

PET-Crops, Karamoja

A Pictorial Evaluation Tool for Crop Assessment in Karamoja, Uganda



PET-Crops, Karamoja, Uganda

A Pictorial Evaluation Tool (PET) for Crop Assessment
in Karamoja Region, Uganda.

Ian Robinson

Food and Agriculture Organization of the United Nations

UKaid from the British people

FOR GOD AND MY COUNTRY

AA International

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INSTRUCTIONS FOR USE OF THIS MANUAL

This manual is printed on polypropylene. If you use this PET manual in the rain, DRY THE WET PAGES with a soft dry cloth before closing.

Preface

In 2003, the first PET-Crops manual was produced in order to provide crop assessors in Ethiopia with a rapid means of assessing yields in an objective and standard manner that could be easily demonstrated, explained and repeated over and over again for as long as the crops were left standing in the field. PET-Crops, Karamoja is the latest version in a series of manuals that have been prepared for such a purpose for crop assessors in Palestine, Sudan, Somalia, South Sudan and Ethiopia.

The manual provides sets of **photo-indicators** and **instructions** on how to use them to best effect, employing little more than the crop assessor's own powers of observation. As is stated regularly by practitioners:

"*The manual provides a very rapid way to assess how much product is likely to be harvested from growing crops at harvest time in a specific area"....*and..."*the process enables us to explain to farmers, administrators and other agency staff how we arrive at our conclusions".*

The manual also explains how assessors should *cross-check* their estimates by taking samples and weighing the harvest[1].The effectiveness of the cross-check depends on attention to detail and the application of a rigour that is not always easy under field conditions. However, the time taken to cross-check visual estimates is well worthwhile in terms of establishing confidence in yourself and enabling you to convince others of the validity of your findings.

Crop assessing is a specialist operation that needs time and space to deliver comprehensive estimates of performance and to determine the reasons behind the results. Consequently, planners should make sure that assessors have sufficient time and facilities (dedicated vehicle for transects and case-studies, manual, PET quadrat and PET balance) to do the field work; and, should not load the teams with extra tasks connected to other aspects of food security.

Ian Robinson.

[1] A process equally available to others while the crops are still standing.

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What is PET-Crops, Karamoja?

This manual is called PET-Crops, Karamoja. It shows you how to estimate the amount of crop produce in the fields at harvest time. The manual contains photographs (termed *photo-indicators*) of the main crops in Karamoja taken at harvest time, and arranged according to their actual levels of production.

By comparing the *photo-indicators* with the crop in a field, you can decide how much product may be harvested from that field. By adding-up all the values and calculating weighted averages you can arrive at an estimate of production for an area of your choice.

When you estimate the production from a standing crop in the field at harvest time, it is called a **crop assessment**. PET-Crops, Karamoja will help you to complete a rapid crop assessment for a farm, for a village, for a locality and for a state.

Whatever the situation you are working in, at harvest time:

Production = Area x Yield per unit area

Therefore, to estimate the harvest you will need to know both:

1. The size or **area** of the crop to be harvested.
2. Average **crop yield** per unit area of the land to be harvested.

Area: At the simplest level of assessment, field size and farm size may be measured or told to you by the farmer. At the village or locality level, crop areas can be estimated either a) by collecting data from all of the farmers and adding them together; b) by taking samples from a few farmers and multiplying the sample averages by the number of families farming in that village or locality; or c) if access to farms is difficult or denied, using historical data as a template and a combination of transects, case-studies or key-informant interviews (that may be conducted away from the areas in question by telephone/text) to determine percentage changes from the norm.

In areas with well developed infra-structure and services, the local authorities, ministries or commissions usually use techniques a) or b). Where such levels of organisation are not available, area farmed may be calculated by multiplying estimates of the numbers of households or farming businesses (from livelihoods surveys) by an estimate of the average area known to have been farmed in the past, adjusted by data obtained during the assessment for the year in question including:

- Data collected from statements by individual farmers.
- Data collected by active administrations.
- Data collected by projects and NGOs.
- Data extrapolated from household surveys by other agencies.
- Remote-sensed data.

Area estimates for each crop are then multiplied by estimates of crop yield per unit area to determine production. More information to help you estimate area is given in Annex 8.

Yield per unit area: To estimate crop yield from a known area, you could harvest the whole area and weigh the crop. However, it is much easier to mark out a *sample plot* of known area in the field, then harvest and weigh the crop within it. This weight can then be used to estimate the yield for the whole field. For small fields of less than one hectare *with an even crop*, an area of one square metre (**1 m^2**) may be cut, harvested and weighed. The crop yield can then be recorded as the weight of crop harvested per one square metre or crop yield/m^2. This sum may then be multiplied by 10 000 to obtain the estimated yield per *hectare* (ha).

If the field is *large and variable* you will have to take more than one sample, add up the values and calculate the average to get a representative estimate of the production of the whole field. However, taking samples from each field is a time-consuming process. During rapid assessments there is NOT ENOUGH time to sample every field, let alone take many samples per field. Therefore, we have done the job for you!

PET-Crops Karamoja has been prepared to provide ALL ASSESSORS with a manual containing a) *photo-indicators* of crops with different levels of production; and b) instructions on how to use these *photo-indicators* to assess the yields of the crops seen. The *photo-indicators*, prepared from fields in Karamoja, have been grouped according to performance. Colours (red, yellow and blue) are used to define the groups because notations such as high, medium and low are arbitrary terms. That is to say, depending on their location, one person's *high* may be another's *low*. Colours are not judgemental, so you may group fields without suggesting a sense of value.

In the first instance, categorize the crop by selecting a *photo-indicator* **colour group** that best matches the view of fields you see in passing. Later, close-up examination of fewer fields will allow you to assign a probable yield, by consulting the more detailed information that the *photo-indicators* provide.

The yields noted will vary greatly from season to season, so all the *photo-indicators* must be consulted for all locations, that is to say don't 'guess'. It is important to have an open mind and not to pre-judge based on any impressions about how 'good' or 'bad' the season is said to be in 'early warning' information. Remember, your work is invariably the first properly constituted check on 'early-warning' information.

To use PET-Crops, Karamoja:

- Look at the field.
- Look at the *photo-indicators.*
- Pick the *photo-indicator* that matches your field.
- Read off the yield in kilograms or tonnes per hectare (kg/ha or t/ha) or tonnes per acre (t/ac).

Because crop yield at harvest will differ every year in the same fields, in order to get a good idea of yield at field, farm, village and locality level, you will need to cover vast distances and visit many farms. Proper use of the manual allows you to decide for yourself, in a very short time, how much crop will be harvested from every field you have seen. You can then compare your estimates with information given by farmers, other agencies and authorities, who each have their own agendas.

Using PET-Crops, Karamoja will allow you to complete all **crop assessments** within the time available and with confidence. The methods used to prepare PET-Crops, Karamoja are noted in Annex 7. The map provided illustrates the location of the samples and *photo-indicator* sites.

The advantages/disadvantages of using the **PET approach**, versus traditional census surveys based on agricultural statistics, are presented in Annex 9.

BEFORE YOU START

It is important that you spend time reading this introduction. It explains how to use the PET-Crops, Karamoja manual correctly and how to check your results.

In the gallery of *photo-indicators* beginning on page 25 of PET-Crops, Karamoja you will find photographs of crops with known yields of product.

All the photographs in the manual were taken of crops growing in Karamoja. Also, all the photos and related data were obtained in the presence of senior FAO-staff, who assisted when fields were selected and samples identified, harvested, threshed/cleaned and weighed. The presentation of the *photo-indicators* of each crop follows a similar sequence conforming to all the most recent PET-Crop manuals used in other countries.

Each yield range (represented by colour) has a double page spread of **three rows** of photographs, divided into **five columns** showing **(1)** field **from-a-distance**; **(2)** 1 m^2 in **close-up**; **(3)** the **harvest** taken from 1 m^2; **(4)** the **product** *e.g.* **grain or tubers** harvested from the 1 m^2; **(5) yield** estimate figures in grams per square metre (g/m^2) and tonnes per hectare (t/ha) and, in this case, tonnes per acre (t/ac).

When using the manual in the field, you should move directly from the **close-up (2)** to the **yield** estimate **(5)**, *only harvesting the product of 1 m^2 from time-to-time to cross-check your judgement* (see **Step 6**).

