8 Farm management skills

8.1 Observing the crop and its environment

Why should we do routine observation?

Field observation is the key to making appropriate crop cultivation decisions. By observing the field and its surrounding environment thoroughly and regularly, farmers will keep up to date on what the conditions in the field are like. Hence, they will not have to be afraid of any unexpected problems, such as a pest outbreak or drought, as they will usually then be able to handle an upcoming problem in time.

For a crop like sweetpotato, weekly observations are usually frequent enough to anticipate problems, unless the weather or water supply conditions are unfavourable, or when a pest population develops more rapidly than the natural enemy populations. After each observation we should determine when we have to do the next observation, based on the conditions found in the field. Field observation can be done best during the morning hours before 10:00 a.m., because later in the day the sun becomes too hot and bright for careful observation and causes most insects to hide in cool, dark places where they are harder to see.

Observation of the environment

Observation of the surrounding environment of the field helps us to identify and understand sources of problems that appear in the field. If there is no obvious problem, a quick check should be made by looking at:

- The weather condition
- The condition of the soil
- The condition along the edge of the field (hedges, ditches, roads) with regard to potentially harmful plants and animals (weeds, pests) or beneficial ones (natural enemies, plants providing food and shelter for natural enemies)
- The condition of the neighbouring fields with regard to crop damage as an indicator of the existence of a source of pests and/or diseases.

Crop observation

In order to draw conclusions about the condition of the crop and actions to be taken, we do not have to observe the entire field; observation of a representative sample is sufficient. Based on the sample, we can make a decision about what has to be done. For a field smaller than 2,000 m^2, the sample should be taken using about ten observation points: for a larger field, more observation points should be taken. These ten observation points in a field are selected randomly on a diagonal line, i.e. from corner to corner crossing through the centre of the field. Crossing through a field is important so that both edges and centre areas are represented in the sample, since conditions (e.g. water, pest occurrence) may vary from place to place in a field. Some pests only eat at the edges (e.g. mole crickets), while others prefer the centre of the field (e.g. rats).

To determine the location of each observation point in a random manner, we could walk a certain number of steps from one point to another and observe the spot in front of our feet at the last step. For instance, if the length of the diagonal line cutting through the field is about 75 m (100 steps), the distance between observation points should be 7.5 m or 10 steps. We should avoid purposely selecting observation points with either good or bad looking plants. For sweetpotato, one observation point should cover an area of 0.5 m^2 across the width of the ridge, or mound, or 0.5 by 0.5 m in the case of raised or flat beds. Try and walk quietly and carefully through the field so that you don't disturb or damage the insects or plants which you are trying to observe. Observation should be done in the following sequence:

- Observe anything flying above the foliage (e.g. dragonflies, butterflies), and on the foliage (e.g. ladybird beetles, rove beetles, spider webs, grasshoppers)
- Lift the vines carefully to see what can be found in the foliage and on the soil surface (e.g. hunting spiders, ants, rove beetles, frogs)
- Check leaves and vines for insects (e.g. leaf eating caterpillars, aphids, thrips), diseases and nutrient deficiency symptoms
- If available, sweep nets can also be used to help sample highly mobile insects
- Remove some soil so that the roots are partly exposed, and observe the growth stage of the storage roots. Check the roots for damage by weevils or other insects
- Observe the condition of the soil (structure and moisture).

8.2 Experimentation

Experimentation at the farm-level is a major tool to test and adjust technologies according to the local conditions. In order to develop technologies that suit specific conditions of a farm, farmers need to be able to experiment or test and modify new technologies according to the local conditions. Farmers must therefore get involved in the design, implementation and evaluation of simple experiments in order that they can determine the merits of different technologies. The experiments should provide reliable information for decision making.

8.2.1 Experimental design

Experimentation begins by identifying constraints and potential solutions, and goes through the following stages:

- Identification of problem or opportunity (e.g., declining yields in a field, new varieties)
- Setting a clear objective
- Determining the treatments to test
- Designing the experiment (replication, randomization and field layout)
- Determining the variables to measure
- Implementation (site location, inputs, planting, monitoring, measuring growth variables, harvesting, yield data)
- Evaluation (data processing, analysis, interpretation, conclusion, recommendation)
- Sharing of results

The experimental design stage includes the determination of the research topic, objectives, treatments, number of replications and field layout. It also has to specify aspects of the management of the experiment, what variables will be observed, when and how measurements will be taken and the procedures for evaluating the experiment.

