for transplanting (Rope C) will be at a **90-degree** angle to the two sideline ropes, so that the grid will be square and straight. Also make sure that the two sideline ropes start and end at the same places.

***Using one rope only:*** If only one rope is used for transplanting (Rope C), use it first to mark the sidelines (A and B), by either placing sticks at every 25cm mark or making holes each 25 cm. Make sure the marks are in **straight, parallel** lines.

### ***Creating the perfect grid***

Creating a perfect grid is easy, but the following points need to be respected: one of the two people who move the transplanting rope C backwards will be designated at the beginning of the transplanting to align one of the 25cm marks of Rope C with the 25cm mark on either Rope A or B. This has to be done consistently only on one side (as the second side might not align perfectly at 25cm).

How can you check if a field was planted in a perfect grid-pattern? Check if the diagonals of the field show straight lines! The photo at right shows



well-done transplanting, with clear diagonal lines. The advantage of a grid-pattern is that the mechanical weeder can be used in two directions.

### ***Transplanting techniques with a rope***

Starting at one end of the field, use Rope C at a 90-degree angle to Ropes A and B. While two people hold Rope C tightly on each side, others can begin to transplant one plant at each 25cm mark along the Rope C. Make sure the plants are pushed closely to the mark, so that all plants are well aligned with the rope. Move the rope down to the next 25cm marks and transplant as before.

### ***Advantages of transplanting with a rope***

- The field doesn't need to be perfectly level, flat or dry to mark
- It can be very fast to use once people are trained
- It takes advantage of large groups of labor, when available, but can be done with small groups as well
- It can be used for any soil type

### ***Challenges of transplanting with a rope***

- Requires some practice, patience and supervision the first time using this method
- Cannot mark fields before transplanting, and requires good coordination

## **5.1.2 Marking Rakes**

Marking rakes are simple wood, metal or bamboo rakes that are custom made for a specific spacing, such as 25cm.

### ***How to use a marking rake***

1. Drag the rake along one straight edge of the field (if there is no straight edge, use a rope and stakes to create one, preferably along a *long* edge of the field), checking continuously to make sure that marks are visible and the lines are straight and in line with the edge of the field. When you reach the far end, turn around and repeat, using the last row of the previously marked lines as the first row of the next set of lines
2. Next, begin marking a straight line along an edge of the field **perpendicular** to the first edge marked (using stakes and a string again if the edge is not yet straight). Lines marked need to be perpendicular to the first set of marking, creating a square grid. Repeat as above, until the entire field is marked.
3. Transplanting is done at the intersections, where the two sets of lines cross





**IMPORTANT:** when using a rake, transplanting is done moving forward—not backward—in order to control where to put the feet and not to step on the marks. When using a rope, however, transplanting is done by moving backwards.



### Types of marking rakes

1. Wood/bamboo marking rakes
  - Easy to make (15 min – 1 hour), but less durable than metal rakes
  - Can use nails, boards, or sticks as pegs
  - Lighter weight rakes can 'lift' out of the soil, and might require weights or a second person to push down on the rake while the first person drags it
  - Wood pegs create more drag and friction than metal pegs, and make less clean of lines, but in muddy soils their lines may show better than metal pegs
2. Metal marking rakes
  - Must be made in advance
  - More expensive than wood, but more durable, and easy to weld using simple hollow tubes
  - Less friction when dragging than with wood

### Advantage of using a marking rake

- Easy to make, and depending on quality, can last a long time
- Requires only one person to mark the fields.
- Allows fields to be marked *before* transplanting begins, meaning people can transplant at their own pace—unlike when using a rope, where people need to be well coordinated during the transplanting process



### Challenges of using a marking rake

- For lowland soils: if the field has puddles of water then the marks will not show, and the method is ineffective; drying the field to obtain a muddy surface area without standing water puddles can be a challenge in high rainfall areas, where leveling is not done very well, or when farmers are in a hurry to plant after finishing soil preparation
- For upland soils: fields need to be very level and flat, or else the rake marks may not show; longer pegs can help with this—small or short pegs may not show very well
- Not as fast as a roller—must rake in both directions to create a grid
- If a field has lots of uprooted weeds on the soil surface, the weeds will quickly accumulate, and the stakes and need to be cleaned off regularly

### 5.1.3 Marking Rollers

Rollers are an adaptation based on marking rakes, but unlike marking rakes, rollers mark the entire grid in one pass.



#### *How to use a roller*

1. Roll the marker along one straight edge of the field (if there is no straight edge, use a rope and stakes to create one), checking continuously to make sure that marks are visible and the grid is straight and inline with the edge of the field
2. Continue until the far end of the field, and repeat, using the previous row as a guide
3. Be careful not to step on lines and obscure the marked grid
4. Transplant at the intersection of each line

#### *Types of rollers*

- Rollers can be pushed or pulled, and be made from many materials (e.g., wood, metal) and objects—see the photo above of a roller made using bicycle wheels for a frame
- One great adaptation is a simple triangular frame—shown below—which combines a roller with the rope method to allow marking and transplanting in one pass, and can be used for any soil type or condition, with fields that aren't perfectly level, and with few or many people; extra care should be taken though in making sure the grid stays straight

#### *Advantages of transplanting with a roller*

- Are faster than a rake because they mark both directions of the planting grid at the same time
- As with a marking rake, marking can be done by one person
- Allows transplanting to be done with a small group or even one person, at their own time and pace



#### *Challenges of transplanting with a roller*

- Field must be **very level**, or well puddled, or else the marks from the roller may not show up very well
- Cannot be used if field is inundated
- More complicated to make than rakes—be careful to ensure that the spacing is precise in each direction.

## 5.2 Uprooting and Transporting Seedlings from Nursery to Field

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The most important part of transplanting is to minimize stress and trauma to each seedling. Be gentle, careful and quick.