NB: The photographs of the harvest in column 3 are present to show you how the yield was derived and what the harvest from **one square metre** looks like, when compared to a reporter's notebook (200 mm x 127 mm) and a **sickle** or a **jembe** (East African hoe), placed on the ground next to the products.

The following *photo-indicators* come from the red group of early maturing sorghum harvested in early October, 2014.

(1) From-a-distance: These photographs show you the field from-a-distance, giving you an idea of the *health* of the crop, *how many* plants are in the field, how *uniformly* they have grown, how *weedy* the field has become and how well the harvestable parts have *developed.*

(2) Close-up: These photographs show the harvestable crop in an area of **1 m^2**. The photographs show the extent of cover and the size and quality of the heads and stems (stover).

(3) The harvest: These photographs show those parts of the crop that have been harvested from the **1 m^2** shown in **(2)** above. In this case, the sorghum heads have been cut just below the head, which is the local method of harvesting.

(4) The product: These photographs show the product (grain/tubers/pegs) of the harvested crop shown in **(3)** above, in this case sorghum grain.

Fresh weight
400 g/m^2

Air-dry 100%

Dry Matter
400 g/m^2

4.00 t/ha

1.62 t/acre

(5) The yield: Weights are shown as fresh and dry weights in g/m^2, extrapolated to t/ha and t/acre. Samples were either air-dry at harvest (so fresh and dry matter weights are the same) or were dried to constant weight after harvest.

NB Groundnut pegs and cassava tubers are given as fresh-dug weights.

STEP 1
Is it an intercrop or a sole crop?

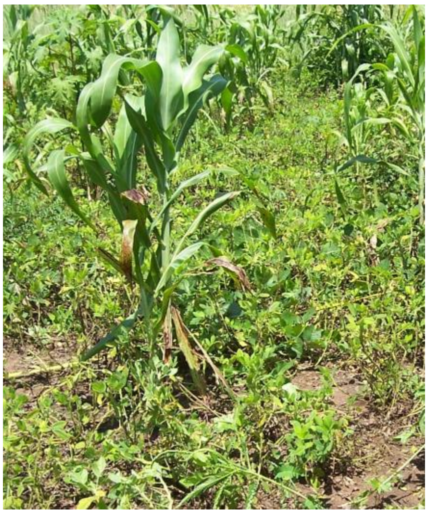
To begin the crop assessment you must first identify which cropping system the farmer is using. If the field has a mixture of plants, are they crops and weeds or are they a mixture of crops? Does the field have just one crop or are there two or more crops grown together?

Although most crops in Karamoja are sole crops or mono-crops of cereals, pulses or oilseeds, crops are sometimes grown together in a mixed stand, known as *intercrops*, such as combinations of maize and beans; and cassava and groundnuts.

Firstly, you need to confirm that your crop is a mono-crop. The photographs below show a mono–crop of maize, and an intercrop of sorghum and groundnuts. In between the two images is a photo of a weedy crop of maize, which might be confused with an intercrop.

Mono crop of maize

Weedy crop of maize



Intercrop of sorghum and groundnuts

Therefore:

1. Confirm that your crop is a monocrop and not a weedy crop – then continue to **Step 2** and onwards.
2. If your crop is an intercrop treat each crop as if the other is not there. If you feel confident continue to **Step 2**. If you want more assurance read **Annex 1** first, then continue to **Step 2**.

STEP 2
Is it a 'red', 'yellow' or 'blue' crop?

In Step 2, you decide if the general condition of the field is indicative of a 'red', 'yellow' or 'blue' crop. To do this you should look at the 'from-a-distance' *photo-indicators* in the gallery section of this manual. Compare these with the farmer's field. Looking from-a-distance will give you an impression of the overall quality of the crop and tell you if the crop is variable or even.

Turn to the *photo-indicator* gallery beginning on page 25 and select the crop you wish to assess. Look at the **'from-a-distance'** photographs for the red, yellow and blue levels of production for that crop.

There are three levels within the *photo-indicators* for each colour, making nine possible yields to choose from, PLUS levels may be judged to be *above*, *below* or *in-between* the values indicated.

The photographs **'from-a-distance'** have been taken from several metres away. If you stand at a similar distance from the field (or you can do this from a slow-moving vehicle), you may compare your whole crop with the first *photo-indicator* column and decide which colour group most closely matches your field.

There are notes next to the photographs; read these carefully because they will tell you what to look for when deciding if your field is in the **'red'**, **'yellow'** or **'blue'** group.

The following pictures summarise the process of placing your crop in the correct group.

Which photograph is the best fit from-a-distance?

Is this a match?

Photo-indicator; mid-range

In the RED group

No

Farmer's crop is in foreground

In the YELLOW group

No

In the BLUE group

Yes

In the above example, the crop yield is clearly lower than red and yellow *photo-indicators*. Therefore, the farmer's crop falls in the blue group of *photo-indicators*. The selection should be confirmed by working through **Step 3.**

STEP 3
Confirming your choice

Confirm your choice in Step 3 by looking more closely at the field. If the field is small, walk up to it and look closely at a small area that you think represents the field. Compare it with the 'close-up' photo-indicators to confirm your choice of colour and then pick the level within that colour that the field most closely matches.

For larger fields, you will need to take a close look at several places, either by a) walking around the edge; or b) walking through the middle of the field in an organised fashion, matching crop with indicators at regular intervals.

When using the **'close-up'** *photo-indicators*, you should concentrate your gaze on **one square metre of crop**, which you can judge by standing with your feet one metre apart and projecting your gaze forward to make a square. **If you are uncertain** about how to do this, use a 1 m^2 **PET quadrat** to define your area by placing the quadrat where it will be clearly visible, as shown in the next group of photographs. Your **close-up** view is unlikely to be exactly the same as a *photo-indicator*, so you will need to decide which one is the best match; or between which two *photo-indicators* your plot falls. For instance:

- You may see more soil through the canopy, more gaps, more weeds and the plants may look less strong and healthy than they looked when viewed from-a-distance.
- Or, the plants may look stronger and the parts that will be harvested, such as the heads or cobs and the stems, may also look larger or stronger (thicker) than when you looked at the crop from-a-distance.
- Due to tiller and flower formation, the number of plants may not necessarily be the same as the number of heads or cobs in the *photo-indicator*, so you need to consider head/cob number and size.

NB: Your brain is better than any computer in its flexible reading of situations. So do not be afraid if your **intuitive response** is to adjust your decision and, if necessary, change your mind from your initial selection based on the **from-a-distance** observation.

In **Step 2** (**from-a-distance**), the **blue group** was identified. The **close-up** shows that the **closest fit** is the lowest blue *photo-indicator.* Although there are more heads than in the medium blue *photo-indicator*, the panicles are very small.

Photo-indicator

Is this a match?

No

NOT High Blue

Close-up 1m²

No

NOT Medium Blue

YES

YES Low Blue - although there are more heads (13) than in medium blue (7) and high blue (12) the panicles in the farmer's field are very small.

In **Step 2** you observed **from-a-distance** that the crop is probably in the blue group.

In **Step 3** you confirmed from the **close-up** *photo-indicators* that your crop is at the lowest end of the range.

STEP 4
Estimating the yield in tonnes/hectare

In Step 4, you assign a value in t/ha or t/acre to your crop, using the final column in the sequence, which shows the value of the 'harvest' from 1 m^2, as well as final yield estimates per hectare and per acre.

The photographs on the right hand page (columns 3 and 4) show how the yields of the products were derived in grams per square metre*. These only need to be referred to when cross-checking your results* (**Step 6**):

- Depending on the crop, the photos in column 3 show the heads, cobs, tubers or plants harvested from 1 m^2 sample plots of the crop shown in column 2.
- The photos in column 4 show either threshed grain, tubers or pegs harvested from the 1 m^2 sample plot.

The yield in column 5 gives the weighed production of the sample plot in units of grams per square metre (**g/m^2**), extrapolated to tonnes per hectare (**t/ha**) and tonnes per acre (**t/acre**). Once you have selected the **close-up** *photo-indicator* that best fits your farmer's field, you can read off the yield from column 5.

In the example above, the closest fit is **low blue** at **25 g/m^2** which is **0.25 t/ha or c. 0.10 t/acre.** Record this yield, move on to the next plot and repeat the exercise[2].

