

**Tool and Guideline # 8**

**Practical Tools on Soil Productivity  
and Crop Protection**

**Rwanda Environment Management Authority  
Republic of Rwanda  
Kigali, 2010**

## PREFACE

In 2010, REMA prepared 11 practical technical tools intended to strengthen environmental management capacities of districts, sectors and towns. Although not intended to provide an exhaustive account of approaches and situations, these tools are part of REMA's objective to address capacity-building needs of officers by providing practical guidelines and tools for an array of investments initiatives.

Tools and Guidelines in this series are as follows:

#	<i>TOOLS AND GUIDELINES</i>
1	Practical Tools for Sectoral Environmental Planning : A - Building Constructions B - Rural Roads C - Water Supply D - Sanitation Systems E - Forestry F - Crop Production G - Animal Husbandry H - Irrigation I - Fish Farming J - Solid Waste Management
2	Practical Tools on Land Management - GPS, Mapping and GIS
3	Practical Tools on Restoration and Conservation of Protected Wetlands
4	Practical Tools on Sustainable Agriculture
5	Practical Tools on Soil and Water Conservation Measures
6	Practical Tools on Agroforestry
7	Practical Tools of Irrigated Agriculture on Non-Protected Wetlands
8	Practical Tools on Soil Productivity and Crop Production
9	Practical Technical Information on Low-cost Technologies: Composting Latrines & Rainwater Harvesting Infrastructure
10	Practical Tools on Water Monitoring Methods and Instrumentation
11	11.1 Practical Tools on Solid Waste Management of Imidugudu, Small Towns and Cities : Landfill and Composting Facilities
	11.2 Practical Tools on Small-scale Incinerators for Biomedical Waste Management

These tools are based on the compilation of relevant subject literature, observations, experience, and advice of colleagues in REMA and other institutions. Mainstreaming gender and social issues has been addressed as cross-cutting issues under the relevant themes during the development of these tools.

The Tool and Guideline # 8 provides practical information on the safe application of soil productivity and crop protection methods and approaches.

These tools could not have been produced without the dedication and cooperation of the REMA editorial staff. Their work is gratefully acknowledged.

**Dr. Rose Mukankomeje**

*Director General, Rwanda Environment Management Authority*

## TABLE OF CONTENT

<b>1. INTRODUCTION.....</b>	<b>4</b>
<b>1.1 OVERVIEW .....</b>	<b>4</b>
<b>1.2 PURPOSE.....</b>	<b>5</b>
<b>2. SOIL PRODUCTIVITY.....</b>	<b>6</b>
<b>2.1 PLANT NUTRITION AND ENVIRONMENTAL ISSUES.....</b>	<b>6</b>
<b>2.2 ENVIRONMENTAL EFFECTS OF NUTRIENTS.....</b>	<b>6</b>
2.2.1 <i>Positive Effects</i> .....	6
2.2.2 <i>Negative Effects</i> .....	6
<b>2.3 PLANT NUTRIENTS.....</b>	<b>8</b>
2.3.1 <i>Nitrogen</i> .....	8
2.3.2 <i>Phosphorus</i> .....	9
2.3.3 <i>Other Nutrients</i> .....	9
<b>2.4 MINIMIZING THE NEGATIVE ENVIRONMENTAL EFFECTS OF NUTRIENT USE .....</b>	<b>9</b>
2.4.1 <i>Improving Fertilizer-use Efficiency</i> .....	9
2.4.2 <i>Managing Nutrients to Minimize Losses</i> .....	10
<b>2.5 SOIL TEST KITS .....</b>	<b>12</b>
<b>2.6 GENDER AND SOCIAL ISSUES IN SOIL PRODUCTIVITY .....</b>	<b>12</b>
<b>3. CROP PROTECTION .....</b>	<b>14</b>
<b>3.1 PLANT PROTECTION AND ENVIRONMENTAL ISSUES.....</b>	<b>14</b>
<b>3.2 POSITIVE AND NEGATIVE EFFECTS OF PESTICIDES .....</b>	<b>14</b>
<b>3.3 SAFE AND EFFICIENT USE OF PESTICIDES .....</b>	<b>15</b>
3.3.1 <i>Introduction</i> .....	15
3.3.2 <i>The Decision Making Process</i> .....	16
3.3.3 <i>Safety Aspects</i> .....	17
3.3.4 <i>Application</i> .....	19
3.3.5 <i>Records</i> .....	20
<b>3.4 GENDER AND SOCIAL ISSUES IN CROP PROTECTION.....</b>	<b>21</b>
<b>ANNEX 1: REFERENCES AND USEFUL RESOURCES .....</b>	<b>23</b>

## TABLES

TABLE 1: ENVIRONMENTAL PROBLEMS ASSOCIATED WITH FERTILIZER.....	7
TABLE 2: STRATEGIES FOR MINIMIZING NITROGEN LOSSES .....	11

# Tools and Guideline # 8

## Practical Tools on Soil Productivity and Crop Protection

### 1. INTRODUCTION

#### 1.1 Overview

The present Government of Rwanda Policy is to increase crop production and raise productivity in the coming years. The opportunity is the increasing focus on land consolidation, crop processing industries, and introduction of new crops of the high market value crops. The opportunities to increase crop production will vary from one area to another. Local development plans will address specific needs to achieve goals.

The government views agriculture as a major driver of national economic growth. Vision 2020 sets out key targets to be achieved by the agricultural sector, which includes:

- Increase the proportion of the country farmed under modern agricultural methods from 3 to 50 percent;
- Increase in fertiliser use from an average of 0.5 to 15 kg ha<sup>-1</sup> yr<sup>-1</sup>;
- Expansion of soil protection from 20 to 90 percent of the country;
- Increase in agricultural production from 1612 to 2200 kcal day<sup>-1</sup> person<sup>-1</sup> (minimum daily needs are typically 2100 kcal); and
- Major increases in export earnings from crops such as tea and coffee.

Agriculture in Rwanda is comprised of two main sub-sectors: rain-fed subsistence agriculture and irrigated land.

#### *Rain-fed agriculture*

Most land in Rwanda is farmed as very small landholdings, primarily for household subsistence. More than 60 percent of households cultivate less than 0.7 ha. Fifty percent cultivate less than 0.5 ha and about 30 percent cultivate less than 0.2 ha. Small plot sizes are aggravated by the fact that most farms consist of multiple, scattered plots. Subsistence agriculture in Rwanda is generally characterised by the high diversity of crops grown throughout the country.

The main types of cultivated crops are food staples, namely: bananas (plantain), beans, sorghum, potatoes (including sweet potatoes), cassava, and maize. Of these, bananas are the most important staple crop in Rwanda, providing a major component of daily calorific intake as well as a key income source. On the other hand, cash crops occupy less than three percent of the harvested land area and consist mainly of coffee and tea. It is important to note that most food crops are inter-cropped and are not cultivated as monocultures, as is the case with some cash crops (e.g. tea). Inter-cropping is a common land-use strategy applied by poor farmers to help them minimise the risk of crop failures.