- Water the nursery the morning before transplanting
  - In a very hot climate, this is important, as it will minimize the danger of desiccation and improve how quickly the seedlings can get reestablished after transplanting
- Carefully remove seedlings from the nursery
  - If the nursery was lined with plastic sheets or banana leaves, lift the soil and seedlings together
  - If the nursery bed was not lined, carefully cut in with a shovel, parallel to the soil surface and well underneath the roots (about 15-20cm deep), then lift up the seedling/root mat in whole sections, and place them carefully on a tray
- Leave the soil intact on each plant's roots as much as possible, don't shake the seedlings to get rid of the soil and don't wash the roots—farmers might be used doing this traditionally, so explain the logic for protecting the roots to the workers
- Transplant uprooted seedlings within 15-30 minutes, and take care to not let them dry out before transplanting. Uproot only as many seedlings as your group will be able to transplant within this 15-30 minute window
- Designate 1-2 people for uprooting and transporting seedlings to assure the constant supply of seedlings

## 5.3 Careful Transplanting

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Once seedlings reach the field:

1. Plant only one seedling per hill
  - Make sure farmers understand the importance of planting only one seedling per hill, and check in to make sure they are doing it properly
  - Plant only vigorous seedlings. If seedlings are weak, damaged or small, don't plant them. If proper care was taken in sorting the seeds and establishing the nursery, weak seedlings should be an exception rather than a norm, and there should be plenty of healthy seedlings to complete the transplanting—don't worry about discarding any weak seedlings
2. Gently place seedlings in the soil
  - Farmers typically transplant by pushing seedlings into the ground with their finger, which causes the roots to bend upwards toward the surface, forming a 'J' shape. Plants are then required to spend time to repositioning their roots, slowing their growth and development
  - Roots should be in a horizontal, 'L' shape, or in a vertical, 'I' shape; this allows them to start growing down faster, and enables quick and efficient plant establishment
  - Gently lay or slide seedlings into a shallow trench or hole created with your finger or a stick. Sliding the seedlings through the mud for a few centimeters towards the marked rope is a good way of assuring the 'L' shape of the roots and a precise placement on the line

- Plant seedlings superficially - Keep them as close to the soil surface as possible. This will favor a good tillering of the plants. Seedlings that are planted too deeply have trouble developing tillers!
3. Water the field lightly after transplanting to ensure root/soil contact
    - In **irrigated paddy fields**, introduce a shallow layer of water right after transplanting, making sure not to drown the seedlings
    - In **upland fields**, use some watering technique if possible, or wait for the next rain, which hopefully arrives the same evening or night; transplanting directly after a large rain can also help provide a higher soil moisture level to start out with, but the timing for this can be difficult as SRI plants should be transplanted as close to the two-leaf stage as possible
  4. Supervise all workers to make sure that they are:
    - Planting carefully
    - Planting only one seedling per hill
    - Plant seedlings superficially and not placing them too deep in the soil
    - Planting on the grid, using the correct spacing; make sure that all workers plant seedlings on exactly the same side of the guide rope (if using a rope), and as close to the rope as possible—this ensures that each row is perfectly straight and spacing is uniform

All these elements are not difficult to do; they just need to be explained well in the beginning, and farmers need to understand the reasons behind each of them

## Section 6. Plant Establishment (After Transplanting or Direct Seeding)

*Plant establishment covers the first 1½-2 weeks after transplanting, or the first 3-4 weeks after direct seeding.*

Until the young plants are well established it's important to keep them from experiencing drought stress. In **irrigated fields**, keep the soil moist, not flooded or only slightly flooded, and do not let the soil dry out. Check plants on a daily basis and water as necessary. Alternate wetting and drying irrigation can start when plants are well established, which is typically 1½-2 weeks after transplanting, or 3-4 weeks after direct seeding. In **rainfed fields**, take whatever measures are available to minimize stress to the establishing plants, and assure the soil stays moist for the first 1½-2 weeks after transplanting, or 3-4 weeks after direct seeding.

Mechanical weeding (using a rotary weeder, chisel hoe, hand hoe or other device) **does not** start until after the plants are established. (See Section 7, below, for more information). After about 1½-2 weeks for transplanted rice or 3-4 weeks for direct seeded rice, the fields can begin to be left to dry between each watering, and mechanical weeding can start.



## Section 7. Vegetative Growth Stage

*The vegetative growth stage lasts from plant establishment until flowers emerge.*

### 7.1 Water Management

Once the plants are well established, allow the soil to dry between each watering, which is called **intermittent irrigation**, or **alternate wetting and drying (AWD)**. How this is done will vary depending on irrigation water availability, local soil conditions, amount of organic matter added to the soil, weather conditions, the quality of field preparation (leveling and bunding), and the variety of rice used.

*The key with watering is to find a balance that works for your local conditions. **There is no fixed watering schedule for SRI**, but the principle of creating aerated soil conditions in-between waterings should be respected. Make sure the plants have enough water that they are not stressed or wilting, yet at the same time allow enough time between waterings for the soil to aerate, and the rice roots to grow deeper - being able to breath and looking for water.*

Some guiding ideas are:

- Water as needed, about every 7 to 10 days (or according to soil conditions and weather)
- Water enough to saturate the field, but not more
- Both irrigation *intensity* (the amount of water given and the duration of each watering) and irrigation *frequency* (how often waterings occur) can be varied, and are interdependent

In many West African rice-cropping systems, full control over water is not possible. This is especially true in rainfed upland and rainfed lowland systems, where water management can be a challenge. Nevertheless, even in upland rainfed systems with no irrigation there is still some ability to manage water, even if not with complete control. Take full advantage of any means or opportunities that are available, as they will contribute to higher and more stable yields.

Tips for the different rice systems:

*For **all** rice cropping systems:*

- Level the field well, and divide it into smaller plots if necessary
- Dig drainage canals and build small bunds to help control water in and out of your plots and prevent erosion and channeling
- Maintain a damp but aerobic soil (as possible) during the vegetative growth phase

*For **irrigated** systems:*

- Flood/irrigate up to 1-2cm of water every 7-10 days or as needed

*For **lowland flooded/flooded/swamp** systems:*

- Plant rice in an area not prone to complete flooding. If possible move out of the floodplains to slightly higher grounds that are still part of the lowlands and still get flooded, but where some part of water management is easier, whether for drainage or irrigation (from surface soil water or high ground water tables)

**For upland rainfed systems:**

- Bund your fields to keep rain water in the field
- Use organic matter applications to increase water retention
- In high rainfall areas: create drainage canals in case of excessive rainfall
- In low rainfall areas: apply surface mulch to retain soil moisture
- If available, use supplemental irrigation during dry periods, but let the field dry well between waterings.

### ***Timing within the rainy season***

Time your trial carefully to make sure it coincides with the best possible period of the rainy season. Since rice cultivation under SRI uses less water, planting early is a real advantage: the crop can get a good head start while conditions are not too humid, and once the rainy season is in full swing, the crop is already in the reproductive phase. This kind of timing requires of course a careful balance to avoid planting too early in the season.

If water is available during the dry season, it is possible to start planting rice far ahead of the normal cropping season, as is done by the SRI practitioners in Liberia. Before the heavy rains set in—which often flood and damage the rice fields—the rice crop can already be harvested.

## **7.2 Weed Management**

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In conventional flooded rice systems, standing water is used as a primary means of weed control. Because SRI doesn't use flooding to control weeds, a different strategy is required. Weeding suppression can be achieved by using a cover mulch of OM, as is done with CA, or can be done with mechanical weeding. Both weed control strategies have secondary benefits besides simply preventing weed competition, and are discussed below.