NB: As noted earlier, it is unlikely that your crop will look exactly like the one in the photograph. If this is the case, choose a yield in-between the values of the two closest *photo-indicators*. For example, if your crop looks half-way between the low blue (0.25 t/ha) and high blue (0.75 t/ha) *photo-indicators*, you can estimate your yield as:
(0.25 + 0.75) / 2 = 0.5 t/ha.

[2]Remember - only harvest and weigh your sample of 1 m^2 when you decide to cross-check your results (see **Step 6**).

STEP 5
Accounting for field variability

Often you see parts of the field where the crop has been damaged by too much or too little water, pests or diseases, weeds, poor seed quality or shallow top soil. Therefore, the crop will vary across the field and the yield per square metre will be different from place-to-place.

When you are assessing, you will need to take account of this variability. How you will do this will depend on whether you are assessing a small (less than 0.5 ha) or large field:

Small fields

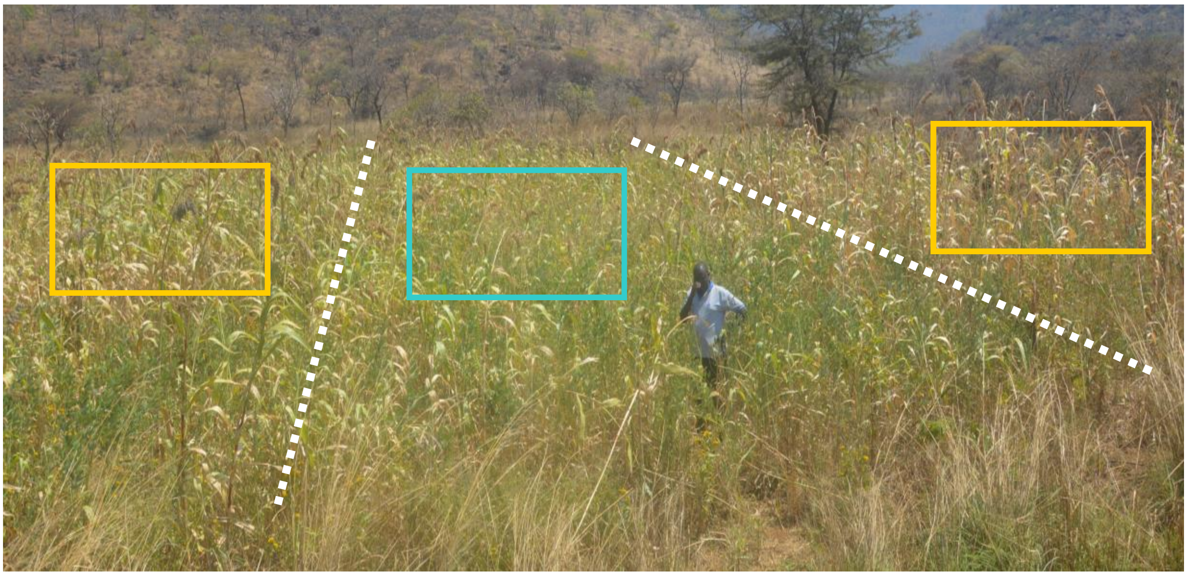
When a small field is variable, stand back and study it, to decide which proportions are **'high'** or **'medium'** or **'low'**. For example, look closely at the photograph of *abir* sorghum below, taken **from-a-distance**. You can see that, where the man is standing, is less productive with more weeds, fewer plants and smaller heads than crop development on the left and right of the picture.

From-a-distance *photo-indicators* point to a combination of yellow and blue levels. Therefore, **two** PET estimates are needed for this field, from which a *weighted average* will be calculated as shown below.

Estimating the yield of a variable field of *abir* sorghum - follow notes 1 to 5.

1. Stand where you can see the whole field.

2. This field divides into three parts. Within two parts the crop looks similar. Therefore, in this case, two estimates are required: one for the yellow parts (2) and one for blue part (1).



3. Determine whether each part is 'red', 'yellow' or 'blue'.

Approximately one third of the field looks most like a **blue** PET crop *photo-indicator.*

Two thirds of the field looks most like a **yellow** PET crop *photo-indicator*.

This part of the field is similar to the 50 g/m^2 *photo-indicator.*

4. Estimate crop yield for each part of the field by following the instructions for STEP 4 of PET-Crops Karamoja.

This part of the field is similar to the 190 g/m^2 *photo-indicator*.

0.5 t/ha **= Estimated yield =** **1.9 t/ha**

5. Calculate the crop yield of the variable *abir* sorghum field.

The *abir* sorghum field is producing at two levels, one **'low blue'** and one **'low yellow'**.

The **'blue'** makes up approximately **one third** (33%). The **'yellow'** makes up approximately **two thirds** (67%).

Therefore, the weighted average yield per hectare (**wA**) in the variable *abir* sorghum field is:

a) **wA** in t/ha = (low blue yield in t/ha x 33%) + (low yellow yield in t/ha x 67%)

b) Crop yield from the **'low blue'** part = 0.5 x 0.33 = 0.16

c) Crop yield from the **'low yellow'** part = 1.9 x 0.67 = 1.27

To calculate the total crop yield for the field you therefore simply add together the crop yield of each part of the field (b + c):

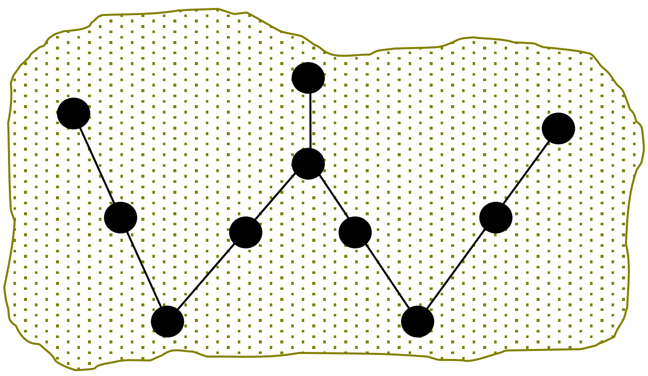
wA in t/ha= 0.16 t/ha + 1.27 t/ha **= 1.43 t/ha**

Therefore the estimated *abir* sorghum yield of this small field is 1.43 t/ha.

__Large fields__

When assessing large, variable fields, it is difficult to visually assess the proportions of the field that are **'high'**, **'medium'** or **'low'**. Therefore, for large fields, you should walk in a W shape across the field (Figure 1 below) and make assessments of yield at up to 10 stations spaced at regular intervals.

Figure 1: Sampling up to 10 stations at regularly spaced intervals.



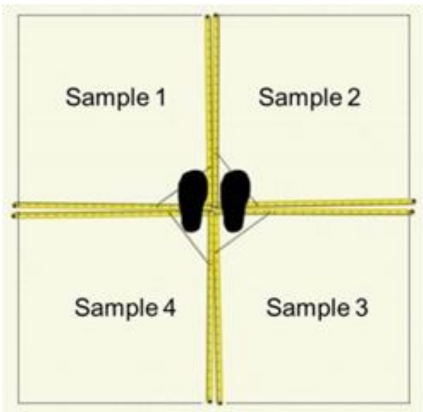
As described in **Step 3**, concentrate your gaze on **one square metre of crop** or, if you are uncertain about doing this, use a 1 m^2 **PET quadrat** to define the area. Compare it with the

'Close-up' *photo-indicators* in the gallery to confirm your choice of colour and then pick the level and yield within that colour that the field most closely matches.

To work more accurately, you can increase your sample number by rotating through 360 degrees at each sampling station. Rotate 90° clockwise after each estimate is made, so that 1 m^2 is sampled 4 times, as shown in Figures 2 and 3 below.

Figure 2: Rapid scoring of yield.

Figure 3: Arrangement of samples taken at each station.



Calculate the average (**mean**) yield of each station, by adding up the 4 sample yields and dividing this result by 4.

Then estimate the overall yield of the whole field, by adding up the mean yields of ALL of the stations and dividing this result by the total number of stations visited.

STEP 6
Cross-checking your results

To make sure that your estimates of crop yield based on the *photo-indicators* are accurate and that mistakes are not being made, it is important that you regularly *cross-check* your results.