Crop cultivation practices are generally characterised by very low levels of inputs (e.g. fertilisers and pesticides) and limited mechanisation throughout the production process. As a consequence, crop yields remain low. The yields of several food crops are falling despite increases in the cropped area. Productivity varies in different parts of the country. The most

fertile areas are the volcanic soils of the northwest as well as the larger river valleys and extensive marshlands. In lowland areas in the east, soils are relatively fertile, but there is a long dry season during which irrigation is required to sustain crops.

Traditionally, the lowland savanna landscapes in Rwanda have been pastoral areas, in which large herds of Ankole cattle ranged over large open spaces. As a result of the growing population, much of the lowland areas, especially the wetter and more fertile areas, have been converted to arable farming. Highland areas to the west are characterised by steep slopes and high rainfall. Soil erosion by surface runoff and landslides are common. In highland areas, soils are deep but often heavily leached of nutrient and mineral content. As a consequence, soils in these parts are typically acidic (with a pH of less than 5.0). At low pH levels, aluminum in soil becomes increasingly soluble, which are toxic to plants and could lead to high soil phosphorus fixation. In addition, the organic matter in highland soils is rapidly depleted by deforestation and tillage, which make these areas problematic for long-term cultivation.

### *Irrigated agriculture*

Cultivated area under irrigation is expected to expand significantly with the current programme of agricultural intensification. MINAGRI has planned a program to implement increased agriculture productivity in watersheds covering 30,250 ha of land. Some of these investments may require the construction of dams. Irrigation development may affect the hydrology of catchments that drain into waterways. These types of investments may lead to increased use of inputs (fertilizer, and agricultural chemicals and pesticides).

### *Soil Productivity and Crop Protection*

Use of fertilizers, agricultural chemicals and pesticides can pollute water, springs and wetlands. The intensive agricultural policy is geared to increased use of mineral and organic fertilizers, pesticides and selected seeds. Misuse of agro-chemical products has harmful consequences on natural and artificial biocenosis and on man's health. The effects of these products may also become apparent through deep changes in biological balance.

## **1.2 Purpose**

The objective of this tool is to propose practical information on the safe application of soil productivity and crop protection methods and approaches.

Although not intended to provide an exhaustive account of approaches and situations, this tool is intended to address capacity-building needs of officers by providing information on safe use of soil productivity and crop protection methods and approaches. This tool can be used as field guides or as checklists of elements for discussion during training and during implementation of agriculture investments.

This document was produced to address REMA's proposed policy action to strengthen the resource capacity of environmental and related institutions at national and district level for environmental assessment, policy analysis, monitoring, and enforcement.

## **2. SOIL PRODUCTIVITY**

### **2.1 Plant Nutrition and Environmental Issues**

The section examines the effect of nutrients or other constituents of fertilizers and manures on environment quality, pollution, and human health. Depletion or improvement in soil fertility is also a part of environmental degradation or improvement. Nutrient depletion from soils is a major form of soil degradation. On a global scale, soil fertility depletion is far more widespread than is soil fertility improvement. Nutrient depletion destroys the productive capital of the valuable soil resource. Depletion of soil nutrients is caused primarily by negative nutrient balances, faulty nutrient management strategies and a lack of resources for investment in soil-fertility-enhancing inputs.

Nutrients added through fertilizers, manures and composts can have negative as well as positive effects on the environment depending on how poorly or properly these inputs are managed. The added nutrients may be absorbed by crops, immobilized by the soil or lost from the soil system. Depending on the nutrient and various conditions, these can be lost to the atmosphere by volatilization, lost through soil and water erosion, lost from the soil profile by leaching. Leached Nitrogen (N) can also be lost to the atmosphere through denitrification.

### **2.2 Environmental Effects of Nutrients**

#### **2.2.1 Positive Effects**

The positive effects of nutrients on the environment are:

- Efficient use of plant nutrients ensures that yields are higher than those obtained on the basis of inherent soil fertility by correcting either an overall deficiency or an imbalance of nutrients.
- Nutrients removed from the soil through harvesting and export of produce can be largely replenished through various types of recycling in order to maintain and enhance the production potential of the soil.
- By increasing yields per unit area from suitable arable land, application of plant nutrients allows land of low quality, e.g. land susceptible to erosion, to be withdrawn from cultivation. This reduces the overall pressure on land, including deforestation and overgrazing on non-cropped areas.
- Efficient use of plant nutrients eases the problem of erosion control on the cropped area because of the protection provided by a dense crop cover.
- Balanced plant nutrition also results in an increased addition of organic matter through greater leaf residues, and root and stubble biomass.
- Where balanced fertilization is practised, there is greater N uptake by crops and fewer nitrates are leached down the profile for the pollution of groundwater or further loss through denitrification.
- Integrate nutrient management promotes the correct management of all plant nutrient sources on the farm and helps reduce the losses of plant nutrients to the environment.

#### **2.2.2 Negative Effects**

The negative effects of plant nutrients on the environment need to be considered both at high and low input levels. At high levels of input use, the nutrients applied to the soil are not taken up completely by the growing crop even under the best conditions. Out of the remaining fractions, the soil constituents are able to bind and immobilize most of them so that they do not move freely with soil water and create possible negative impacts on the environment (water and air). Nitrate and, to a lesser extent, sulphate, are not held strongly by the soil and can leach down with percolating waters and contribute to the undesirable enrichment of water.

Phosphate generally moves very little way away from the site of application. Where it does, it is mainly through soil erosion or surface runoff. Over a period of years, phosphate applied through fertilizers or organic manures can move to deeper layers of coarse-textured soils in high rainfall areas. If it exits the soil profile and moves into water bodies, its concentration increases and it can lead to excessive growth of algae, etc. and result in eutrophication to the detriment of other organisms. The relative importance of these phenomena depends on the physico-chemical and biological reactions in which the nutrients take part.

Table 1 summarizes the environmental problems associated with fertilizer use and general strategies to minimize them.

**Table 1: Environmental Problems Associated with Fertilizer**

<i>Problems</i>	<i>Cause Mechanism</i>	<i>Possible Solutions</i>
Surface and groundwater contamination	Leaching of weakly held nutrient forms such as nitrate (most important), chloride, sulphate and boric acid.	Balanced use of fertilizers; optimal loading rates of animal slurry, organic manure and wastewaters; improved practices for increasing nitrogen (N) efficiency; including use of nitrification inhibitors, coated fertilizers and deep placement of N fertilizer super granules where economic; integrated N and water management.
Eutrophication	Nutrients carried away from soils with erosion, surface runoff or groundwater discharge.	Reduce runoff, grow cover crops, adopt water harvesting and controlled irrigation, and control soil erosion.
Stratospheric ozone depletion and global warming	Nitrous oxide emission from soil as a result of denitrification.	Use of nitrification inhibitors, urease inhibitors, increase nitrogen-use efficiency, prevent denitrification.