### **7.2.1 Mechanical Weeders**

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Mechanical weeding has a number of important advantages. Besides simply killing weeds, mechanical weeding helps to aerate the soil *and* reincorporate weeds into the soil to enrich it with more organic matter. It further helps to improve the leveling of the field, to reduce the areas of ponded water and to redistribute water across the field more evenly. When using a weeder after irrigation, soil nutrients solubilize more readily, providing a flush of nutrients to the rice plants and contributing to a clear fertilizing effect.

All these roles are vital to SRI, and using a weeder is therefore an important management intervention for improving yields. Furthermore, with each additional weeding (farmers can typically do up to four weedings in a season), yields will continue to increase.

#### ***When and how often to use a weeder***

- Mechanical weeding should be done right after each watering for irrigated/flooded fields and when soils are neither too wet nor too dry for upland rainfed fields. This helps maximize aeration and keeps weeds from reestablishing
- Early on during the vegetative growth stage the plants are small, leaving plenty of space between rows for weeding. As the plants grow, the space between rows fills in and weeding becomes more difficult, and eventually impossible. Farmers can typically do up to four weedings in 7-10 day intervals before running out of space. Once the plant canopy closes in, weeds are usually controlled by shade

### **Weeders for different cropping systems**

Rotary weeders (like the cono-weeder) work well with lowland fields and heavy soils. Chisel-type weeders are better suited for sandier or upland soils. If no special weeder is available, use a hand-hoe or animal traction

#### **1. Lowland/Heavy Soil Type Weeders**

- Weeding in lowland systems is usually done with a small layer of water, to help keep mud from sticking to the weeder
- Common lowland weeders include the “cono weeder” (center), and variations:



#### **2. Upland/Sandy Soil/Dry Climate Type Weeders**

- Weeding in upland/dry soil systems is usually done with no standing water on the surface, when soils are not too wet (soil would stick to weeder), nor too dry (soil would be too hard for good weeder action)
- Common upland weeder designs include:



### **Weeding without a special weeder**

You don't need a special SRI weeder to do SRI. If you're just getting started with SRI, and don't want to wait for a local craftsman to build a weeder, simply plant a small trial plot and use a hand hoe or any other hand tools you have available and are familiar with using. Weeding with a hand hoe can take a long time, so to avoid discouraging the farmers, make sure they start with a

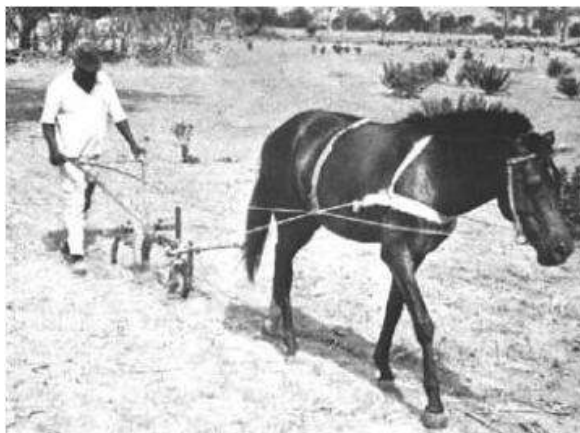


small trial—they can always increase the area the following season as they become more familiar with SRI, or produce/search for mechanical weeders before starting their next trial.

Experiment with new weeders, as well; often the simplest designs are the most effective. In some communities in the Philippines, for example, farmers prefer using a simple rectangle board with nails sticking out of it, and fixed to the end of a pole, even though they can readily purchase cono-weeders nearby.



You can use other locally available methods of mechanical weed control, as long as they can work with the wider spacing of SRI. In Senegal, for instance, animal drawn weeding 'machines' (on left, below) are fairly common, and can be adapted for weeding SRI plots.



## 7.2.2 Weeding with Conservation Agriculture and SRI

One of the key principles of CA is minimizing soil disturbance, therefore prohibiting mechanical weeding. CA also mandates using a permanent organic soil cover, which can be an organic matter mulch, crop residues, or cover crops. This permanent cover can effectively prevent weed growth, and any weeds that do emerge can be readily removed by hand with greater ease due to the enhanced soil moisture provided by the organic matter soil cover. When adopting CA there is typically a transition period during which the organic matter cover is not fully established, and where weed emergence may remain high or even increase temporarily. Within 2-3 seasons, however, this transition is typically complete, and weed emergence and competition is dramatically reduced.

Another principle of CA that affects weed emergence and competition is crop diversification, whether through crop rotation (i.e., chronological diversification), or through crop associations (i.e., bio-spatial diversification). Both of these strategies help to reduce the ability of specific weed population to become dominant.

## Section 8. Fertilization

*Organic matter (OM) application represents the basis of soil fertilization using SRI.*

*See Section 1.1, above, for more on working with OM. See section 1.2, above, for more on field preparation. Manuals and guides for producing compost and working with manure are listed in the resources found in Section 11, below.*

### **Using organic matter**

Applications of nitrogen or other chemical fertilizers may be needed in order to maintain a balanced uptake of nutrients, but use of OM is fundamentally important to SRI, and in most cases will allow farmers to substantially reduce their need for chemical fertilizer. Furthermore, OM offers many benefits that synthetic fertilizers like urea lack. Application of OM helps to:

- Improve soil fertility and create a healthier soil
- Enhance soil biota, most importantly soil microbial life, which is essential in making nutrients and water more readily available to plants—soil microbes also help protect against diseases, etc.
- Improve fertilizer use efficiency
- Improve the moisture retention capacity of the soil
- Reduce input costs, as locally available organic material can be used to improve soils

Organic matter application is important for irrigated as well as rainfed systems, but might show a higher effect in rainfed systems, and can be a vital component of moisture retention in upland soils. In areas with low rainfall or long dry periods, surface mulch or Conservation Agriculture can help maintain or enhance soil microbial life, and retain OM in the soil. For irrigated rice production, even though organic matter application is not a common practice, many rice producing areas in the world are facing soil fertility depletion with a decrease in soil organic matter, which translates directly into yield declines.

Good field leveling and bunding can help keep OM in the field, and incorporating OM into the soil can keep it protected from desiccation by the sun/wind, which will maximize its positive effects on the soil (see Section 1.2 for more on soil preparation). Fresh manure should certainly be incorporated into the soil and allowed to age, or composted, and in any case should be applied to well-leveled and banded fields. Fresh manure can be high in nitrogen and phosphorous, which if not handled properly can wash into local rivers and ponds, and can cause environmental damage such as eutrophication. Compost production should be done carefully as well to avoid nutrient-rich runoff from entering into nearby water (see Section 1.1 for more on working with OM).