It is recommended that you cross-check your estimates regularly, especially in the following situations:

- If your estimates are different to what you expected – for example significantly lower or higher than other contemporary assessments.
- When using PET-Crops, Karamoja for the first time.
- When estimating the yield for a new crop in your experience.
- When estimating crop yield in a new region.
- When there is a dramatic change in the ecology of the area in which you are travelling.
- Finally, at regular intervals even if you are always working on the same crop in the same region, because mistakes can be made through complacency.

Cross-checking involves cutting, harvesting and weighing the harvested parts of *a sample* from a station in the field that you have **previously** estimated using the *photo-indicators*. This means harvesting and threshing 1 m^2 areas of the farmer's crop; and *if necessary*, drying them to a constant weight; then comparing these final weights with earlier estimates made using the method described in **Steps 1** to **5** above.

When cross-checking, samples should be taken from a minimum of three separate fields during the day. To implement, follow the notes below:

1. Choosing the field

Try to choose a field where the crop does not change too much[3]. If this is not possible and the fields are very variable, then divide the field into different parts, and take a sample from the easiest section as explained in **Step 5**.

Ideally, the fields you sample from should be harvestable *i.e.* the crop is dry and ready to harvest. For cereals, you can test this by biting into the grains - harvestable grains will be hard to bite into and will break when bitten. Fields of grain which have a soft bite (*i.e.* the teeth sinking into the grain) may be used, but more drying will be required later to determine the dry matter content of the crop (see **Step 7**).

2. Selecting the areas of the field for crop cutting (sampling)

This depends on the crop you are cross-checking:

- For all short stover/straw crops, such as rice, finger millet or groundnuts, take a long stick, mark the end clearly and ask the farmer to turn their back to the crop and throw the stick over their head into the crop. Where the stick lands in the crop is where you will position your square frame or quadrat for the crop cutting. Push the marked end of the stick upright into the ground.
- For tall crops (including tall stover crops) such as sorghum, maize, pearl millet or cassava, select your sample position by lottery[4].

3. Placing the quadrat in the crop

A quadrat is used to mark the area from which the crop cutting is to be taken. The quadrat should be placed with the stick in its centre or, for tall crops, with the sample position that was picked by lottery in its centre.

4. Score

Now, using the **close-up** *photo-indicators*, assess the crop inside the quadrat and record your yield estimate in g/m^2 (as described earlier in **Steps 1-5**).

5. Harvesting

Harvest the plants growing from the soil inside the quadrat. Cut off all the heads or cobs from the stems, then count and record the number before placing them in a clean, empty plastic bag. When sampling groundnut or cassava, lift the whole plant carefully from the soil,

[3] Choosing a highly variable field IS NOT RECOMMENDED because you are cross-checking your own judgement to see how far 'out' you are in your estimate. Experience shows that a variable field is more distracting - so make it as easy as possible!

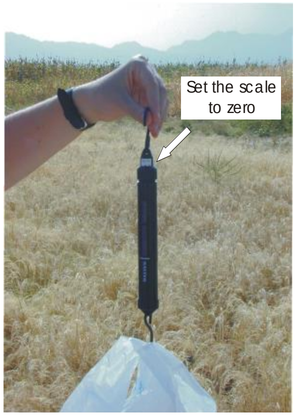
[4] The actions described in point 2 involve the farmers, which helps them identify with the results. A spontaneous lottery may be derived by dividing the field (mentally) into a grid with letters and numbers as the two axes; writing the combinations on pieces of paper (tickets) and asking the farmer to select a ticket from an unseen source (*e.g.* hat, box, envelope).

ensuring that you do not leave pegs or tubers in the ground. Gently shake or rub any surplus soil from the pegs or tubers.

6. Threshing cereal samples

Remove the heads or cobs from the bag and thresh or shell them, trying to minimise any loss of grain as you do so. If possible, ask the farmer to thresh and winnow the harvested parts in their usual manner. The threshed grain should then be placed in a clean bag and weighed.

7. Weighing



Before each weighing, the **spring balance scale (supplied with the PET manual and quadrat)** should be set to zero when a clean, empty bag is attached to the hook. Weigh your samples in a sheltered position away from wind and record the weight as Wf which is termed fresh weight. Samples taken from field dry crops can now be returned to the farmer. Samples from fields that are not air dry will need to be removed for further drying (see **Step 7**).

8. Comparing your results

The weights of sample from field dry crops can now be compared with the g/m^2 yield estimated from the **close-up** *photo-indicators* in item **4** above. They will not be exactly the same, but as long as they are closer to these yields than those of other *photo-indicators*, you will know that you have been correct in your choice. If they are not, you will need to adjust your estimates.

9. Repeating the measurements

A single sample should be taken from each significantly variable portion of the field. However, remember that this is a rapid technique and that sample numbers should be kept as low as possible. For small fields less than 0.5 ha, one is usually enough but no more than 2 cross-check samples are recommended[5].

10. Converting grams per square metre to kg per hectare and tonnes per hectare

If the fresh weight Wf is in grams per square metre (g/m^2); to obtain fresh yield (Yf) in g/hectare = multiply by 10 000 (10 000 sq m = 1 ha).

To obtain Yf in kg/hectare, divide this answer by 1 000 (1 kg = 1 000 g).
To obtain Yf in tonnes/hectare, divide the answer in kg/hectare by 1 000 (1 t = 1 000 kg).
To obtain Yf in tonnes/acre, divide the answer in tonnes/hectare by 2.47 (see Annex 2).

[5] Stratified sampling - divide the field in two and take one sample from each part of the field.

STEP 7
Drying to constant weight

Grain crops harvested before they are 'ready' contain moisture that may make up 20%-30%-40% of their weight, depending on how far off they are from normal harvesting condition. When checking your use of the *photo-indicators*, samples of cereal crops should be *dry* if they are to provide accurate estimations of actual yield of grain.

When it is not possible to find a crop that is already air dry in the field, samples should be dried after harvest, so that all that remains is dry matter (DM), which is is a more accurate estimate of the value of the crop*.* The weight of dry matter can be determined by drying the sample until its weight does not change, that is to say drying the sample until the weight doesn't change; *i.e.* the sample reaches a *constant weight*.

NB: Groundnut and cassava crops do not need drying as they are quoted as fresh-dug weights.

Therefore:

1. If the grains are hard to bite and break (snap) when bitten, *record their weight* in grams per square metre; and (as outlined in **Step 6**) *give the sample back* to the farmer – there is no need to do any more weighing or drying.

2. If the grains are soft to bite, they must be dried until they lose no more weight. In this case, the assessor needs to take the sample back to base for repeat drying and weighing. Follow the steps as listed below:

a) *Record the fresh weight;* that is the weight (Wf) in grams per square metre straight after threshing or shelling.

b) *Negotiate* a purchase price with the farmer for the sample.

c) Place each sample separately in clearly marked cotton bags or thick paper envelopes. Do not store in polythene bags as the samples will 'sweat' and spoil. A label fixed firmly to the bag or stuck on the envelope should show the assessor's name, region, district, village, date, crop, farmer's name, sample number, fresh weight and the time when the sample was taken.

d) *Seal* the bag/envelope and place securely in the vehicle.

e) Upon arrival, *re-weigh* the sample and *record* this *weight* $W_{1.}$

f) *Dry* the sample in a micro-wave oven at *low* intensity for two minutes, *allow to cool*, *re-weigh*, and *record the weight* $W_{2.}$

g) *Repeat* the process until two consecutive weights are the same *i.e.* you have reached *constant weight,* Wc.

h) As long as no grain has been lost in transit and in the operations at base, Wc is the Dry Matter (DM) weight of your sample. Look to see which *photo-indicator* matches Wc. If this is the same as your initial choice, then you know that your initial choice was correct.

Sub-sampling

If the sample is too big to bring back to base (bigger than 150 g), you need to *sub-sample*. To do this, weigh your sample in the field to obtain Wf as usual. Mix it thoroughly, then immediately remove a portion of this main sample (the sub-sample) and weigh it to obtain Wfs; package and label the sub-sample as normal and take it back to base; dry the whole sub-sample to constant weight Wcs as described in f) and g).

To find the dry matter (DM) yield in g/m^2, multiply the weight of the original harvested sample Wf by the dry matter percentage, DM% i.e. Wcs / Wfs X 100%.

For example, using the photo-indicators, an assessor estimates the yield of a uniform maize field that is not yet field dry at 3.42 t/ha (middle yellow indicator).