Most of the problems are largely caused by the incorrect use of nutrients and their poor integration with other production inputs. This implies that most of the problems observed can be controlled if appropriate measures are taken. The negative effect of levels of input use can be summarized as follows:

- The constant removal of crop produce without sufficient replenishment of plant nutrients exported by the crop causes a steady decline in soil fertility. This mining of plant nutrients, leading to severe depletion of soil fertility, is also a kind of soil degradation and a major environmental hazard. The use of low levels of input places additional stress on soil nutrient supplies, resulting in excessive mining of soil nutrients and in depletion of soil fertility, leading to land degradation.
- To the extent that land and labour resources are available, low crop yields resulting from nutrient depletion force farmers to cultivate land under forests or marginal soils that are subject to erosion or desertification and, therefore, not normally fit for cropping. Bringing unsuitable land into cultivation promotes land degradation.
- Soils poor in soil nutrients may suffer from problems such as acidity, salinity, alkalinity and toxicity. Such soils can be made productive with appropriate amendments and a basic input of plant nutrients. Low or zero use of plant nutrients on such soils prevents the development of agriculture on a sustained basis. Organic recycling can only partially solve the problem as the biomass produced on poor soils is itself extremely poor in essential plant nutrients

Effective management practices can prevent or remedy the negative effects of the applications of plant nutrients, both at low and high levels of input. Optimal fertilization can overcome the problem of nutrient depletion and of mining soil fertility. Judicious management of plant nutrients can prevent pollution, mainly through practices that reduce losses of nutrients into

the aquifers or the atmosphere. This can be achieved through balanced, timely, targeted fertilization such as site-specific nutrient management combined with other practices (e.g. improved varieties, water management, and plant protection) that stimulate maximum uptake of plant nutrients by the crop. At the same time, due attention should be given to controlling losses through soil erosion, runoff and land management.

The excessive use of inputs is not advised under any circumstances. High-input application is only justified where the nutrients are balanced and used efficiently. These are also justified only where the crop varieties grown can use the “high input” to achieve high production. Towards this end, farmer education is of utmost importance because these measures have to be taken by individual farmers, often on very small landholdings. Integrate nutrient management is an excellent approach for such improvement at all productivity levels if farmers are advised properly.

## **2.3 Plant Nutrients**

### **2.3.1 Nitrogen**

#### *Nitrogen Losses*

Of all the inputs, nitrogen (N) additions have had the single largest effect on crop yields and also have contributed most to environmental concerns, discussions and problems. Added N that is not absorbed by the crop or immobilized by the soil can be lost from the soil by various means. These include: leaching of nitrate to groundwater; and volatilization of ammonia into the atmosphere and as nitrous oxide (NO) to the atmosphere resulting from denitrification of nitrate by soil organisms. In addition to these, soil and applied N can also be lost through soil erosion and surface runoff. The magnitude of these losses varies greatly between systems and environments. Fertilizers, organic manures, crop residues and crop management (as also the water input) have a major influence on N losses. In flooded-rice cultivation, it is common that 20–30 percent of the applied N is unaccounted for lost after crop harvest. Often, a sizeable portion (30–50 percent) of the applied N remains in the soil and only a small proportion of this is recovered in the following crop. Except for the natural leaching of soil nitrate as a result of rain, most other reasons can be attributed to inadequate fertilization practices and poor water management.

#### *Nitrate Leaching*

Nitrate (NO<sub>3</sub>) is not bound by soil particles and remains in the soil solution where it moves freely with the soil water. Even where the N is applied in the ammonium or amide form, soil bacteria readily transform it under aerobic conditions to nitrate. Given that most N fertilizers are readily soluble, there is generally an excess supply of N immediately after application. The amount that is not taken up by the plant or immobilized by the soil is susceptible to loss. Considerable quantities of nitrate can also be lost from the mineralization of soil organic matter, organic manures, animal slurry, and crop residues. This generally occurs soon after harvest. Losses from animal manures are important contributors to nitrate losses in some areas. Leached nitrate can originate from any potential source. Nitrate lost by leaching or transported in surface runoff can result in increased nitrate concentrations in drinking-water, eutrophication of surface waters and increased production of NO. Factors contributing to nitrate leaching to groundwater are:

- Coarse-textured or extensively cracked soils;
- High concentration of nitrates in the soil profile as a result of excessive applications of N through fertilizers and manures;
- Heavy rainfall that moves nitrates downward;
- Restricted plant root zone (due to plant species, time of year) to intercept nitrates for crop use;

- High water table;
- Uncontrolled flood irrigation.

Not all of the above conditions have to be met for nitrate leaching to occur. However, nitrate leaching is at its maximum where all these factors exist and minimum where the reverse is the case. A deep and extensive root system enables crops to utilize N more efficiently, thus minimizing the risk of leaching. Leaching losses of N can be very high where N is applied to crops that have a shallow root system or that contain a small amount of N in the produce.

### **2.3.2 Phosphorus**

Phosphate (P) occurs in soil in both organic and inorganic forms that differ greatly in terms of their solubility and mobility. P applied through mineral fertilizers is in inorganic forms of varying solubility. Even at optimal rates, the use of mineral fertilizers and organic manures can lead to a build-up of soil P over time. The P thus retained is beneficial rather than harmful as it improves soil fertility and crop productivity.

The P that can contribute to the enrichment of water bodies, and hence lead to eutrophication, is a combination of the P that is attached to soil particles that are transported during soil movement. The risk of P losses to the environment through surface runoff is greatest on sloping lands, and where the fertilizer is surface applied and then followed by rainfall or irrigation.

Phosphate leaching is only a problem on soils that are well supplied or oversupplied with P, especially where they have inadequate capacity to immobilize P. Maintenance of good soil cover is the best protection against such losses. Subsurface leaching of P can take place where:

- (i) P is in soluble organic form, as in manure;
- (ii) The capacity of the soil for binding inorganic P has been exceeded; and
- (iii) A preferential flow of water through channels and cracks in the soil prevents contact with the adsorption sites in the soil.

With good nutrient management, the phosphate losses to the environment can be kept low and within a tolerable range. Losses of P to the environment can be reduced by: (i) avoiding excessive application rates of animal manures and slurries; (ii) soil and water conservation measures to reduce surface runoff and soil erosion; and (iii) balanced nutrient application to enhance crop utilization of available P.

### **2.3.3 Other Nutrients**

Losses of K, Ca, Mg and S to the environment are not considered very important. Deficiencies of some or all of these nutrients result in poor plant growth and the increased risk of soil erosion. Losses of basic cations can occur along with the leaching of anions such as nitrate and chloride. In general, leaching losses are greater where soluble nutrients are not fully utilized by the crop and the soil particles do not have sufficient capacity or reactive surfaces to adsorb them. K can be lost through leaching from coarse-textured soils under heavy rainfall or flood irrigation. The loss of K through leaching and erosion is a waste of resources but it is not known to constitute any environmental or health hazard.

## **2.4 Minimizing the Negative Environmental Effects of Nutrient Use**

### **2.4.1 Improving Fertilizer-use Efficiency**

The negative effects of plant nutrients on the environment are mainly the result of undesirable losses of N through various means and losses of P through surface runoff and soil erosion. The nutrients thus lost enter the atmosphere (in the case of N) and water bodies (in the cases

of N and P). Most of such losses can be reduced by management practices that minimize the negative effects on the environment. These negative effects are not caused by any fundamental properties of these elements but as a result of their interaction with soils and plants under human intervention. Where such losses are small, the negative effects on the environment are also minimal.