### **When and how to use urea**

In addition to organic matter, many SRI farmers use some nitrogen fertilizer, most often urea. Urea is ideally applied at the tillering stage (or 15-20 days after transplanting) and during panicle initiation, which coincides with the beginning of internode elongation.

In conventional systems, applying urea to irrigation water is associated with very high nitrogen losses and potential eutrophication of local waterways, causing environmental damage and loss of fish populations. With SRI it is recommended to apply urea to the soil after watering or irrigation—just before the water dries up—and ideally slightly incorporated with a weeder. Having urea superficially incorporated into the soil allows for a slower nutrient release, which is directly beneficial to the plants, prevents volatilization of Nitrogen as well as surface runoff into local waterways. Good field leveling and bunding is also important for preventing fertilizer from running off the field.

As with other parts of SRI, farmers are encouraged to do side-by-side trials to compare different fertilization strategies. When doing this, it's very important to properly level and bund fields to keep fertilizers from migrating between beds.

## Section 9. Flowering, grain-filling and maturing

*This stage lasts from the beginning of flower emergence until harvest.*

SRI management is most important in the early phases of the crop. Once flowers emerge, SRI management interventions are limited. Drying periods as applied during the vegetative phase should be avoided, but soils should be kept moist, so that flowering and grain filling can be optimal.

### **Shortening of the crop cycle**

SRI typically shortens the growing cycle by 1-2 weeks. This can result in earlier harvest compared to neighboring plots, and has several implications:

*Advantages for earlier harvest can include:*

- Birds who feed on the rice crop might not have arrived yet on location
- Crop might mature before the cold period arrives, a problem in some areas in the Sahel, obviously reducing yields when grain filling is still in process.
- In locations with restricted length in the growing seasons, farmers might be able to switch from short-cycle to medium-cycle varieties, with higher yield potential, as seen in some locations in Northern Mali
- Farmers can gain some time for preparation and planting of the off-season crops in a timely manner, which influences the yield potential

*Disadvantages of an earlier harvest can include:*

- If grain-feeding migratory birds have arrived early on location, the early maturing SRI fields could be heavily attacked. If this seems to be the case, plan ahead to have a strategy for preventing bird damage, such as the use of nets, scarecrows, cassette tape, CDs, camping in the field with a slingshot, or other methods farmers use in the area

### **Before harvesting**

- Stop watering the field two weeks before harvesting the grain
- When the rice is ripe, encourage farmers to collect their seed for next year, harvesting one panicle at the time as described in Section 2.3
- Review the material on scientific harvesting practices in Section 10, below, well before grain maturation to ensure a proper strategy is in place in time for harvesting

## Section 10. Rice Harvesting Guidelines for Yield Evaluation

*These guidelines can be used for undertaking a rice yield evaluation, whether for a demonstration plot, a farmer's plot, a SRI or farmer's practice plot, or any other rice plot.*

When harvesting a farmer plot or a demonstration plot managed by farmers, the technician should make an appointment with the farmer for the harvest. For any harvest the farmer should be associated, including other farmers from nearby who can participate, witness and help out with the harvest.

**Important:** *follow the exact same procedures for harvesting the various plots, for instance the SRI plot and the control plot. Use the same scale and measurement tools.*

Depending on the materials available and the plot size, there are two possibilities for harvesting:

1. Harvest the entire plot (see 10.1, below)
2. Harvest samples within the plot (see 10.2, below)

If the technician cannot be present, some simple but effective instructions can be provided to the farmers (over the phone for instance):

3. Simple harvest methodology when technicians/trained farmers are absent

### 10.1 Harvesting the Entire Plot

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This can be done when:

1. The trial plot is small; and/or
2. No field scales are available

Trial plot: for instance 10m x 10m (can be smaller or larger; can be rectangular or square)

Materials needed:

- Measuring tape (ideally > 20 meters)
- A shovel / hoe to dig up the 10 sample plants
- Harvesting scythe
- Scale found in the village (that can measure weight of the bags)
- Rice bags
- Materials for threshing and winnowing (what farmers usually use), including mats.

All the materials should be readily available in the village; a measuring tape might have to be bought at the market.

#### ***Step-by-step procedure for harvesting the entire plot***

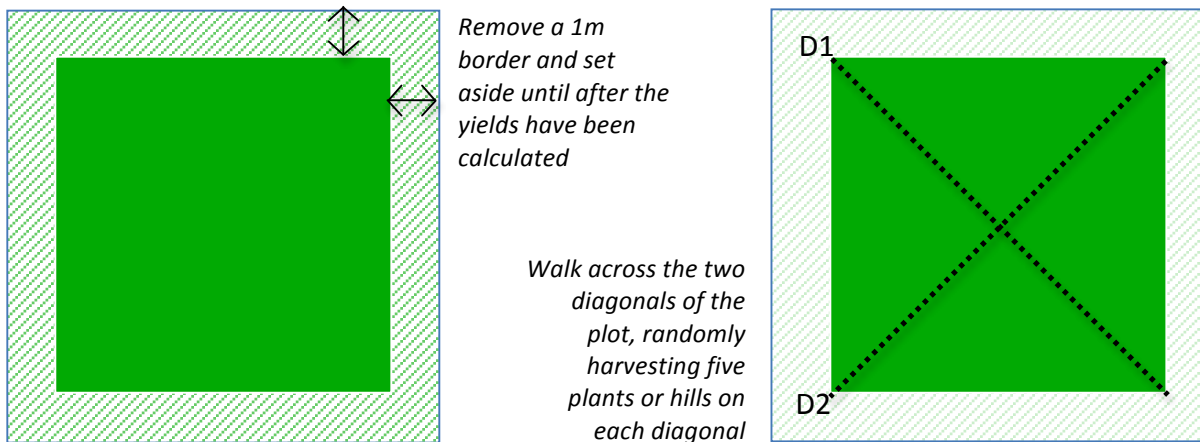
##### Step 1: Observations before the harvest

- Walk around the plot with the farmer or group of farmers, and discuss the evenness or unevenness of plant development within the plot. Discuss the reasons. Take notes.