To cross-check this estimate, a threshed sample taken from 1m^2 is weighed, at 510 g (Wf). This is thought too large to remove for drying, so a sub-sample is taken and weighed, at 100 g (Wfs). This is packaged and labelled and taken back to base, then dried to a constant weight and reweighed, at 76 g (Wcs).

The dry matter percentage of the sample is therefore:
76/100 x 100% = 76%.

The DM yield is 76% x 510 = 388 g/m^2.

Adjustment to use of photo-indicator

Because 388 g/m^2 is much nearer to 385 g/m^2 (which is the top of the yellow *photo-indicator*), than 342 g/m^2, this suggests that the assessor may have been estimating yield too low and needs to make adjustments.

Photo-indicator gallery

Crops in order of appearance

Sorghum *red* - early and main crops **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 2.75 t/ha to 4.00 t/ha**
- **Yellow** **Range 1.45 t/ha to 2.35 t/ha**
- **Blue** **Range 0.25 t/ha to 1.05 t/ha**

Sorghum *abir* - late maturing **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 2.25 t/ha to 3.35 t/ha**
- **Yellow** **Range 1.90 t/ha to 2.10 t/ha**
- **Blue** **Range 0.50 t/ha to 1.10 t/ha**

Maize **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 4.75 t/ha to 7.05 t/ha**
- **Yellow** **Range 2.17 t/ha to 3.85 t/ha**
- **Blue** **Range 0.32 t/ha to 1.68 t/ha**

Pearl Millet **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 1.65 t/ha to 2.46 t/ha**
- **Yellow** **Range 1.10 t/ha to 1.45 t/ha**
- **Blue** **Range 0.27 t/ha to 1.05 t/ha**

Finger millet **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 2.52 t/ha to 3.30 t/ha**
- **Yellow** **Range 1.11 t/ha to 2.15 t/ha**
- **Blue** **Range 0.50 t/ha to 0.94 t/ha**

Rice **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 3.80 t/ha to 6.12 t/ha**
- **Yellow** **Range 1.50 t/ha to 3.05 t/ha**
- **Blue** **Range 0.10 t/ha to 1.00 t/ha**

Cassava **(3 double pages - 9 *photo-indicators*)**

- **Red** **Range 25.14 t/ha to 41.52 t/ha**
- **Yellow** **Range 15.23 t/ha to 20.15 t/ha**
- **Blue** **Range 3.25 t/ha to 8.80 t/ha**

Groundnut **(3 double pages - 6 *photo-indicators*)**

- **Red** **Range 2.60 t/ha to 3.00 t/ha**
- **Yellow** **Range 1.50 t/ha to 2.40 t/ha**
- **Blue** **Range 0.60 t/ha to 1.25 t/ha**

Sunflower **(3 double pages - 6 *photo-indicators*)**

- **Red** **Range 2.66 t/ha to 2.85 t/ha**
- **Yellow** **Range 1.25 t/ha to 2.10 t/ha**
- **Blue** **Range 0.42 t/ha to 1.00 t/ha**

Sorghum - early and main crops

From-a-distance | **Close-up**

- Landrace *Akiriri and Tintinyi*
- Tall, even stand
- High plant density
- Well developed plants
- 9 plants/m^2
- Many elongated heads, variable size

- Landrace *Ikwa lleth and Tintinyi*
- Tall, variable stand
- Well developed plants
- 6 plants/m^2
- Well formed, elongated heads
- Weedy crop - has reduced yield

- Landrace *Akiriri and Tintinyi*
- Tall, even stand
- High plant density
- Well developed plants
- 6 plants/m^2
- Well formed, elongated heads

Sorghum - early and main crops

Harvest from 1m² | **Grain from 1m²** | **Yield**

Fresh weight
400 g/m²

Air-dry 100%

Dry Matter
400 g/m²

4.00 t/ha

1.62 t/acre

Fresh weight
360 g/m²

Air-dry 100%

Dry Matter
360 g/m²

3.60 t/ha

1.46 t/acre

Fresh weight
275 g/m²

Air-dry 100%

Dry Matter
275 g/m²

2.75 t/ha

1.11 t/acre

Sorghum - early and main crops

From-a-distance | **Close-up**

- Landrace *Akiriri and Tintinyi*
- Dense stand
- Tall, even crop
- Well developed plants
- 11 plants/m^2
- Elongated heads, variable in size

- Landrace *Akiriri, Natum and Tintinyi*
- High plant density
- Tall, even crop
- 18 plants/m^2
- Mixed heads, elongated

- Landrace *Akiriri*
- Variable stand
- Tall, even crop
- 7 plants/m^2
- Elongated heads, varying in size

Sorghum - early and main crops

Harvest from 1m^2	Grain from 1m^2	Yield

11 heads/m^2

235 g/m^2

Fresh weight 235 g/m^2

Air-dry 100%

Dry Matter 235 g/m^2

2.35 t/ha

0.95 t/acre

18 heads/m^2

207 g/m^2

Fresh weight 207 g/m^2

Air-dry 100%

Dry Matter 207 g/m^2

2.07 t/ha

0.84 t/acre

7 heads/m^2

145 g/m^2

Fresh weight 145 g/m^2

Air-dry 100%

Dry Matter 145 g/m^2

1.45 t/ha

0.59 t/acre

Sorghum - early and main crops

From-a-distance | **Close-up**

- Landrace *Akiriri, Natum and Tintinyi*
- Variable stand
- Poorly developed plants
- 12 plants/m^2
- Weedy crop, no weeding done
- Many heads, elongated, mostly small in size

12 plants/m^2

- Landrace *Akiriri*
- Variable stand
- Low plant density
- Poorly developed plants
- 7 plants/m^2
- Elongated heads of variable size

7 plants/m^2

- Landrace *Tintinyi*
- Variable stand
- Poorly developed plants
- Weedy crop, no weeding done
- 13 plants/m^2
- Very small, elongated heads

13 plants/m^2

Sorghum - early and main crops

Harvest from 1m^2 | **Grain from 1m^2** | **Yield**

12 heads/m^2

105 g/m^2

Fresh weight
105 g/m^2

Air-dry 100%

Dry Matter
105 g/m^2

1.05 t/ha

0.43 t/acre

7 heads/m^2

75 g/m^2

Fresh weight
75 g/m^2

Air-dry 100%

Dry Matter
75 g/m^2

0.75 t/ha

0.30 t/acre

13 heads/m^2

25 g/m^2

Fresh weight
25 g/m^2

Air-dry 100%

Dry Matter
25 g/m^2

0.25 t/ha

0.10 t/acre

Sorghum *abir* - late maturing

	From-a-distance	Close-up
• *Abir* • Even stand - appropriate plant density • 8 plants/m^2 • 8 heads/m^2 • Fairly weedy - weeded once only • Below potential		 8 plants/m^2
• *Abir* • Even stand • Low plant density • 4 plants/m^2 • 4 heads/m^2 • Fairly weedy - weeded once only • Below potential		 4 plants/m^2
• *Abir* • Uneven stand • Plant density high • 13 plants/m^2 • 13 smaller heads/m^2 • Fairly weedy - weeded once only • High density lowers weed competition		 13 plants/m^2