Several guidelines are suggested here for designing an experiment that provides reliable information for decision making:

A. Prioritise and determine the main **research topic**. One experiment should only test one topic at a time, e.g., crop variety, planting method, dose of manure, pest or disease management practice.
B. Define a **clear objective** of the experiment to be conducted, making it as detailed as possible. What is to be tested and what result do we expect?
C. Determine the **treatments** to test. Too many or too few treatments will not result in useful information. The optimum number of treatments is usually 3-5 per experiment. First, determine a control treatment, which could be a standardised practice with known results, such as farmers' practice, or the standard recommendations of the agricultural extension service. The other treatments contain variations from the control, taking into consideration the conditions of field and the capacity of the farm household.
D. To ensure reliability of the experiment, each treatment should be replicated. Replications help reduce the effect of variable factors in the field, e.g. soil, water availability and shade. In farm-level experiments, two replications per treatment are considered sufficient.

<u>Example</u>:

Objective:	*To test to what extent an increased dose of manure can increase sweetpotato yield*
Research topic:	*Effect of manure on yield*
Treatments:	*No manure*
	0.5 kg manure per 10 plants (about 2 t/ha)
	1.0 kg manure per 10 plants (about 4 t/ha)
Replications:	*2 (A and B)*

The treatments are determined based on the control of no manure, which is the prevailing practice of the farmers. Considering that the objective aims to look at the effects of manure, the treatments include two different doses that are considered feasible to farmers. A follow-up experiment could look at higher doses if a positive effect is found in this experiment.

E. Prepare a field with plots for each replication at a size of at least 10 m^2 each. The shape of each plot should be similar, preferably square. In a sweetpotato field, for instance, we could make plots of three ridges wide and 4 m long. If the shape of the field does not allow us to make square plots of the same size, the area (m^2) of each plot has to be carefully measured and the treatment adjusted accordingly. The different treatments should be placed in the field in such an order that the two replications per treatment are not adjacent.

Example of the layout of the above organic manure experiment with two replications (A and B):

Treatment	*No manure*	*0.5 kg/10 plants*	*1.0 kg/10 plants*
Replication	*A*	*A*	*A*
Treatment	*1.0 kg/10 plants*	*No manure*	*0.5 kg/10 plants*
Replication	*B*	*B*	*B*

↑ 4 m ↓

← 3 m →

F. A simpler but less accurate way is to make plots with the same number of plants, for instance, one ridge with 60 plants forms one plot. However, planting distance must remain similar; otherwise this could provide an advantage to particular treatments. When we evaluate the result, we have to determine the yield per plant. The best method, however, is to keep both area and number of plants constant.

G. Each plot is provided with a label (a stick, for instance) on which the treatment and replication are clearly written with a waterproof marker.

H. Observe the plots regularly during the course of the experiment, and note down any remarks relating to the development of plants and the conditions of the field. This is necessary in order to interpret the results of the experiment later on.

I. Measure all variables at each observation time.

J. Process the data by calculating the average of the replications per treatment, analyse the results and draw a conclusion.

8.2.2 Replication and randomisation

Replication, randomisation and control of variation in the experimental area are basic requirements of a good experiment.

Replication
The term replication is used when we apply a treatment to more than one plot. An experiment is replicated two times if each treatment occurs on 2 plots (see the diagram below for an example of an experiment with three treatments each replicated two times).

Treatment B (replicate 1)	Treatment A (replicate 1)	Treatment C (replicate 1)
Treatment C (replicate 2)	Treatment A (replicate 2)	Treatment B (replicate 2)

Replication of the treatments in an experiment, allows us to determine if the differences we observe between treatments are due to the treatments themselves as it allows us to 'average out' variability within the field.

Replications can be:
- next to each other in one field
- in different areas of a field
- in different fields of one farmer
- in different farmers' fields

Replication across farms validates recommendations for the range of farms represented in the trials, while replication within a field can result in precisely developed technologies for a restricted set of fields with conditions similar to those of the experimental field.

Repeating the whole experiment for several seasons provides replication over time. By replicating over seasons, the new technology/ practice is tested in a variety of growing conditions, increasing the reliability of the results.