### Step 2: Remove the boundary around the plot

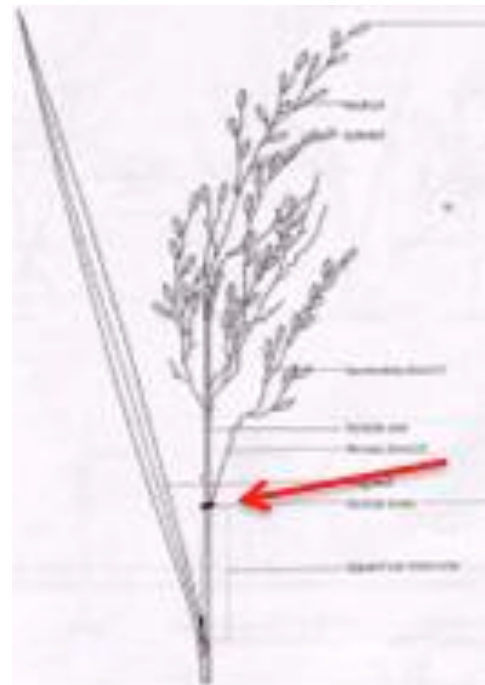
- Measure 1 meter from the plot boundary all around the plot, and harvest the rice of this border zone; set aside. The plants growing at the border of the plot show an edge effect, as plants develop differently (usually they show a fuller development, not having any neighbors on one side) compared to plants in the middle of the plot. To eliminate the boundary effect, the 1-meter band is eliminated all around the plot. If the plot is very small (only 3-5 meters long or wide), one or two plant rows can be removed. If the plot is very large, a 1.5-meter boundary can be respected. Set the boundary harvest well aside, so that it will not be accidentally mixed in with the harvest of the yield evaluation.



- Once the boundary is removed, measure the square you are going to harvest in meters (length x width); mark on the data collection sheet.

### Step 3: Harvest 10 plants

- Before harvesting, walk carefully across the two diagonals of the plot, randomly harvesting five plants or hills on each of the diagonals. (In the SRI plot, 1 hill represents 1 plant; in the control plot, 1 hill represents usually 3-4 plants).
- Measure the height of the plant (in cm): this is done with the measuring tape (mounted on a straight wooden stick): hold plant in your hand; slide your hand upward along the plant until the end of the last leaf or panicle; total height is measured from the base of the plant to where the longest leaf/panicle ends.
- Cut/harvest the plant/hill at the base or dig it up (to keep the hill intact),
- Take the 10 plants/hills individually out from the field and put them individually on a mat. Measure/count the following variables and fill in the data collection sheet:



- Count the number of tillers per plant/hill
- Count the number panicles per plant/hill
- Randomly select 5 panicles from the 10 plants
- Measure the length of the panicles (in mm!): place the panicle on a flat surface and measure from the panicle node (obvious mark, see flash in picture) to the top of the panicle.
- If possible, count the number of grains of 3-5 panicles
- After taking all the measures in the field, add all the panicles from the 10 plants to the rice you will be harvesting next

#### Step 4: Harvest the plot

- Harvest the entire plot and collect all the grain in one location. Be careful not to mix it with the border harvest (explain this to farmers ahead of time: to keep the two separated until the weight is determined)
- Discuss with farmers if it is necessary to dry the paddy before threshing and follow their advice. If paddy shows still signs of green, it is best to dry the paddy in a shaded environment for 2-3 days to loose excess moisture. Drying the paddy in the sun should be avoided, in order not to loose too much of its moisture content (and thus loss in weight). If the paddy is stored and dried for 1-3 days, there is also a danger for the grain to be disturbed or lost (due to animals, wind, etc.)
- Ideally the harvested rice should be threshed and winnowed as soon as possible, followed by measuring the weight as soon as possible

#### Step 5: Measuring yield

- If a scale is available: weigh the paddy, and write into datasheet
- If no scale is available: use a measure of **volume** that farmers usually use. This can be a rice bag of 50 kg, or in some places, farmers make their own volumes (calabash or others). Get to know how many kilos the Volume holds. (In Zambia a 50 kg rice bag holds between 38-42 kg of paddy rice, or an average of 40kg). Villagers might have an idea on how many kilos a volume holds, but it is best to weigh a Volume with rice filled. Then deduct the weight of the empty Volume container to get the kg of paddy/Volume. Since you know the harvested area (m<sup>2</sup>), you can calculate the yield of kg/ha

#### Step 6: Calculating yield

- Kg of paddy / volume x number of volumes = total paddy harvested in kg
- Yield: kg harvested paddy / surface area m<sup>2</sup> \* 10,000 = kg/ha
- Example: on a 400 m<sup>2</sup> plot, the harvest is 325 kg. Yield: 325/400 \*10,000 = 8,125 kg/ha, equal 8.125 t/ha

Measurement units	
Weight:	<ul style="list-style-type: none"> <li>• 1000 grams (g) = 1 kilogram (kg)</li> <li>• 1000 kg = 1 metric ton = 1 ton (t)</li> </ul>
Area:	<ul style="list-style-type: none"> <li>• 1 hectare (ha): 100 m x 100 m = 10,000 m<sup>2</sup></li> </ul>

## 10.2 Harvesting Samples within a Plot

This method is used when:

1. The plot is large, and
2. A precision scale is available.

Materials needed:

- Harvesting frame of 1m<sup>2</sup>
- Precision field scale (this is preferably a scale with smallest measurement unit being 10-50 grams); we recommended a PESOLA 1000 g scale
- Moisture meter
- Medium thin plastic bags (5-10) for weighing the rice. If the samples are being taken back to the village a paper label must be placed inside the bag. The precision scale is calibrated with the bag attached to the scale.
- Measuring tape
- A shovel / hoe to dig up the plant
- Harvesting scythe
- Rice bags
- Materials for threshing and winnowing (what farmers usually use)



### ***Step-by-step procedure for harvesting***

Steps 1-3: Follow steps 1, 2 and 3 as described in 10.1, above

Step 4: Harvest of 5 sub-plots

The harvest data collection is done on 5 squares, each 1m x 1m in size. Procedures for SRI and control plots are the same.

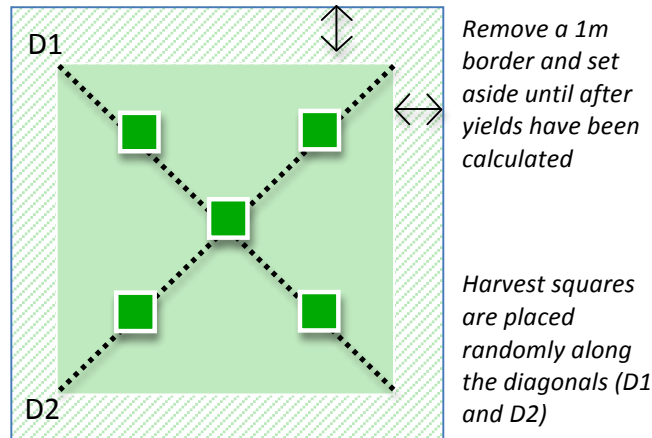
Harvest squares: a rectangular wooden square is put together, 1m x 1m, preferably with light sturdy wood. The inner length of the wood square is exactly 100 cm! You should let the carpenter know that it is important to be precise, and before you accept the finished product, verify with the carpenter the accuracy of the square, in case there is a need for correction. It is also possible to produce a square out of metal.