Sorghum *abir* - late maturing

Harvest from $1m^2$	Grain from $1m^2$	Yield

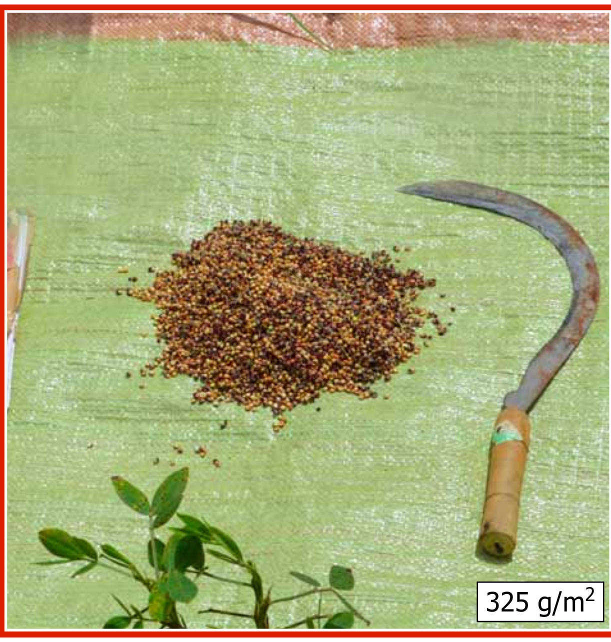
Fresh weight
335 g/m^2

Air-dry 100%

Dry Matter
335 g/m^2

3.35 t/ha

1.36 t/acre



Fresh weight
325 g/m^2

Air-dry 81%

Dry Matter
264 g/m^2

2.64 t/ha

1.07 t/acre

Fresh weight
225 g/m^2

Air-dry 100%

Dry Matter
225 g/m^2

2.25 t/ha

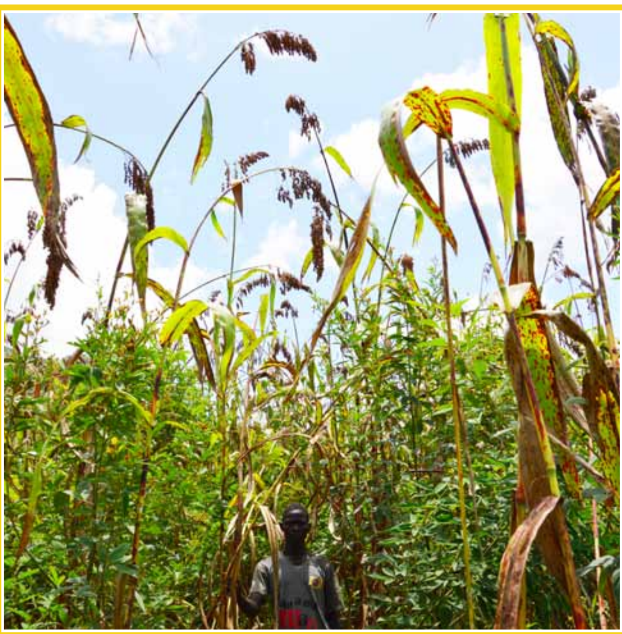
0.91 t/acre

Sorghum *abir* - late maturing

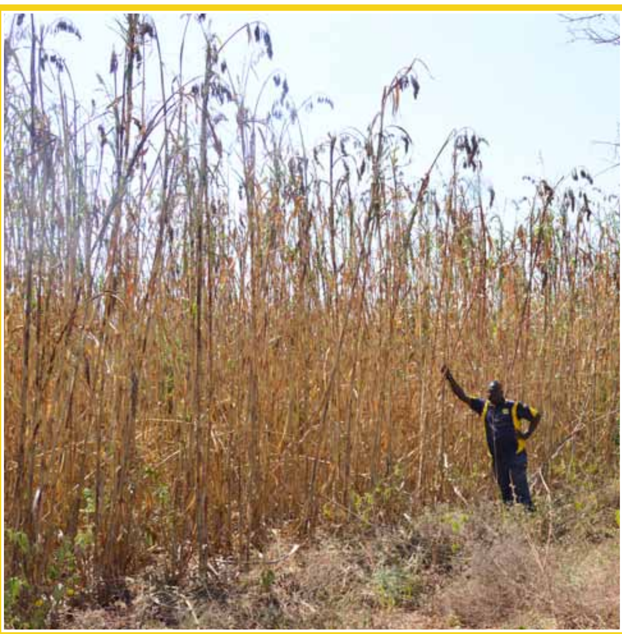
From-a-distance	Close-up

- *Abir*
- Very dry crop
- Even stand
- Plant density fair
- 7 plants/m^2
- 6 heads/m^2
- Low weeds
- Has been weeded twice

- *Abir*
- Variable stand
- Low plant density
- 3 plants/m^2
- 3 heads/m^2
- High weeds
- No weeding



- *Abir*
- Even stand
- Plant density fair
- 7 plants/m^2
- 6 heads/m^2
- Low weeds
- Has been weeded twice



Sorghum *abir* - late maturing

Harvest from 1m^2 | **Grain from 1m^2** | **Yield**

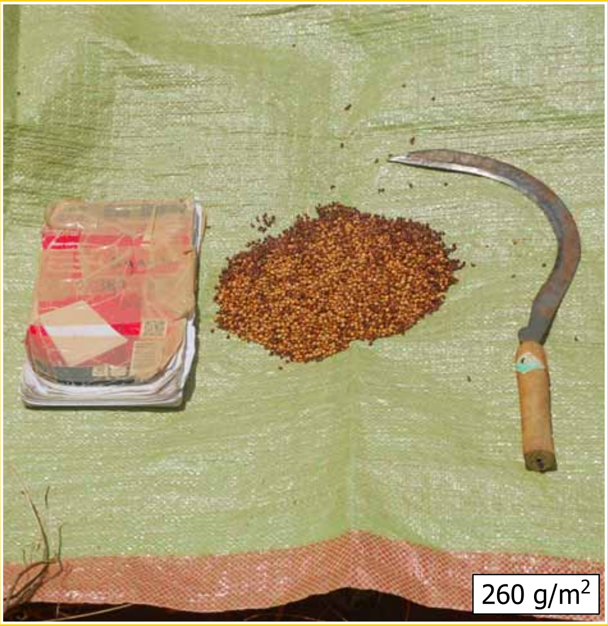
Fresh weight
210 g/m^2

Air-dry 100%

Dry Matter
210 g/m^2

2.10 t/ha

0.85 t/acre



Fresh weight
260 g/m^2

Air-dry 75%

Dry Matter
195 g/m^2

1.95 t/ha

0.79 t/acre

Fresh weight
190 g/m^2

Air-dry 100%

Dry Matter
190 g/m^2

1.90 t/ha

0.77 t/acre

Sorghum *abir* - late maturing

From-a-distance | **Close-up**

- *Abir*
- Variable stand
- Low plant density
- 4 plants/m^2
- 4 heads/m^2
- Weeds
- Has been weeded once only

- *Abir*
- Poor stand
- Not dry
- Low plant density
- 3 plants/m^2
- 3 heads/m^2
- Very weedy
- No weeding

- *Abir*
- Poor stand
- Dry
- Low plant density
- 2 plants/m^2
- 2 variable heads/m^2
- Choked with weeds
- No weeding of plot