Randomisation
Randomisation refers to the process by which treatments are randomly allocated to experimental plots. Chance is used to allocate the treatments to the experimental plots in such a way that each treatment has an equal opportunity of being applied to each plot.

The different treatments can be written on pieces of paper, which are then folded up and placed in a bag or hat. The pieces of paper are then one by one picked out of the bag or hat and recorded (they should not be replaced until all have been picked out); the order in which they are drawn will be random. The process is repeated for each replication. For example, in the above diagram, the 1st piece of paper to be picked out was Treatment B, the 2nd was Treatment A, the 3rd was Treatment C, the pieces of paper were then refolded and again put into the hat, during the second picking (for allocation of treatments in the 2nd replicate), the pieces of paper were picked in the following order: Treatment C; Treatment A; Treatment B.

When you are randomising your treatments in an experiment it becomes very important to clearly label the different plots.

The reasons for randomisation are:
- to balance the possible effects of uncontrolled sources of variability
- to ensure that each treatment has an equal chance of expressing its potential (e.g. if the plots on one side of the field have more fertile soil than those on the other side, the difference between the treatments might be due to the soil they are planted in as

opposed to the treatment itself, randomising and replicating treatments helps avoid these kind of biases).

- to guard against possible, but unidentified sources of variation that may exist in the experimental material
- to help insure that results are not biased by unforeseen patterns of variation amongst the plots.

Occasionally, practical considerations may become more important than the statistical requirement for randomisation. An example of this might be if farmers wanted to test four different planting densities of vine per mound (1 vine/ mound, 2 vines/ mound, 4 vines/ mound, 8 vines/ mound). If the four treatments were replicated twice and randomised the field might look like Field 1 below. If the four treatments were replicated twice and arranged systematically as opposed to randomly the field might look like Field 2 below. It might be that farmers would find it easier to see the effect of the increasing planting densities of vines in the given replicates if it were laid out as per Field 2. This should be discussed with the participants.

Field 1

	Plot 1	Plot 2	Plot 3	Plot 4
Replicate 1 Treatment	3 vines/ mound	1 vine/ mound	4 vines/ mound	2 vines/ mound
Replicate 2 Treatment	2 vines/ mound	1 vine/ mound	3 vines/ mound	4 vines/ mound

Randomised treatments

Field 2

	Plot 1	Plot 2	Plot 3	Plot 4
Replicate 1 Treatment	1 vine/ mound	2 vines/ mound	3 vines/ mound	4 vines/ mound
Replicate 2 Treatment	4 vines/ mound	3 vines/ mound	2 vines/ mound	1 vine/ mound

Treatments arranged systematically not randomised

8.2.3 Field plot techniques

Other important considerations in layout and management of experimental plots include labelling, use of appropriate plot size and shape and proper maintenance or experimental plots during the crop growth.

Plot labels

Each experimental plot should have a label indicating the treatment and replicate.

Size of plots

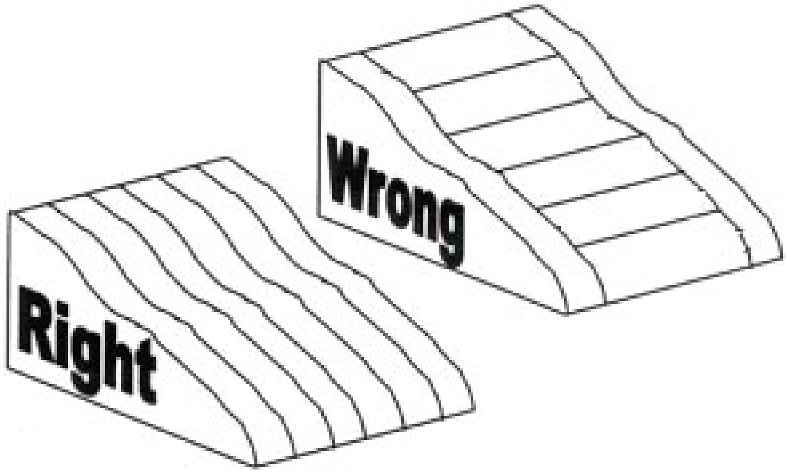
In a sweetpotato field experiment, each plot for each replication should be at least $10m^2$, the shape of each plot should preferably be the same size and as square as possible.