N losses can be reduced significantly by adopting practices that improve N utilization by crops and N conservation in the soil. Towards this goal, the integrated management of N with water and balanced nutrient application are of utmost importance for increasing nitrogen-use efficiency. This requires that N application rates not be excessively above the optimum whether delivered through mineral fertilizers or organic manures. In the case of P, appropriate soil and water conservation measures, application rates based on soil P levels and best methods of application are very important. The practices that can lead to improved nitrogen-use efficiency are listed below. These are also practices that will reduce N losses as efficiency and losses are inversely related:

- Matching N application rates with the nature and yield potential of the crop.
- Ensuring a good crop stand and optimal plant population.
- Correcting all nutrient deficiencies in order to provide balanced nutrition.
- Distributing of total N to be applied in splits of 25–40 kg N/ha during crop growth.
- Increasing the number of splits in coarse-textured soils and high rates of N.
- Increasing the number of splits in the case of long-duration varieties.
- Synchronizing N application with moisture availability either through rainfall or irrigation.
- Using nitrification inhibitors where economical and feasible with N fertilizers.
- Avoiding over-irrigation.
- Withholding N application during attacks by pests and diseases.
- Applying pre-plant N below the soil surface for dryland crops.
- Minimizing surface application of urea and ammonia fertilizers to alkaline soils.
- Deep placement of super granules in flooded-rice fields.
- Minimizing nitrate fertilizers to flooded-rice soils.
- Following integrate nutrient management practices i.e. combined application of mineral fertilizers with organic/green manures.
- Preferring S-containing N sources in soils that are also deficient in S.
- Adopting conservation tillage and residue recycling to control surface runoff and promote infiltration.
- Using organic manures to improve infiltration and enhance water holding capacities.

Advances in agricultural technologies (e.g. improved soil sampling and analysis, better plant diagnostic methods, less soil-degrading tillage methods, use of starter fertilizers, and better timing and placement of nutrients) now enable farmers to apply nutrients with greater accuracy, minimizing or avoiding altogether any damage to soil, water, and air.

#### **2.4.2 Managing Nutrients to Minimize Losses**

The best agricultural practices to optimize fertilizer use should include:

- The principles of economic crop production with environmental protection;
- Public confidence that farmers use fertilizers responsibly;
- Planners and policy-makers with a sound understanding of the role of fertilizer in sustainable systems of crop production.

The need for widespread dissemination and adoption of best agricultural practices cannot be overemphasized. When this happens, nutrient management will be based on scientific findings, it will be efficient, profitable and associated with minimum adverse effect on the environment, a concern common to all sources of nutrients be they mineral fertilizers or organic manures.

Efficient use of fertilizers and manures ensure that minimum amounts are left to be lost permanently from a site. Developments of nutrient budgets are the most practical way of preventing losses of nutrients to the environment. This, together with an understanding of the loss processes, can help to reduce losses to an environmentally acceptable level or even eliminate them. Table 2 summarizes the conditions favouring N losses and general strategies for minimizing them.

**Table 2: Strategies for Minimizing Nitrogen Losses**

<i>Channel of N loss</i>	<i>Conditions that favour loss of N</i>	<i>Strategies for minimizing N loss</i>
Volatilization (loss as ammonia)	Sandy soils	Mix fertilizers with soil
	Ammonium or urea fertilizer left on soil surface	Drill basal dose for upland crops, follow N broadcast by hoeing, light irrigation, etc.
	Alkaline soils/over liming	Use gypsum, pyrite and organic manure
	Shallow N application in flooded-rice soils	Practice split application of N
Leaching (loss of N from root zone with drainage water)	Sandy soils	Add organic matter
	High rainfall areas	Split application of N (more splits at higher rates of N)
	Heavily irrigated fields (more water/irrigation)	Controlled/light irrigations (less water per irrigation)
	Heavy N applications or all N as basal	More splits of N for long duration crops/varieties and in high rainfall areas
	Unbalanced fertilizer application leading to poor utilization of N	Balanced fertilization to ensure better utilization of applied N fertilizer  Use soil-cured urea or neem coated urea
Denitrification (Gaseous loss owing to biological or chemical decomposition of nitrate)	Conditions favouring movement of nitrate into lower depths, compact pockets	High temperature Acidic pH (for chemical denitrification), nonacidic condition (for biological denitrification)
	Waterlogged soils, poor soil aeration	Improve drainage and soil aeration, avoid soil compaction
	Addition of nitrate N to waterlogged soils	Adopt practices to conserve N in ammonium form in reduced soils (flooded rice)  Use non-nitrate sources for basal application
	Surface application of N to flooded rice soils	Place USG or NH <sub>4</sub> -N 10–15 cm deep in flooded-rice soils  Lime acid soils
Erosion/runoff (loss of N through surface flow due to heavy rains, over irrigation or soil erosion)	Sloping lands	Inadequate moisture conservation Contour cultivation Land levelling Lack of soil cover Minimum/zero tillage
	Poorly levelled fields	Suitable moisture conservation practices (ploughing before rain, bunding, mulching etc)
	High level of tillage	Incorporate fertilizer in soil  Controlled and light irrigations

## **2.5 Soil Test Kits**

It is suggested that some section or district officers be equipped with Soil Fertility test kits. These are designed for economical on-site evaluations of soil fertility. The test kit provides a simple, effective way for analysts to determine nitrogen, phosphorus, and potassium content of the soil. Some test kits also includes a pH tester for quick pH measurements.

## **2.6 Gender and Social Issues in Soil Productivity**

In Rwanda, productive agriculture land is scarce and soil quality is declining. Growth in food production will depend primarily on further intensification of agriculture, mostly in high-potential areas. Yet unless considerable care is taken, intensification can exact a heavy toll on soil health, fertility, and productivity.

Improving soil health is the first entry point for correcting soil nutrient imbalances, improving agricultural productivity. Soil fertility is an important component of soil health, along with organic matter content and microorganism populations. Another critical entry point for improving soil productivity is the adequate, location-specific choice of crops and crop management practices.

Women—especially if they are the main providers of staple food crops—are particularly affected by declining soil fertility. Men often control the best land with the best soil to produce commercial crops, and women more often farm marginal land. They have limited or no access to external inputs such as fertilizer. Often they have less access to land because inheritance laws and other legal and cultural norms favour men. When women own farmland, their plots are generally smaller than those owned by men.

The approach to soil fertility management has evolved considerably. Alternatives to inorganic fertilizer are available. The use of animal manure, agro-forestry, legumes, living mulch, compost, and other technologies that enhance soil fertility is traditional in many farming systems, especially systems that are managed and controlled by women. Low-external-input strategies to improve soil fertility are often labour and knowledge intensive. Consequently they may be difficult for resource-poor farmers to adopt, given their limited access to labour and information, especially in remote areas where few formal institutions exist to strengthen human and social capital.