In case there is no square available, it is possible to use a measuring tape. Four people hold each on to a corner of the measuring tape; when the angles are 90°, the tape can be lowered to the base of the plants as shown in the picture above.

*The placement of the squares :*

- 5 squares are placed on the two diagonals as shown in the diagram below. The squares should not be placed side by side. Minimum distance between the squares is 1m. Where exactly the squares are placed within the field is a judgment call for the technician. If the field is uniform, the squares can be distributed randomly within the field along the diagonals. If the field is not uniform [this was identified under step 1], the technician should think about placing the squares in order to represent the field conditions. For instance: two squares can be placed in the better part of the plot, one square in the middle part and two squares in the inferior part of the plot, so that the overall

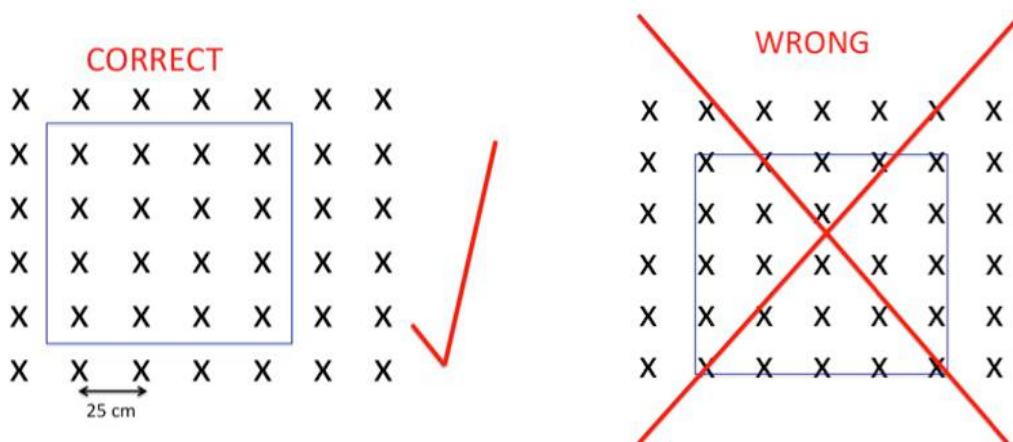
sampling of the 5 plots represents an average of the entire field. This is of course an estimate, but all yield measurements are estimates, the task is to make sure the estimates are as good as possible!



**IMPORTANT:** Place two *sides* of the square exactly in the middle between two lines of plants, and do not put the square at the base of a plant row. This could cause an error as explained below.

Example: if the spacing between hills is 25cm, there are four plants within 1 meter (1m divided by 25cm = 4 plants). In one square meter, this is 4 plants x 4 plants = 16 plants.

- DO IT RIGHT: The frame is to be put in equal distance between two plant rows!
- AVOID THE ERROR: If the frame is pushed towards the base of the plants within a row, it might be possible to include 5 lines of plants instead of 4 into the 1m<sup>2</sup> square, which can lead either to 4 x 5 plants = 20 plants, or even 5 x 5 plants = 25 plants, which will increase the yield falsely by 56%!



Thus, placing the square needs to be done carefully. Take your time and count the number of plants within the square and adjust if necessary, before the cutting is done. For the control plot (which might not be planted in line), try to align **two sides of the square** the same way, placing the frame in the middle between two plants, even though

there might not be clear lines as in the SRI treatment. There is no control where the third and fourth side of the square will fall, which is fine.

Harvesting of the plots: Five plots of 1m x 1m. Different scenarios are described below, depending on availability of materials:

*i) A precision scale and moisture meter are available at harvest in the field:*

- The square is cut very carefully. The number of plants/hills within the square are counted and marked on the form (you can also do that after cutting, by counting the number of hills of stubbles).
- Once cut, threshing and winnowing of 1m x 1m square is ideally done on site with the help of the farmer on a mat that is brought to the field.
- The grain weight is determined with the precision scale. Grain moisture content is determined at the same time!

*ii) A precision scale and moisture meter are not available at harvest in the field, but at the office*

- If the weight cannot be determined on site, the rice of the 5 squares is placed in 5 bags with paper labels (indicating the name of the plot, if it is SRI or Control, date of harvest; labels should be written with a pencil and not with a pen. Pencil writing will not smear when in touch with moisture). Weight can be measured at the office, at the same time moisture needs to be determined.

*iii) A precision scale is available but moisture meter is not available*

- If no moisture meter is available: Rice samples are dried in shade for 2-3 days. This can be done by simply opening the bags, and store them at a safe and dry place, where no rodents can reach, and where the samples are not knocked over by accident.
- It is not advisable to dry the grains in the sun, because the grains can lose too much moisture when exposed to the sun for too long.
- Weight is determined with precision scale, and results marked on the form.

*iv) A precision scale is not available*

- In that case, the one square meter harvesting method is not appropriate, as the precision needed will be lacking. Thus, it is recommended to harvest larger plots as described under 10.1, above, *Harvesting the Entire Plot*.

Steps 5-6: Proceed with steps 5 and 6 as indicated in 10.1, above.

### 10.3 Simple Harvesting Method Undertaken by the Farmer

This method can be used when technicians are not able to reach the field, but the project would nevertheless like to obtain some yield estimates that help in obtaining yield figures. The instructions have to be communicated to the farmer who will be undertaking the harvest, and then report the data back to the technician. The technician should provide the farmer with the data sheet ahead of time and discuss the harvesting procedure carefully step-by-step.



### Materials needed:

- Measuring tape (ideally > 20 meters)
- Harvesting scythe
- Scale found in the village (that can measure weight of the bags)
- Rice bags
- Materials for threshing and winnowing (what farmers usually use), including mats.

### Step 1: Observations before the harvest

- Farmer needs to decide about the size of the plot to be harvested. He/she should first assess the plot and decide either to harvest the entire plot or to harvest part of the plot that is representative of the entire field. This means not to harvest the best or worst part of the field, but a part that represents the average performance of the field.

### Step 2: Remove the boundary around the plot

- Farmer should remove approximately 1 meter of the plot boundary. This does not have to be precise, but can be estimated.
- The plot to be harvested should be a simple square.
- Once the plot is delimited, the square to be harvested needs to be measured with the measuring tape in meters (length x width). Mark the numbers on the data collection sheet.



- 
- Step 3: Harvest the plot
- Farmer is harvesting the entire plot and collects all the grain in one location, separate from the rice harvested from the borders.
- Farmers might dry paddy for a few days, before threshing
- Threshing of rice, and fill rice into bags: report on number of bags (with quarter bag precision at least!)
- 
- Farmer will therefore report to the technician,
- Length x width (in meters) of the harvested area
- Number of bags (quarter bag precision) harvested from the area.
- 

The technician will be able to calculate the yield as indicated above.