In a sweetpotato field, for instance, we could make plots of three ridges wide and 4 m long. If the shape of the field does not allow us to make square plots of the same size, the area (m^2) of each plot has to be carefully measured and the treatment adjusted accordingly. The different treatments should then be randomised for each replication.

Plot shape/ orientation

Plots should preferably have the same shape (square or rectangular). Plots should be arranged to allow for fair comparison among treatments.

The following diagram depicts the Right and Wrong ways to orient field plots in a sloping field. We can see that in the plots in the Right diagram all plots have areas at the top of the slope and areas at the bottom of the slope and we would therefore be able to fairly compare treatments in the different plots and possibly to pick up the effect of that treatment at the top of the slope as opposed to at the bottom of it. In the Wrong diagram some of the plots are only at the bottom of the slope, while others are at the top of the slope, it is very likely that the differences seen between plots has more to do with being at either the top or the bottom of the slope than the treatment that has been applied.



8.2.4 Data collection

The data collected constitutes the foundation of any analysis (simple, statistical, economic). Hence utmost care must be exercised in the development of data collection procedures and while collecting data. If the data collected are faulty, the conclusions drawn will be wrong. Correct decisions can only be taken if the data is correct.

Reasons/ importance of data:

- Data are the raw material for any analysis and decision making
- They act as a permanent record of what we have done
- They enable us to decide whether we are achieving the experimental objectives
- They help us decide on ways of improving future data collection procedures
- They enable us to keep track of any changes in the crop environment

Measurements

The range of questions to be thought about includes:

- What variables to measure
- How much data to collect
- When to measure and at what frequency
- How to measure
- Whether to use destructive or non-destructive measurements
- Whether to use whole plots or sample the plots which will determine sample size and scheme

What you will measure depends on the objective of the experiment. Variables or data of direct interest to the experiment should be measured. We can distinguish between three types of measurement:

- Response measurements – e.g. yield components, time of flowering, pest/ disease scores, pest populations
- Additional variables –
    - either at unit level (e.g. water logging)
    - or at farm level (e.g. soil type, labour, pests)
- Farmers' opinions – in informal discussions
    - these may be the actual farmers involved in the experiment,
    - or others who view the experimental fields

Recording

For ease and good care in taking records:

- Make field books with record/ data sheets that are well printed in columns
- Label experimental plots
- Take care to avoid inter-plot interference during data recording

- Its advisable that one person takes records of one variable throughout (e.g. scales are relative and perceptions may differ from one person to another)
- Ensure that all involved understand that improper records provide improper conclusions
- Scrutinise data as they are recorded to avoid any mistakes, i.e. recheck the collected data at the end of each day
- Make comprehensive notes during the life of the experiment which could be used to explain any extreme observation or deviations from the expected trend, i.e. record anything unusual in the field book for future use
- Retain primary records i.e. bags, tags etc
- Keep data safely and in a well organised way

Challenges in data collection
The collection of good quality data can pose many difficulties. For example, biophysical measurements or yield may require the presence of the facilitator. It is usually hard to arrange for a single harvest date and particularly so with the sweetpotato crop that is often harvested continuously (piecemeal harvesting) over a longer period, creative solutions to accurately recording the yield of plots when using piecemeal harvesting will need to be discussed and agreed on by the participants to ensure the data is collected in a rigorous and well organised way over time. Economic analyses require labour data: this may be one of the main differences between treatments but is often difficult to measure.

8.2.5 Evaluation

Evaluation of an experiment can take place at many different stages: beginning, growth, harvest, post-harvest, processed product, at sale etc. Collecting and recording data throughout the season is important in an experiment. Sometimes unexpected results can be explained by conditions during the growing season etc. The evaluation of the different experimental treatments may differ between different individuals as they may have different preferences depending on their individual needs. Clear presentation of the data collected facilitates the evaluation of an experiment.

Presentation of data
The collected data may be presented in any one or more of the following ways:
- tables (2-way)
- diagrams (e.g. pie charts, bar charts)
- graphs (to depict relationships)
- numerical summaries (averages, differences, percentages)
- text

Analysis of data
Several tools are available, ranging from very simple/ elementary ones to highly sophisticated ones.
For example, one may use the concept of:
- averages
- correlation/ regression analysis – to explore any associations/ relationships
- tests of significance – to detect real differences between treatments etc.