Despite the recognized importance of low-external-input strategies, chemical fertilizer remains the basis of soil fertility management in many farming systems and most intensification trajectories. Chemical fertilizer is central to most extension messages, and the use of nitrogenous fertilizer will increase rapidly in Rwanda. For a host of economic and logistical reasons, however, resource-poor farmers, including women, cannot apply fertilizer at high rates. The cost of fertilizer can represent a high proportion of the total variable cost of production, an investment that poor farmers can ill afford where there is a risk of crop failure.

As mentioned earlier, improving soil productivity is a key to improving food security. Women may benefit from improved crop production by selling surplus in the local market. Enhanced crop productivity could thus be a starting point for livelihood diversification. Increased soil productivity also increases returns to labour, which is especially important for labour-constrained women, because it may free time for additional activities. Zero-tillage systems, cover crops, and mulches, for example, can significantly improve soil productivity and at the same time reduce labour for weeding. These alternatives are often context specific; mulching, for instance, is more appropriate for small-scale farming.

Actions to address key gender and social issues in managing soil productivity can be clustered into three categories:

- *The use of chemical fertilizer:* Many reasons account for women's limited use of fertilizer. As mentioned earlier, because fertilizer is mainly sold in large quantities, it is a big investment, especially for cash-constrained women. Women usually have less access to transport and find it more difficult to carry bags of fertilizer home. In remote rural areas, fertilizer is not usually readily available, and thus it is especially difficult for women, who have fewer opportunities to leave the village, to obtain. All of these constraints reveal strategic entry points for interventions that could improve women's use of fertilizer.
- *The use of low-external-input technologies, including synergistic effects of fertilizer and other practices:* For resource-poor farmers engaged mainly in subsistence production, low-external-input technologies are usually a more affordable way to improve soil productivity. Crop rotations, improved fallows, agro-forestry systems, integrated soil and water management practices, and the choice of suitable crops are some of the options. Recognizing the beneficial effects of legumes on soil productivity, women farmers often grow legumes in combination with other crops such as tubers and cereals, but this practice requires, among other resources, farmers' time and knowledge.
- *The appropriate choice of crops and crop management practices to enhance soil productivity:* Soil fertility is only one component of overall soil productivity. Many more possibilities are available to enhance soil productivity. The selection of appropriate crops, in combination with soil-improving practices, is one alternative. Horticultural crops are management intensive, a variety of crops are grown, the cash outlay is large, and the use of chemicals is heavy (inflicting considerable harm on the environment. Horticultural enterprises are risky, because of pest outbreaks and volatile prices. Fruit production requires an investment of several years to recoup costs. The production of high-value horticultural crops for export leads to labour shortages, which force women to reduce the time devoted to independent income-producing activities or crops under their own control, with potentially negative impacts on food security. Organic production, with the corresponding practices to maintain soil fertility and soil health, may be a potentially more benign alternative to conventional, high-value horticulture. Organic farming fights hunger, tackles climate change, and is good for farmers, consumers, and the environment. Organic farming is now regarded less as a niche market and more as a vibrant commercial agricultural system practiced. The strongest benefits of organic agriculture are its use of resources that are independent of fossil fuels, are locally available, incur minimal agro-ecological stresses, and are cost effective. Some have argued that women farmers, who already rely on few external inputs, may be well positioned to become organic producers and benefit from the rising interest in organic produce. This may be an interesting avenue for Rwanda.

### 3. CROP PROTECTION

#### 3.1 Plant Protection and Environmental Issues

The term "pesticide" is a composite term that includes all chemicals that are used to kill or control pests. In agriculture, this includes herbicides (weeds), insecticides (insects), fungicides (fungi), nematocides (nematodes), and rodenticides (vertebrate poisons).

Pesticides are included in a broad range of organic micro pollutants that have ecological impacts. Different categories of pesticides have different types of effects on living organisms, therefore generalization is difficult. Although terrestrial impacts by pesticides do occur, the principal pathway that causes ecological impacts is that of water contaminated by pesticide runoff. The two principal mechanisms are bioconcentration and biomagnification.

- **Bioconcentration:** This is the movement of a chemical from the surrounding medium into an organism. The primary "sink" for some pesticides is fatty tissue ("lipids"). Some pesticides, such as DDT, are "lipophilic", meaning that they are soluble in, and accumulate in, fatty tissue such as edible fish tissue and human fatty tissue. Other pesticides such as 'glyphosate' are metabolized and excreted.
- **Biomagnification:** This term describes the increasing concentration of a chemical as food energy is transformed within the food chain. As smaller organisms are eaten by larger organisms, the concentration of pesticides and other chemicals are increasingly magnified in tissue and other organs. Very high concentrations can be observed in top predators, including man.

#### 3.2 Positive and Negative Effects of Pesticides

Use of pesticides can have unintended effects on the environment. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non target species, air, water, bottom sediments, and food. Pesticide contaminates land and water when it escapes from production sites and storage tanks, when it runs off from fields, when it is discarded, when it is sprayed aerially, and when it is sprayed into water to kill algae. The amount of pesticide that migrates from the intended application area is influenced by the particular chemical's properties: its propensity for binding to soil, its vapour pressure, its water solubility, and its resistance to being broken down over time. Factors in the soil, such as its texture, its ability to retain water, and the amount of organic matter contained in it, also affect the amount of pesticide that will leave the area. Some pesticides contribute to global warming and the depletion of the ozone layer.

- **Air:** Pesticides can contribute to air pollution. Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Ground spraying produces less pesticide drift.
- **Water:** Pesticides are found to pollute streams and wells. There are four major routes through which pesticides reach the water: it may drift outside of the intended area when it is sprayed, it may percolate, or leach, through the soil, it may be carried to the water as runoff, or it may be spilled, for example accidentally or through neglect. They may also be carried to water by eroding soil. Factors that affect a pesticide's ability to contaminate water include its water solubility, the distance from an application site to a body of water, weather, soil type, presence of a growing crop, and the method used to apply the chemical.
- **Soil:** many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation. The use of pesticides decreases the general biodiversity in the soil. Not using the chemicals

results in higher soil quality, with the additional effect that more organic matter in the soil allows for higher water retention. This helps increase yields for farms in drought years, when organic farms have had yields 20-40% higher than their conventional counterparts. A smaller content of organic matter in the soil increases the amount of pesticide that will leave the area of application, because organic matter binds to and helps break down pesticides.

Persistent organic pollutants (POPs) are compounds that resist degradation and thus remain in the environment for years. Some pesticides, including aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene, are considered POPs. POPs have the ability to volatilize and travel great distances through the atmosphere to become deposited in remote regions. The chemicals also have the ability to bioaccumulate and biomagnify, and can bioconcentrate (i.e. become more concentrated) up to 70,000 times their original concentrations. POPs may continue to poison non-target organisms in the environment and increase risk to humans by disruption in the endocrine, reproductive, and immune systems; cancer; neurobehavioral disorders, infertility and mutagenic effects, although very little is currently known about these chronic effects. Some POPs have been banned, while others continue to be used.

### **3.3 Safe and Efficient Use of Pesticides**

This section looks on how to improve the safe and efficient use of pesticides within systems of sustainable agriculture and integrated pest management. This section cover the application of pesticides using any ground based field crop sprayers, including operator carried and tree and bush crop sprayers.