Sorghum *abir* - late maturing

Harvest from 1m^2 | **Grain from 1m^2** | **Yield**

4 heads/m^2

110 g/m^2

Fresh weight
110 g/m^2

Air-dry 100%

Dry Matter
110 g/m^2

1.10 t/ha

0.45 t/acre

3 heads/m^2

120 g/m^2

Fresh weight
120 g/m^2

Air-dry 77%

Dry Matter
92 g/m^2

0.92 t/ha

0.37 t/acre

2 heads/m^2

50 g/m^2

Fresh weight
50 g/m^2

Air-dry 100%

Dry Matter
50 g/m^2

0.50 t/ha

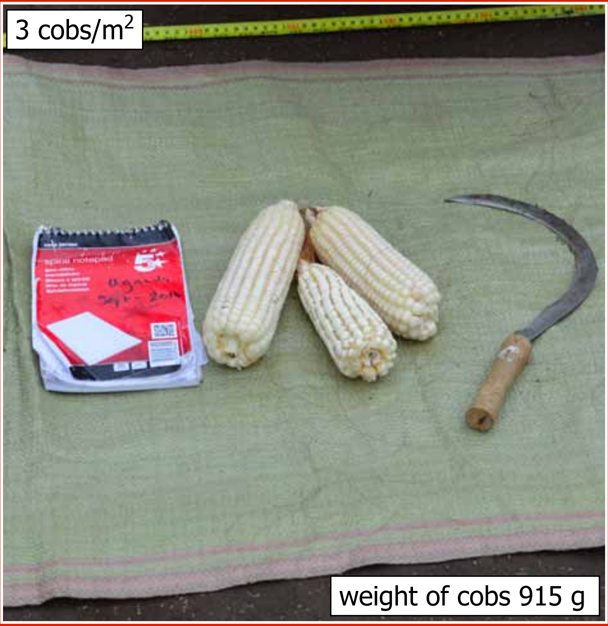
0.20 t/acre

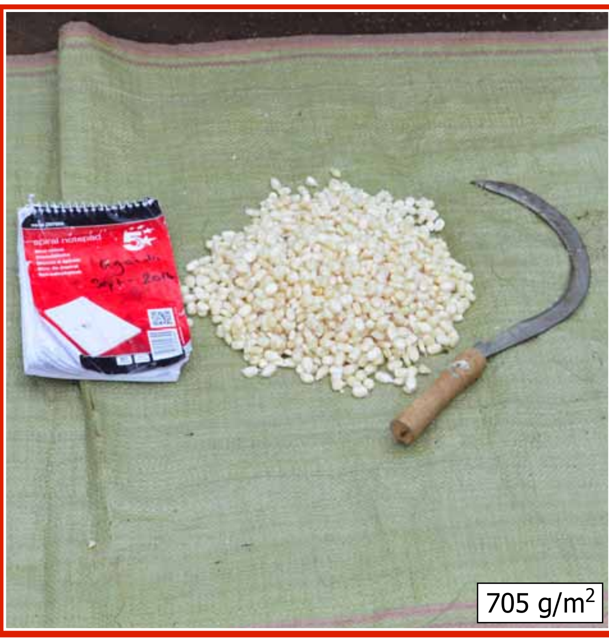
Maize

	From-a-distance	Close-up
• Landrace *Longi 5* • Thick, tall stand • 3 plants/m^2 • Well developed plants • Well developed cobs • Some weeds		
• Landrace *Longi 10* • Thick, tall, even stand • 4 plants/m^2 • 40,000 plants/ha sowing rate • Mostly well developed cobs • Weeded twice • 1 application of basal dressing DAP@125 kg/ha • 1 application of top dressing urea@125 kg/ha		
• Landrace *Morinyang* • Thick, even stand • 3 plants/m^2 • Well developed plants • Cobs of variable size • Weedy		

Maize

Harvest from 1m^2 | **Grain from 1m^2** | **Yield**





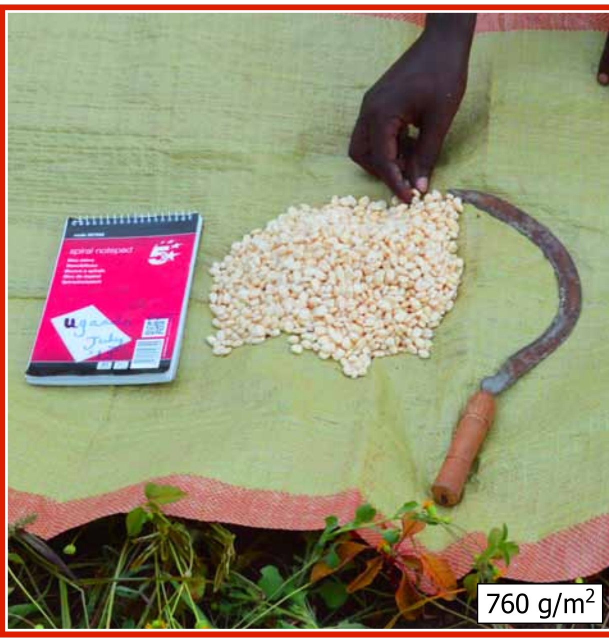
Fresh weight
705 g/m^2

Air-dry 100%

Dry Matter
705 g/m^2

7.05 t/ha

2.85 t/acre



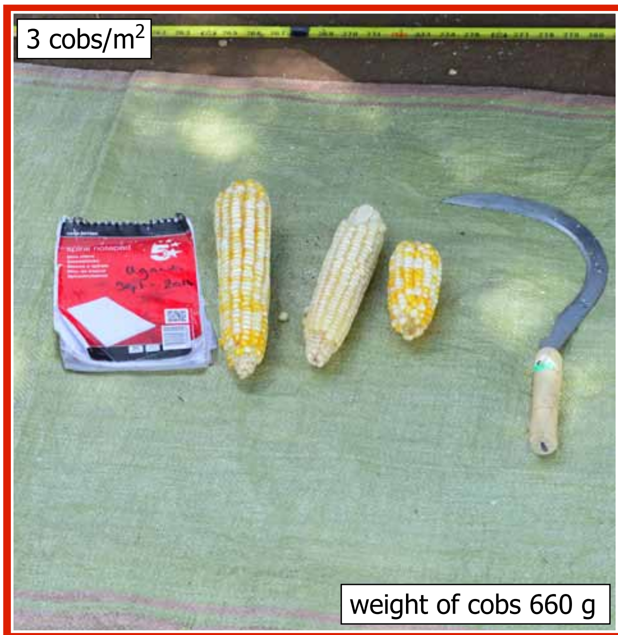
Fresh weight
760 g/m^2

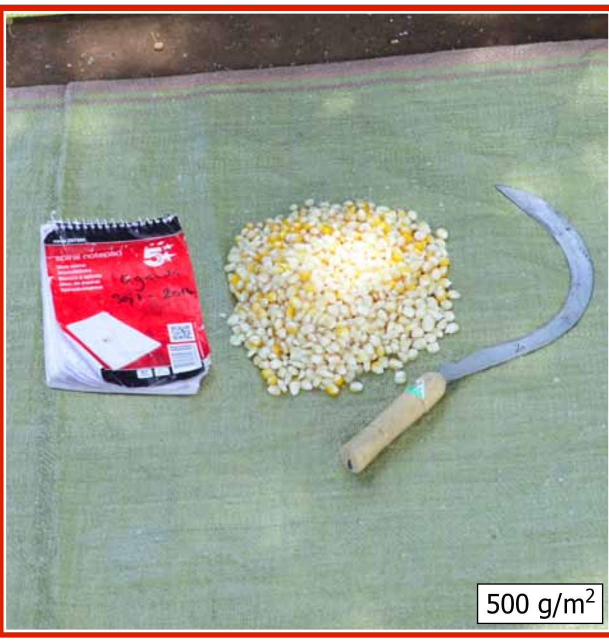
Air-dry 77%

Dry Matter
585 g/m^2

5.85 t/ha

2.36 t/acre





Fresh weight
500 g/m^2

Air-dry 95%

Dry weight
475 g/m^2

4.75 t/ha

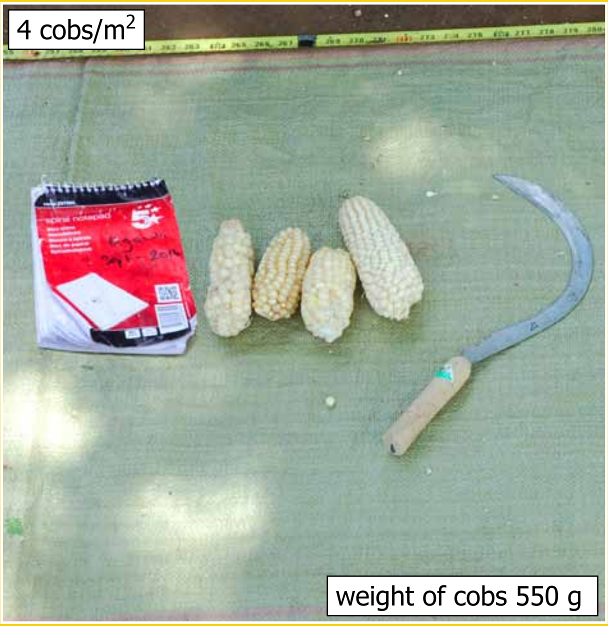
1.92 t/acre

Maize

	From-a-distance	Close-up
• Landrace *Morinyang* • Even stand in rows • 4 plants/m^2 • Well developed plants • Cobs of variable size • Cobs fairly well formed • Weedy crop		
• Landrace *Morinyang* • Variable stand • 2 plants/m^2 • Cobs well formed • Very weedy crop		
• Landrace *Morinyang* • Variable stand, in rows • 3 plants/m^2 • Cobs of variable size • Very weedy crop		