The choice of appropriate techniques of analysis will depend upon the type of data available and the purpose/ objective of the study.

Use of averages is one of the most common means of analysing and presenting data.

How to calculate an average

A. If collecting data on the number of root per plants of 10 sample plants, you will write down in your data form, the sample number of the plant and then the number of roots it has (see example below)

Sample number	*Number of roots/ plant*
1.	*3*
2.	*6*
3.	*2*
4.	*0*
5.	*5*
6.	*2*
7.	*1*
8.	*6*
9.	*7*
10.	*4*

B. To calculate the total number of roots for the ten plants, you would add up all the roots:

$$(3+6+2+0+5+2+1+6+7+4) = 36$$

C. To calculate the average number of roots per plant, you would divide the total number of roots by the total number of plants you had sampled.

$$(36 \div 10) = 3.6$$

The average number of roots per plant is 3.6.

If you were using an experiment which had two replicates, you would work out the average number of roots per plant for Treatment X Replicate 1 which might be 3.6, you would then work out the average number of roots per plant for Treatment X Replicate 2 which might be 4. In order to present the data you then need to work out the overall average number of roots for Treatment X, so you would add up the average you got for Replicate 1 and Replicate 2, and then divide by 2.

$$(3.6 + 4) = 7.6$$

$$(7.6 \div 2) = 3.8$$

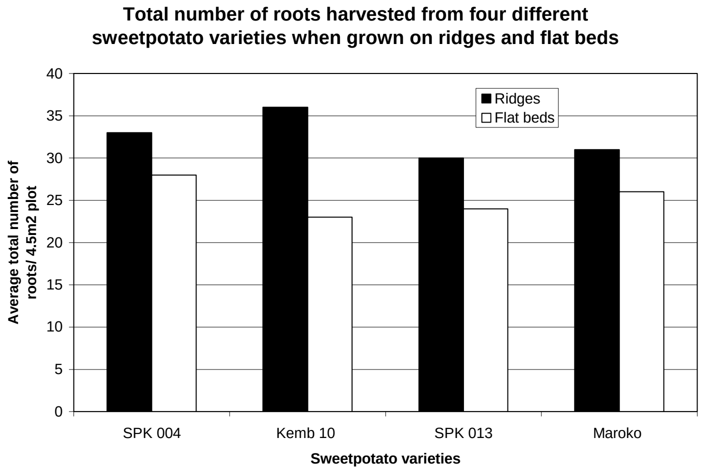
The average number of roots for Treatment X is 3.8

Using data collected by Upendo Sweetpotato IPPM FFS, Busia district, Kenya from an experiment they did on the performance of four different sweetpotato varieties grown on either mounds or ridges during the 2003/2004 season, we can illustrate how some of the data can be presented and analysed.

As a table:

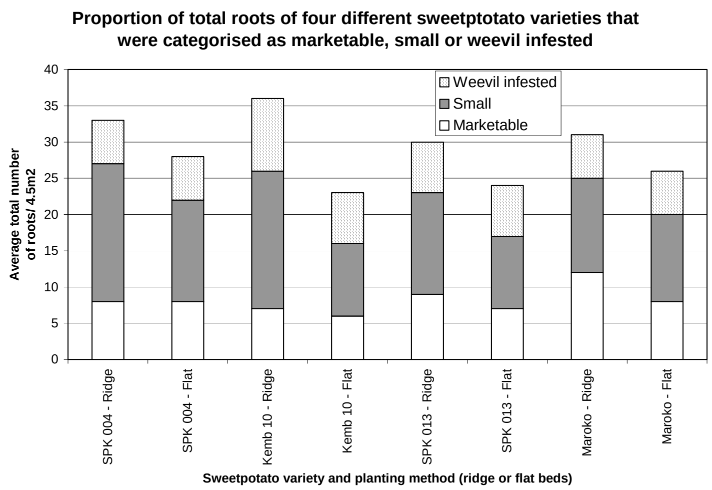
Sweetpotato variety and planting method	No of plants harvested	Number of roots				Weight of roots (kg)			
		Marketable	Small	Weevil infested	Total	Marketable	Small	Weevil infested	Total
SPK 004 - Ridge	14	8	19	6	33	2.75	2	2	6.75
SPK 004 - Flat	13	8	14	6	28	2.25	3.25	1.25	6.75
Kemb 10 - Ridge	15	7	19	10	36	2.25	2	2.5	6.75
Kemb 10 - Flat	15	6	10	7	23	1.75	2.5	1.5	5.75
SPK 013 - Ridge	13	9	14	7	30	2.5	1.5	1.75	5.75
SPK 013 - Flat	15	7	10	7	24	2.25	1.25	1.25	4.75
Maroko - Ridge	15	12	13	6	31	3	2	2	7
Maroko - Flat	16	8	12	6	26	2	1	2.25	5.25