*This represents the easiest scenario. It would be ideal if farmers can be trained in undertaking harvesting described as under 1 or 2.*

*Project staff has to make sure that farmers receive the appropriate data collection sheets.*

## Section 11. Resources

*Technical materials, discussion groups, photo albums and other resources are available to facilitate adoption and adaptation of SRI.*

### **WAAPP project resources**

The SRI West Africa WAAPP project website, available at [sriwestafrica.org](http://sriwestafrica.org), contains news, resources, project documents and much more. Throughout the duration of the project it will be updated on a continual basis, so please check often for new information and resources.

### **SRI-specific resources**

#### *SRI Manuals and Guides*

- India – SRI Training Manual – [sriwestafrica.files.wordpress.com/2014/05/english\\_sribooklet\\_new.pdf](http://sriwestafrica.files.wordpress.com/2014/05/english_sribooklet_new.pdf) (WASSAN)
- Kenya – SRI Training Brochure – [sriwestafrica.files.wordpress.com/2014/05/kenya-sri-training-brochure.pdf](http://sriwestafrica.files.wordpress.com/2014/05/kenya-sri-training-brochure.pdf) (IMAWESA)
- Kenya – SRI Training Manual – [sriwestafrica.files.wordpress.com/2014/05/kenya-sri-training-manual.pdf](http://sriwestafrica.files.wordpress.com/2014/05/kenya-sri-training-manual.pdf) (JKUAT)
- Sierra Leone – SRI Training Manual – [sriwestafrica.files.wordpress.com/2014/05/sierra-leone-sri-training-manual.pdf](http://sriwestafrica.files.wordpress.com/2014/05/sierra-leone-sri-training-manual.pdf) (CRS)
- Sierra Leone – SRI Facilitator's Guide – [sriwestafrica.files.wordpress.com/2014/05/sierra-leone-sri-facilitators-guide.pdf](http://sriwestafrica.files.wordpress.com/2014/05/sierra-leone-sri-facilitators-guide.pdf) (CRS)
- Zambia – Operationalizing the System of Rice Intensification – [sriwestafrica.files.wordpress.com/2014/05/zambia-operationalizing-the-system-of-rice-intensification.pdf](http://sriwestafrica.files.wordpress.com/2014/05/zambia-operationalizing-the-system-of-rice-intensification.pdf) (origin unknown)

#### *Mechanization and equipment for SRI*

- Photo albums of equipment – [goo.gl/xHSPO3](http://goo.gl/xHSPO3)
- YouTube equipment videos – [goo.gl/7UFCws](http://goo.gl/7UFCws)
- YouTube videos on SRI – [youtube.com/user/sricornell](http://youtube.com/user/sricornell)
- SRI Equipment Innovators Facebook group (request permission to join) – [facebook.com/groups/SRI.innovators](http://facebook.com/groups/SRI.innovators)

### **Soil and fertility management**

Healthy soil management is the cornerstone of SRI. While the resources below come from a variety of sources, it should be noted that the Food and Agriculture Organization's (FAO) Conservation Agriculture (CA) portal has many excellent and free publications covering CA and other minimal soil disturbance techniques, some of which are presented in the list below. You can access their online portal at: [fao.org/ag/ca/8.html](http://fao.org/ag/ca/8.html).

#### *Soil Assessment*

- Visual Soil Assessment Field Guide – Annual Crops – [ftp://ftp.fao.org/docrep/fao/010/i0007e/i0007e01.pdf](http://ftp.fao.org/docrep/fao/010/i0007e/i0007e01.pdf) (FAO)
- What's the Texture of your Soil? – [sriwestafrica.files.wordpress.com/2014/05/what\\_s-the-texture-of-your-soil.docx](http://sriwestafrica.files.wordpress.com/2014/05/what_s-the-texture-of-your-soil.docx) (SRI-Rice)



### *Soil Organic Matter*

- The importance of soil organic matter: Key to drought-resistant soil and sustained food and production – <ftp://ftp.fao.org/agl/agll/docs/sb80e.pdf> (FAO)
- Carbon sequestration in dryland soils – <ftp://ftp.fao.org/agl/agll/docs/wsrr102.pdf> (FAO)

### *Conservation Tillage/Agriculture*

- Farmer Field School Facilitator's Manual – Integrated Soil, Water and Nutrient Management – [sriwestafrica.files.wordpress.com/2014/05/ffsfm\\_zim.pdf](http://sriwestafrica.files.wordpress.com/2014/05/ffsfm_zim.pdf) (FAO)
- Soil Conservation Techniques for Hillside Farms – [collection.peacecorps.gov/cdm/ref/collection/p15105coll3/id/82](http://collection.peacecorps.gov/cdm/ref/collection/p15105coll3/id/82) (Peace Corps)
- Conservation Tillage in Senegal – [sriwestafrica.files.wordpress.com/2014/05/conservation-tillage\\_pc-senegal.pdf](http://sriwestafrica.files.wordpress.com/2014/05/conservation-tillage_pc-senegal.pdf) (Peace Corps)
- Manual on Integrated Soil Management and Conservation Practices - <ftp://ftp.fao.org/agl/agll/docs/lw8e.pdf> (IITA/FAO)
- No-Tillage Seeding in Conservation Agriculture – [fao.org/docrep/012/al298e/al298e.pdf](http://fao.org/docrep/012/al298e/al298e.pdf) (FAO)
- Burkina Faso – Enhancing Crop-Livestock Systems in Conservation Agriculture for Sustainable Production Intensification – [fao.org/docrep/012/i1437e/i1437e.pdf](http://fao.org/docrep/012/i1437e/i1437e.pdf) (FAO)
- Conservation Agriculture as Practiced in Ghana – [fao.org/ag/ca/doc/Ghana\\_casestudy.pdf](http://fao.org/ag/ca/doc/Ghana_casestudy.pdf) (FAO)
- Scaling Up Conservation Agriculture in Africa – [fao.org/ag/ca/doc/Kenya%20Workshop%20Proceedings.pdf](http://fao.org/ag/ca/doc/Kenya%20Workshop%20Proceedings.pdf) (FAO)
- Conservation Agriculture Introduction Video – [accessagriculture.org/node/913/en](http://accessagriculture.org/node/913/en) (Access Agriculture)