#### **3.3.1 Introduction**

When using an approved pesticide, the objective is to distribute the correct dose to a defined target with the minimum of wastage due to drift using the most appropriate spraying equipment. Pesticides only give acceptable field results if they are delivered safely and precisely. Unlike other field operations, the results from poor spraying may not become apparent for some time so that it is essential that those involved in pesticide selection and use are fully aware of their responsibilities and obligations, and are trained in pesticide use and application.

These guidelines have been prepared to offer practical help and guidance to all those involved in using pesticides for food and fibre production. They cover the main terrestrial spray application equipment such as knapsack sprayers, boom and air assisted sprayers using hydraulic spray nozzles. This code of practice has been designed to provide supportive information and practical advice on acceptable safe practices once a decision has been taken to use a pesticide.

The guidelines are aimed at decision-makers, managers, field supervisors and spray operatives.

#### ***Operator training***

Operators of spray equipment must receive suitable training before handling and applying pesticides. Training should be provided by a recognized provider and courses are frequently offered by local training groups, agricultural colleges, government extension departments, spray equipment manufacturers and the chemical industry. The satisfactory completion of a course may result in a recognized certificate of competence to cover: safe product handling, delivery of the product to the target instruction on using the relevant spray equipment.

It is important that as technology moves forward, field spray operators are kept up to date with new methodology to help ensuring that pesticides are safely used. In some countries where spray operators are licensed, they can only renew their operator's license if they attended regular refresher courses. Operator training is best to be organized and provided through sustainable permanent national structures.

### ***Spray Equipment Selection***

The selection of appropriate and suitable spray equipment is essential safe and effective pesticide use. Equally important when selecting spraying equipment is access to spare parts, service and support facilities. Ideally, equipment selection should not be based primarily on cost. Safety, design, comfort and ease of use must be major considerations, and ease of maintenance must be a high priority. Knapsack sprayer maintenance should require only simple tools. The combination of operator training to a recognized standard, combined with the selection of appropriate spray equipment will contribute to improving the accuracy of pesticide delivery as well as protecting the environment.

### ***Using Pesticides Correctly***

Pesticides should only be used if there is an economically important need and all pesticides must be used strictly in accordance with their label recommendation. Product selection must assess the potential exposure hazard of the selected formulation and determine what control measures and dose rates the label recommendations advocate.

### ***Managing Operator Exposure***

The use of personnel protective equipment is essential for protecting operator health and advice on its use will be found on the product label. Effective health monitoring records will be able to provide early warnings and identify changes in operator health, which may be attributed to working with pesticides. As well as the workers handling and spraying pesticides, the public must be safeguarded, both during, and after spraying, for example where they might have access to a treated area. Livestock also ought to be prevented from re-entering treated areas immediately after spraying.

## **3.3.2 The Decision Making Process**

The use of pesticides may put people, other life forms and the environment at risk; thus, the decision to use a pesticide should only be taken when all other alternative control measures have been fully considered. Integrated Pest management offers a pest management system that combines all appropriate control techniques to effect satisfactory results.

### ***Alternatives to Pesticide Use***

The alternatives can be divided into natural and applied control measures. Natural control may utilize naturally occurring pest enemies, or rely on meteorological conditions, to affect pest and disease control. Applied control may be based on crop rotation, cultivar or variety selection, changes in sowing dates and or alterations in cultivation practices. The use of some or all of the above techniques, together with carefully selected pesticides, can provide an integrated approach to weed, pest and disease control.

### ***Risk/benefit Considerations***

The risks and benefits of using a pesticide must be addressed before chemical product selection. By completing a risk assessment, harmful effects can be kept to a minimum. In some cases a prophylactic treatment e.g. seed treatment may be justified but the effect of

weeds pest and disease on crop yield reduction should be monitored to determine when it is economically justified to use a pesticide.

Such information should be gathered by systematically by regular inspection of the crop to monitor pest numbers or weed species and their appearance frequency, in combination with the use of insect traps to assist treatment timing. An understanding of the pests' life cycle and the crop's ability to compensate for any pest or disease damage will also help in decision-making.

### ***Product Selection***

The decision to select a given pesticide product must be based on an assessment of the risks and benefits, the materials hazard potential to both man and the environment. Legislation is in place to control and regulate the manufacture, importation, distribution and sale of pesticides. Products are registered for use, after local field evaluation for safety and efficiency and only approved and recommended products can be used. Where there is a choice of product, the material offering the least hazard should always be selected.

### ***Label Information***

The manufacturer's product label is the main source of information for the end user. It must be written in an appropriate local language, so that it can be read and understood by users. Label terminology must be understood by pesticide users. The label is attached to the product container and is usually reproduced on the outer container or wrapper of the transport container or carton. In most countries, adhering to the label recommendation is a legal obligation.

The product label carries statutory instructions for the user, which must cover the crops for which it is registered, the recommended dose rate, the number of permitted treatments during the growing season and how many days before harvest the last treatment may be applied. Additionally, the label will inform the user of the correct personal protective equipment to be used when handling and applying the product and advice on environmental protection measures to be carried out. Labels may refer to "non-spray" barriers for when products are to be used near waterways or sensitive environmental areas. The widths of unsprayed barriers are dictated by the pesticide, the sprayer type and setting, and its drift potential. Label information on suitable application technology, nozzle selection, volume of spray solution and correct spray timing will also help to improve product safety. The label also provides other relevant and useful safety information, which will include the product common name, chemical name, the manufacturers name and a contact in the event of an accident. The label must also be available for medical staff treating anyone who has been accidentally poisoned or contaminated by the pesticide. A good copy of the label must be retained as reference for the emergency services in the event of an accident. Information on the decontamination and disposal of empty containers is also usually included on the label.

### **3.3.3 Safety Aspects**

The overall safety of crop protection chemicals must be the objective of all pesticide users as well as those engaged in the storage, distribution and retailing of agrochemicals.

### ***Operator Health Surveillance***

The health of operators exposed to pesticides must be monitored. The surveillance should cover health records and medical checks, which can alert medical authorities of any health changes, which might be related to exposure during work. The hazard potential of the selected

product, combined with the length of time of operator exposure during use will determine the health surveillance techniques and their frequency.

### ***Application Timing***

In relation to safe and efficient pesticide use correct application timing is often poorly understood. The optimum time to spray is determined by the crop, pest, weed and disease growth stages. The product label will indicate treatment timing but it is usually at the start of an infestation that the lower label dose rates can be used. Application timing will also be influenced by meteorological conditions, which may result in physical, and volatility spray losses. Temperature, relative humidity, wind direction and velocity plus the possibility of rain can all affect the efficiency of spray.

### ***Product Transport and Storage***

Transporting pesticides by road may be controlled by national regulations for the movement of dangerous goods where emergency procedures in the event of a road accident are already in place. Many pesticide manufacturers issue Transport Emergency Cards (“Tremcards”) to vehicle drivers transporting hazardous pesticides. As well as the journey from the retailer to the end user, pesticide containers are also moved in and out of stores on the farm. In all cases, they must be checked for leaks and damage and must always remain clearly labelled.