As a bar chart:



This bar chart enables us to clearly see that all four varieties produced more roots when grown on ridges than on flat beds and that, out of all four varieties, Kemb 10 produced the most roots when grown on a ridge but the least roots when grown on flat beds.

If we look at the data in more detail, the FFS participants actually recorded the number of roots that were marketable, small or infested by weevils. This data is presented in the chart below. We can now see that, although Kemb 10 produced the most roots when grown on ridges, not very many of them were marketable. The variety with the highest number of marketable roots was Maroko when grown on ridges.



8.3 Field area measurement

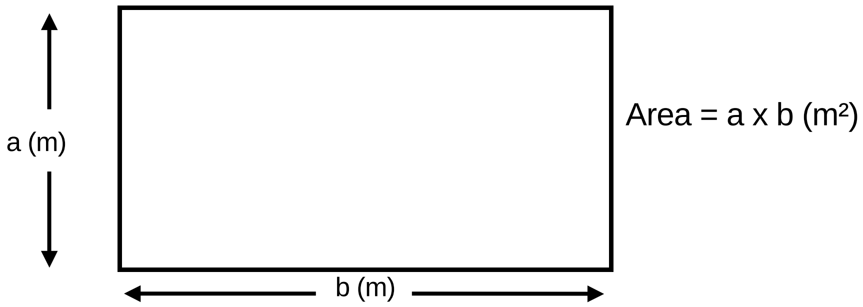
Farmers often use local units to express the area of their field, which vary from place to place. A unit with the same name may even imply a different area when applied in different places. The same holds for local weight units. Internationally accepted units for area measurements include the square meter (m^2) and, for larger areas, the hectare (1 ha = 10,000 m^2) or the acre (1 acre = 0.4 ha or 4,047m^2), and for weight the kilogram (kg) and, for larger amounts, the tonne (1 t = 1,000 kg). If we want to compare yields and treatments across fields, we will always have to express area and weight in standard units.

Fertilizer recommendations are normally given in kg/ha. Yields are normally expressed in t/ha.

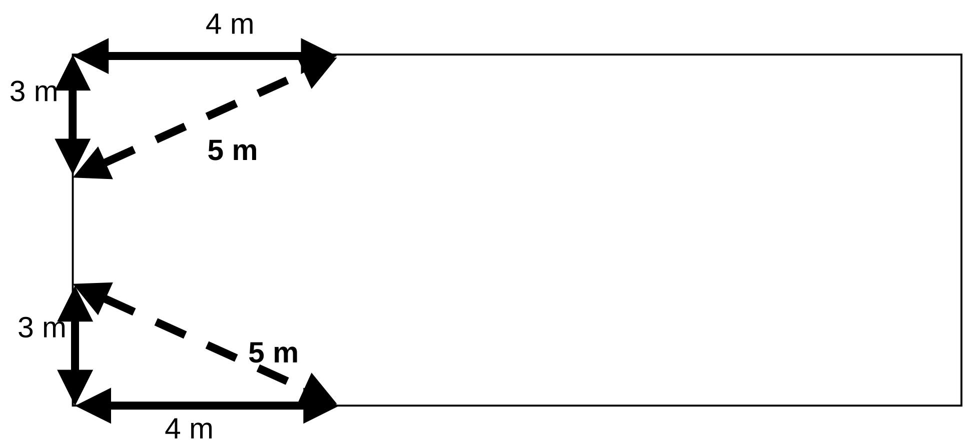
8.3.1 How to measure the field and calculate the area?