### *Compost production*

- Composting in the Tropics 1 – [infonet-biovision.org/res/res/files/496.Compost102.pdf](http://infonet-biovision.org/res/res/files/496.Compost102.pdf) (HDRA)
- Composting in the Tropics 2 – [infonet-biovision.org/res/res/files/497.Compost202.pdf](http://infonet-biovision.org/res/res/files/497.Compost202.pdf) (HDRA)
- Soil Management: Compost Production and Use in Tropical and Subtropical Environments – [fao.org/docrep/018/s8930e/s8930e.pdf](http://fao.org/docrep/018/s8930e/s8930e.pdf) (FAO)
- Enriched Compost for Higher Yields – [sriwestafrica.files.com/2014/05/enriched-compost-for-higher-yields\\_cta1.pdf](http://sriwestafrica.files.com/2014/05/enriched-compost-for-higher-yields_cta1.pdf) (CTA)

### *Green manures and cover crops*

- Green Manures/Cover Crops – [opac.tistr.or.th/Multimedia/Web/0046/wb0046623.pdf](http://opac.tistr.or.th/Multimedia/Web/0046/wb0046623.pdf) (HDRA)
- Restoring the Soil: A Guide to Using Green Manure/Cover Crops to Improve Food Security of Smallholder Farmers – [fao.org/ag/ca/CA-Publications/Restoring\\_the\\_Soil.pdf](http://fao.org/ag/ca/CA-Publications/Restoring_the_Soil.pdf) (Canadian Foodgrains Bank)

### ***Rice production***

The AfricaRice Center publishes guides for rice production that detail every step of the process. While these guides don't reflect the SRI methodology, they are good resources for rice production in general. See also Module 9, from the African Organic Agriculture Training Manual, farther below, for additional rice-specific production information.

### *AfricaRice Guides*

- Growing Lowland Rice – [fao.org/fileadmin/user\\_upload/ivc/docs/Growing\\_lowland\\_rice\\_production\\_handbook\\_prepress\\_final\\_version\\_19-05-08\\_low\\_res.pdf](http://fao.org/fileadmin/user_upload/ivc/docs/Growing_lowland_rice_production_handbook_prepress_final_version_19-05-08_low_res.pdf)
- Growing Upland Rice – [fao.org/fileadmin/user\\_upload/ivc/docs/uplandrice.pdf](http://fao.org/fileadmin/user_upload/ivc/docs/uplandrice.pdf)
- NERICA Compendium – [tropicalmedicinecentre.com/downloads/NERICA%20Compendium.pdf](http://tropicalmedicinecentre.com/downloads/NERICA%20Compendium.pdf)
- Rice Seed Production by Farmers: a Practical Guide – [africarice.org/publications/Rice\\_seed\\_production\\_by\\_farmers.pdf](http://africarice.org/publications/Rice_seed_production_by_farmers.pdf)

### **Access Agriculture training videos (Access Agriculture)**

This excellent series of training videos covers. While these aren't specifically about SRI, many of the techniques shown in these videos can be adapted for use with SRI. A partial list is presented below. To access all of their videos, visit [accessagriculture.org](http://accessagriculture.org).

*Rice Production Videos – see the full list at: [accessagriculture.org/category/50/Rice](http://accessagriculture.org/category/50/Rice)*

- Using the Rotary Weeder in Lowland Rice - [accessagriculture.org/node/1047/en](http://accessagriculture.org/node/1047/en) (Also available in Dagbani and French)
- Contour Bunds – [accessagriculture.org/node/511/en](http://accessagriculture.org/node/511/en) (Also available in 24 other languages)
- Rice Seed Preservation – [accessagriculture.org/node/410/en](http://accessagriculture.org/node/410/en) (Also available in French)

*Sustainable Land Management Videos – see the full list at:*

[accessagriculture.org/category/144/Sustainable\\_Land\\_Management](http://accessagriculture.org/category/144/Sustainable_Land_Management)

- Conservation Agriculture Introduction – [accessagriculture.org/node/913/en](http://accessagriculture.org/node/913/en) (Also available in French)

### **African Organic Agriculture Training Manual (FiBL)**

This excellent manual, produced by FiBL, encompasses a series of modules covering organic agriculture in Africa. For each module there is a presentation, a trainer's manual, and either farmer's booklets or a flyer. The trainer's manual is a guide to help a facilitator present the slides in the presentation to a group of farmers, with notes for each slide. The farmer's booklets and flyers are designed for distribution to farmers.

We have made available here parts of the manual that are particularly relevant for rice production in general, and SRI in particular. The full manual, including modules on animal husbandry, farm management, marketing and trade, management of other non-rice crops, animal management, and conversion to organic production is available for free at: [organic-africa.net/training-manual.html](http://organic-africa.net/training-manual.html).

#### *Introduction*

- African Organic Agriculture Training Manual (Introduction) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/introduction/Africa\\_Manual\\_A2-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/introduction/Africa_Manual_A2-low-res.pdf)

#### *Module 2: Soil Fertility and Management*

- Soil Fertility Management (Trainer's Manual) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa\\_Manual\\_M02\\_low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Manual_M02_low-res.pdf)

- Soil Fertility Management (Presentation) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa\\_Pres\\_M02\\_Soil\\_fertility\\_low.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Pres_M02_Soil_fertility_low.pdf)
- Soil Fertility Management (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa\\_Booklet\\_2-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Booklet_2-low-res.pdf)
- Soil and Water Conservation (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa\\_Booklet\\_3-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Booklet_3-low-res.pdf)
- Soil Organic Matter Management (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa\\_Booklet\\_4-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Booklet_4-low-res.pdf)
- Soil Fertility Supplements (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa\\_Booklet\\_5-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-02/Africa_Booklet_5-low-res.pdf)

*Module 4: Pest, Disease and Weed Management*

- Pest, Disease and Weed Management (Trainer's Manual) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa\\_Manual\\_M04-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa_Manual_M04-low-res.pdf)
- Pest and Disease Management (Presentation) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa\\_Pres\\_M04\\_Pest-Disease\\_low.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa_Pres_M04_Pest-Disease_low.pdf)
- Pest and Disease Management (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa\\_Booklet\\_8-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa_Booklet_8-low-res.pdf)
- Weed Management (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa\\_Booklet\\_9-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa_Booklet_9-low-res.pdf)
- Post Harvest Management and Storage (Farmer's Booklet) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa\\_Booklet\\_10-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa_Booklet_10-low-res.pdf)

*Module 9: Crop Management*

- Rice Crop Management (Trainer's Manual) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-09/Africa\\_Manual\\_M09-01-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-09/Africa_Manual_M09-01-low-res.pdf)
- Rice Crop Management (Presentation) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-09/Africa\\_Pres\\_M09\\_01\\_Rice-low-res.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-09/Africa_Pres_M09_01_Rice-low-res.pdf)
- Rice Crop Management (Farmer's Flyer) – [organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-09/Africa\\_Flyer\\_01.pdf](http://organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-09/Africa_Flyer_01.pdf)