Pesticide containers must be kept closed when not in use and must be secured against unauthorised interference, particularly when spray operators are working away from mixing areas and cannot always see the chemical containers. The storage of pesticides on the farm should be covered by local legislation and farm stocks of pesticides must be kept to a workable minimum to cover peak demand. Correct storage is essential to maintain a safe working environment, to maximise product shelf life and to minimise the risk of fires and spillage. Varying climatic conditions and specific product demands (flammability-toxicity) make it difficult to offer other than general recommendations in these guidelines. Pesticides must be kept in a dedicated store, which is accessible in case of emergency and can be locked when not in use. Under no circumstances must pesticides be stored near foodstuffs!

### ***Product Handling***

The product label is usually the first reference for guidance on handling the formulated pesticide products. It will usually describe the requirements for the use of personal protective equipment both for handling the concentrate and for the diluted spray solution to be used in the field. Only approved safety equipment must be used. Certain toxic chemicals may only be approved for use if they are handled and dispensed via fully tested and officially approved closed dispensing systems. Such systems reduce operator and environmental contamination.

### ***Chemical Container Management***

Unfortunately empty chemical containers often have second-hand values, however, empty pesticide containers must never be re-used by users. Containers can be thoroughly cleaned manually. The problems associated with container rinsing and disposal can be eliminated by using systems of returning chemical containers to suppliers, where they can be re-filled or recycled.

### ***Accident Procedures***

If an accident occurs during transport or handling a pesticide, the spillage may result in fire, injury to humans, property damage or environmental contamination. Rapid action must follow the accident to minimise adverse effects. It is essential that pesticide transporters and users are

familiar with label recommendations and procedures in the event of an accident and the appropriate authorities (Environmental, Water, Police etc) are informed of the accident and the corrective procedures followed. All spillage incidents and the actions taken must be accurately recorded. Vehicles used to transport pesticides must be decontaminated following an accident or spillage.

### ***Personal Protection***

There are three principal routes that chemicals enter the body:

- Accidental or deliberate ingestion.
- Dermal, through handling, measuring and pouring the concentrate.
- Inhalation of small particles or dust during handling and spraying.

Dermal exposure represents the most common hazard. Avoiding exposure by using personal protection equipment and by paying attention to personal hygiene by washing exposed parts of the body after work and before eating, smoking and toileting will minimize risk. Personal protection equipment must be selected in accordance with the label recommendation. It must be comfortable to wear/use and be made of material, which will prevent penetration of the pesticide.

Personal protective equipment will only remain effective if it is correctly selected and maintained. Where the equipment is damaged, repairs must restore it to its original condition otherwise the item must be replaced. Items such as the respirator must be checked on a regular basis and filter elements changed in accordance with the manufacturer's instructions.

### **3.3.4 Application**

#### ***Pre-application***

Time taken to check spray equipment before use will reduce costly delays when the season begins. Pre-season operational checks can be carried out with clean water but safety clothing should always be worn.

#### ***Spray Equipment Selection***

Selecting the appropriate equipment for the pesticide formulation to be used is important. For example, most pesticides will be sprayed as aqueous solutions through portable hydraulic spray systems.

#### ***Field Application***

Adequate pre-preparation will help make sure that the actual spraying is carried out under the safe conditions and accurate spray timing will ensure that the product is applied with optimum effect. Operators must make sure that all safety equipment and clothing is clean and in a good state of repair.

#### ***Meteorological Considerations***

Spray deposit efficiency is greatly influenced by local meteorological conditions at crop height. Wind velocity and direction, temperature, relative humidity and the frequency of rain all influence spray deposit. The distance that a spray droplet travels depends on the droplets downward velocity, the height of release and the wind speed. The larger the drop the less it is effected by wind and the faster it falls thus reducing drift, but the distribution efficiency will also be reduced, which may in turn lessen the performance of a non-systemic product. Wind direction must also be considered as spray droplets may be transported out of the treated area

and onto adjacent susceptible crops or waterways. Wind speeds of between 1 and 2m/sec, (3.6 to 7.2 km/h) are generally considered ideal for hydraulic nozzle treatments.

### ***Treatment Timing***

If application timing is accurate, fewer spray treatments may be needed. The time of day a treatment is applied can be important. The optimum spray timing for efficacy may coincide with the foraging time of beneficial insects. It is therefore important to know and understand crop, insect and disease development and the ecological balance to determine when to spray. An understanding of product mode of action in relation to crop development will also be advantageous.

### ***Post Treatment Warnings***

Immediately after the spray has been applied warning notices should be posted around the treated area in accordance with label recommendations. Recipients of warnings such as beekeepers can be told that the application has been completed. The field notice should alert people of the treatment and instruct them of the re-entry period. Notices should be removed when no longer required. Livestock must be kept out of treated areas for the required time period.

### ***Equipment Storage***

Refer to the equipment instruction book for the manufacturer recommendations. Spray equipment should be dried before final storage, which should preferably be undercover and secure. Where necessary, pumps and spray systems should be fully drained before storage and filled with rust proof inhibitor.

### ***Pesticide Storage***

Unused pesticide must be stored properly. Pesticides in or damaged containers should be emptied into clean replacement containers, which are fully labelled. Store stock control must ensure that old stock is used before recently purchased similar new products. Good stock control and accurate planning will mean that waste concentrate and diluted spray is kept to a minimum. However, where old or obsolete chemical products have to be disposed of an approved contractor must be used. Chemicals for disposal must be secure in their original containers, fully labelled in accordance with local regulations.

### **3.3.5 Records**

Keeping records of pesticide use and application is good management. Good records can be referred to in the event of off-target contamination or if a complaint arises from poor field performance. Records can assist pesticide stock control and can provide a useful reference guide to product performance for future decision-making. In some countries where record keeping is mandatory, enforcement officers are empowered to refer to previous years' records if an investigation is needed, sometimes up to three years. However, where operator health is monitored the records may have to be retained for considerably longer. Records should cover both details of the actual application and any operator health observations carried out.

### ***Field Spray Records***

An accurate and comprehensive recording system must cover all the relevant information and be simple to complete. The following information should be included: application date and

time, operator's name, field location, adjacent crops, treated crop and growth stage, products used and dose rate, target pest and growth stage, tank-mix information, total chemical used, adjuvant used, water volume used, personal protective equipment used, "No-spray" barrier information, meteorological conditions at and after spraying, notes to cover errors/problems, operator exposure and duration.

### ***Equipment Repairs and Maintenance***

Repairs to spray equipment should be noted, and changes in spray technique during the season, nozzle and or operating pressure change, must be listed for future reference. Equipment repairs must be promptly addressed and replacement parts ordered. Spare nozzles, anti-drip valve diaphragms, pump diaphragms and valves for both tractor and knapsack sprayers should be kept in stock.

### ***Operator Health Surveillance***

Where label recommendations or local regulations demand operator health surveillance, a record should be dedicated to each operator to cover name and health details (previous health history) when working with a particular product. Exposure time periods must be listed to include the date of the initial exposure to the product and any recommendations coming from a clinical practitioner completing the monitoring. Contact by the operator with other chemical products must also be recorded.