To measure the field area we need a long measuring tape, preferably at least 50 m long. If we use a rope the length of which has been measured first, it is likely that there is a small error that becomes larger as we start multiplying in the case of large fields. Before measuring the field, it is advisable to draw a map of the field. The length of the edges can then be written on the map for easy calculation later.

The easiest field to measure is one of rectangular shape. It is sufficient to measure the length and the width, each on one side only. The area can then be calculated by multiplying length times width.



In order to ensure the plot is rectangular with right angled corners, a rope can be used at the corner, to measure the distances shown in the diagram below, if a length of 4 m is measured across the field from the corner, and then a length of 3 m is measured down the field from the corner, and the connecting line between these two points is 5 m, the corner will be a right angle. The same exercise can be done in the other corners, if needs be.



8.4 Economic analysis of the sweetpotato enterprise

The net income, or profit, of sweetpotato cultivation is determined by the difference between income from the produce and expenditures:

Income	Expenditures
• From harvest of storage roots = total weight of roots (kg) multiplied by the price per kg or opportunity value; or the price offered for the standing crop for each class quality • From harvest of vines for vegetables, planting materials or feed, or the opportunity value if used on the farm • From production and sale of processed sweetpotato products	• Rent for land • Planting materials • Organic manure • Agrochemicals (fertilisers, pesticides, etc.) • Implements & tools • Labour: - hired labour - opportunity cost of family labour • Transportation when purchasing inputs • Costs of harvesting (transaction costs, marketing, labour, transportation, tools, etc.) • Costs of processing (transportation, sorting/ grading, storage, equipment, labour, ingredients, packaging, promoting and marketing processed products etc.) • Other costs

The level of income will depend on the quantity of the harvest and the price at harvest time, whereas the total expense depends on the quantity of inputs and services used and their price per unit. For income and expense, farmers tend to consider only those activities where money is directly involved. They hardly ever consider the value of their assets or time if used in other ways. This usually includes not considering the rental value of their fields or paying themselves a salary. However, it is important to realise what the value of these opportunities are in order to make the right farm management decisions, especially when alternative opportunities are available, for instance off-farm employment or a market for sweetpotato planting materials.

In the Sweetpotato IPPM FFS, the participants will make an economic analysis of the IPPM FFS field on the Seasonal Cultivation Record form (see following pages), and are encouraged to do the same for their own fields throughout the season. For learning purposes, this analysis will at first only consider concrete, real money items, i.e.:

- Activities: practices implemented
- Labour: amount of money paid for hired labour
- Purchase of inputs: cost of inputs, transaction cost (labour, transportation)
- Remarks: interesting observations.

At the end of the season, the two columns containing labour and inputs are added in the row labelled ‘total expense’. After the harvest is sold, the economic analysis can be made by filling and calculating the lower rows in the cultivation record form, as follows:

- Total expense: the sum of all expense columns
- Harvest: in kg
- Price: total price for the standing crop, or the market price per kg multiplied by the total quantity (kg) harvested (including share sold to the market, and share for own consumption)
- Net income: price of produce deducted by the total expense.

While filling in these forms, it is important for participants to be realistic about costs of their time. There will be a tendency for farmers to automatically put down the amount they would have to pay someone to do the job for them – but they should ask themselves if this is fair. It may be. Alternatively, it may be more generally true that work is only available for peak periods of labour demand.

Sweetpotato seasonal cultivation record

Name:	**Country:**
Season:	**Planting date:**
Field area:	**Sweetpotato variety:**

Week/ date	**Activity**	**Labour**	**Inputs**		**Remarks**
		Shillings	**what**	**Shillings**	
Before planting	*Land preparation*				
Week 1	*Planting*				
Week 2					
Week 3					
Week 4					
Week 5					
Week 6					
Week 7					
Week 8					
Week 9					
Week 10					
Week 11					
Week 12					
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Week 24					

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date</th><th rowspan="2">Activity</th><th>Labour</th><th colspan="2">Inputs</th><th rowspan="2">Remarks</th></tr>
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<tr><td colspan="6">Total expenses:
(labour + inputs)</td></tr>
<tr><td colspan="6">Harvest:</td></tr>
<tr><td colspan="6">Gross income from harvest:</td></tr>
<tr><td colspan="6">Net income:
(Gross income – expenses)</td></tr>
<tr><td colspan="6">Other comments:</td></tr>
</table>