### ***Personal Protective Equipment***

Personal protected equipment is only as good as its maintenance and should be provided to individuals. To make sure safety equipment gives maximum protection full operator training is important. Wearing protective clothing on its own does not guarantee total protection if equipment becomes defective through wear or damage so regular visual checking must be carried out. Specialist equipment, such as respirator must be checked in accordance with the manufacturer's recommendation.

### ***Local Emergency Contacts***

In the event of an accident, an accessible list of local emergency contacts should be available to cover appropriate medical facilities with access to poisons information. A useful starting point would be the local chemical manufacturer and or supplier who should be up to date with product information and accident procedures. Contacts, such as local water authorities, government environmental officers and the emergency services, should all be listed and a trained local first aid practitioner appointed. The first-aider should be conversant with the chemical products in use and the emergency procedures in the event of an accident. The first-aider should have copies of all the latest product labels for reference.

## **3.4 Gender and Social Issues in Crop Protection**

Attempts to control agricultural pests have been dominated by chemical control strategies, but the overuse of chemicals can have adverse affect on human health and the environment. Poor awareness of safe practices for handling chemicals and a lack of appropriate protective equipment also contribute to injuries. Pesticides can increase agricultural productivity, but when handled improperly, they are toxic to humans and other species. Many farmers may also overuse pesticides and may not take proper safety precautions because they do not understand the risks and fear smaller harvests.

Pesticides may cause particular health hazards for women, who often do the planting and weeding work. Compared to men, women are usually less informed about safe pesticide

practices and the dangerous side effects of pesticide use. High levels of pesticide poisoning among resource-poor farmers, especially women, are often reported to be linked to low levels of literacy and education. In many cases, the husband is responsible for buying pesticide from the cooperative, market, or storekeeper, and no information is passed between the husband and wife about safe use—with the result, for example, that women reuse pesticide containers for storing or transporting their crops or cooking supplies. Often pesticide products are not labelled, but even if they are, many women cannot read the information. Although educating people in proper pesticide management is extremely important, education alone will not prevent poisoning.

Pesticide use is capital intensive; the pesticide, sprayer, and protective gear all must be purchased. Women's limited access to productive resources often makes them more reluctant than men to purchase inputs such as pesticides to use on their crops (which are usually food crops). To benefit women, pest control mechanisms must be tailored to the pests encountered in staple and minor crop production.

Crops can be protected from pests in ways that preclude the use of hazardous chemicals, including integrated pest management, organic crop production, and the use of less toxic chemical products. Integrated pest management is an approach to enhancing crop and livestock production, based on an understanding of ecological principles, that empowers farmers to promote the health of crops and animals within a well-balanced agro-ecosystem, making full use of available technologies, especially host resistance, biological control and cultural control methods. Chemical pesticides are used only when the above measures fail to keep pests below acceptable levels, and when assessment of associated risks and benefits indicates that the benefits of their use outweigh the costs. Integrated pest management should go hand in hand with appropriate pesticide management to allow for pesticide regulation and control, and for the safe handling and disposal of pesticides, particularly those that are toxic and persistent. Cumulative evidence shows that farmers trained in appropriate methods of pesticide use suffer lower exposure and can achieve higher net returns than those who are not trained. Other approaches to reduce pesticide use are the promotion of less toxic pesticides, the promotion of organic farming, and the development of pest- and disease-resistant crops.

Only safe, correct management will minimize the negative consequences of pesticides for human and environmental health and foster their sustained, positive impact on crop production and farmers' overall livelihoods. Given rural women's generally poor access to information and extension exposure, it remains a challenge to convey message about safe pesticide use to them.

Pest control is undoubtedly essential for commercial and subsistence farming systems to meet the growing demand for food and contribute to other development goals, but evidence is mounting that the sole reliance on pesticides to achieve such objectives is unsustainable. The high environmental and human costs of pesticide use must now be taken into account, along with the considerable gender effects of pesticide use, which despite their seriousness have been largely ignored. Several actions could be considered, such as:

- Alternatives to pesticide use must be promoted actively.
- Farmers require solutions to their crop protection problems that take account of gender-specific needs.
- Training, information, and extension services to women are essential or else they will continue to bear many of the consequences of unsafe pesticide use.
- Messages designed to improve women's awareness, knowledge, and skills with respect to safe pesticide use must be designed to overcome the barriers that are often raised by women's lower socioeconomic status, more limited education, and other constraints.
- The use of alternative communication channels should be explored.

## Annex 1: References and Useful Resources

- REMA (2009): Rwanda State of Environment and Outlook Report, Rwanda Environment Management Authority, P.O. Box 7436 Kigali, Rwanda  
<http://www.rema.gov.rw/soe/>
- CIDA, Environmental Handbook for Community Development Initiatives (2002), Second Edition of the *Handbook on Environmental Assessment of Non-Governmental Organizations and Institutions Programs and Projects (1997)* <http://www.acdi-cida.gc.ca/acdi-cida/ACDI-CIDA.nsf/eng/JUD-47134825-NVT>
- USAID, Environmental Guidelines for Small-Scale Activities in Africa: Environmentally Sound Design for Planning and Implementing Development Activities, U.S. Agency for International Development, Office of Sustainable Development, Draft Version, January 2005, [www.encapafrika.org](http://www.encapafrika.org).
- Sustainable agriculture extension manual for Eastern and Southern Africa: (<http://www.mamud.com/sustagafrica.htm>)
- FAO (1988). *Good Practice for Ground and Aerial Applications of Pesticides*. Rome: Food and Agriculture Organization of the United Nations.  
[http://www.fao.org/documents/show\\_cdr.asp?url\\_file=/DOCREP/006/Y2766E/Y2766E00.HTM](http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/Y2766E/Y2766E00.HTM)
- FAO (1995). *Guidelines on Good Labelling Practice for Pesticides*. Rome: Food and Agriculture Organization of the United Nations.  
[http://www.fao.org/documents/show\\_cdr.asp?url\\_file=/DOCREP/006/Y2767E/Y2767E00.HTM](http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/Y2767E/Y2767E00.HTM)
- FAO (1990). *Guidelines for Personal Protection When Working with Pesticides in Tropical Climates*. Rome: Food and Agriculture Organization of the United Nations.  
<http://www.fao.org/ag/agp/agpp/pesticide/Code/Download/protect.doc>.
- FAO (1995). *Pesticide Storage and Stock Control Manual*. Rome: Food and Agriculture Organization of the United Nations.  
[http://www.fao.org/documents/show\\_cdr.asp?url\\_file=/docrep/V8966E/V8966E00.htm](http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/V8966E/V8966E00.htm)
- Overholt, W., and C. Castleton (1989). *Pesticide User's Guide: A Handbook for African Extension Workers*. African Emergency Locust/Grasshopper Project 698-0517. Bureau for Africa's Office of Technical Resources. Washington, D.C.: USAID.
- CARE (2003). *Guidelines for Promoting Safer and More Effective Pest Management with Smallholder Farmers: A Contribution to USAID-FFP Environmental Compliance*. Prepared for CARE's FRCT by Sarah Gladstone and Allan Hruska. Atlanta, Georgia: CARE.