Maize

Harvest from $1m^2$ | **Grain from $1m^2$** | **Yield**



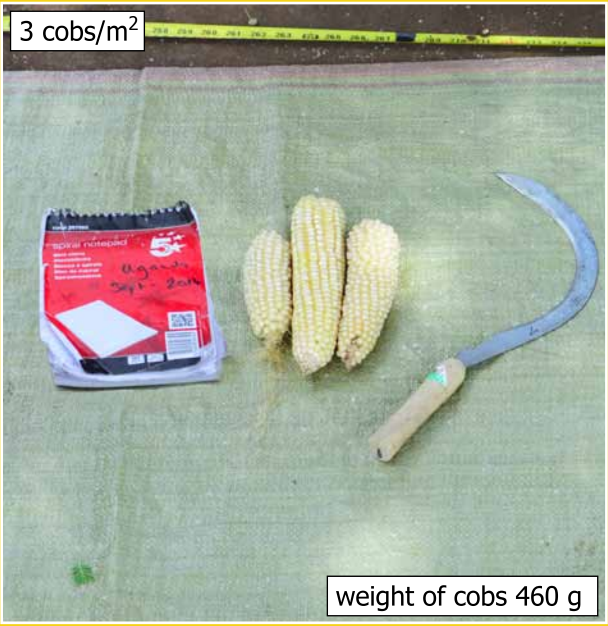
Fresh weight
405 g/m^2

Air-dry 95%

Dry Matter
385 g/m^2

3.85 t/ha

1.56 t/acre



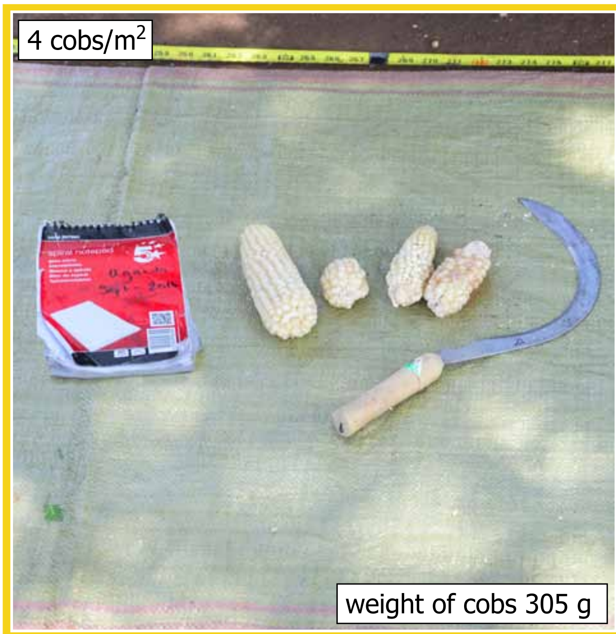
Fresh weight
360 g/m^2

Air-dry 95%

Dry Matter
342 g/m^2

3.42 t/ha

1.38 t/acre



Fresh weight
217 g/m^2

Air-dry 100%

Dry Matter
217 g/m^2

2.17 t/ha

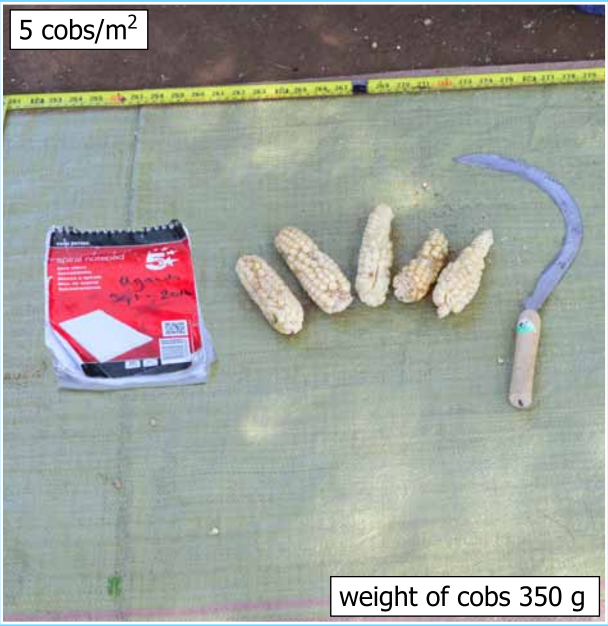
0.88 t/acre

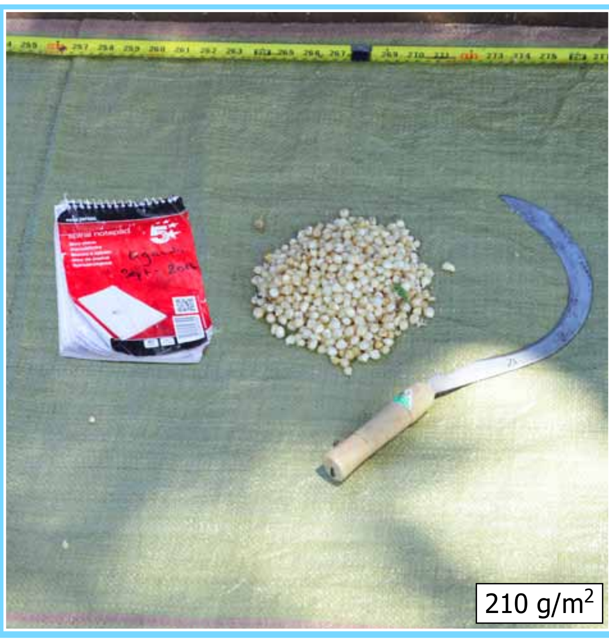
Maize

	From-a-distance	Close-up
• Landrace *Morinyang* • Variable stand, in rows • Poor plant development • 5 plants/m^2 • Poorly formed cobs • Cobs uneven in size • Weedy crop		
• Landrace *Morinyang* • Low plant density • 1 plant/m^2 • Poor plant development • Well formed, small cob • Average 1 cob per plant • Weedy crop		
• Landrace *Morinyang* • Low plant density • 4 plants/m^2 • Very poor plant development • Uneven stand • Average less than 1 cob per plant • Weedy crop		

Maize

Harvest from 1m² | **Grain from 1m²** | **Yield**





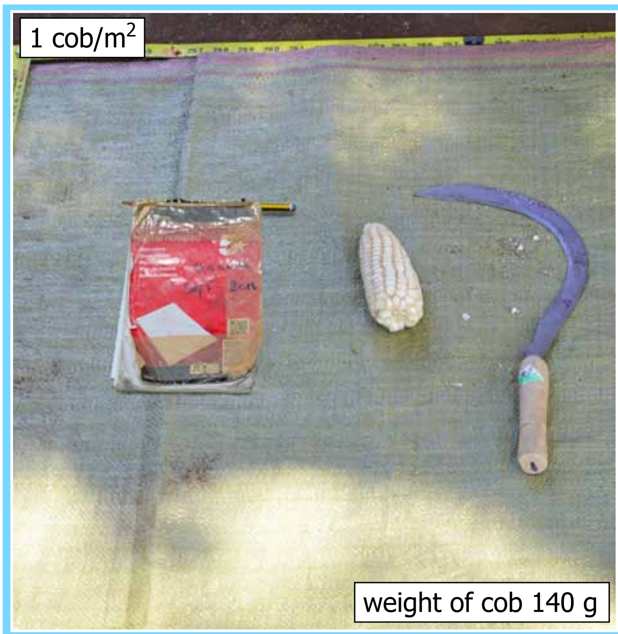
Fresh weight
210 g/m²

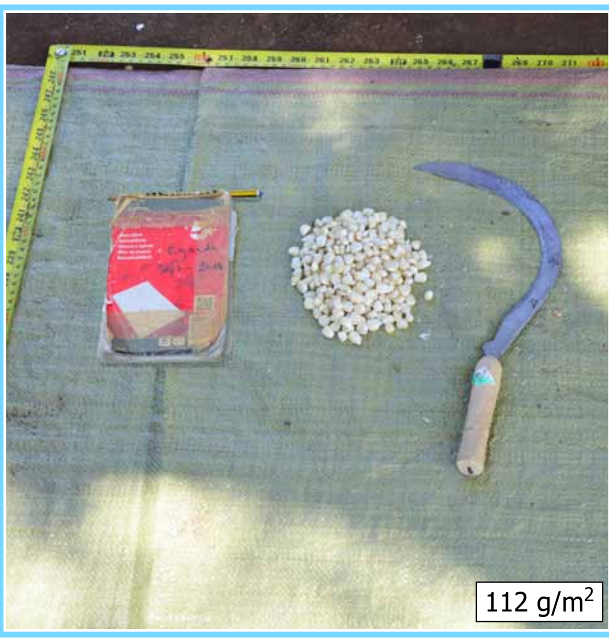
Air-dry 80%

Dry Matter
168 g/m²

1.68 t/ha

0.68 t/acre





Fresh weight
112 g/m²

Air-dry 95%

Dry Matter
106 g/m²

1.06 t/ha

0.43 t/acre

Fresh weight
32 g/m²

Air-dry 100%

Dry Matter
32 g/m²

0.32 t/ha

0.13 t/acre

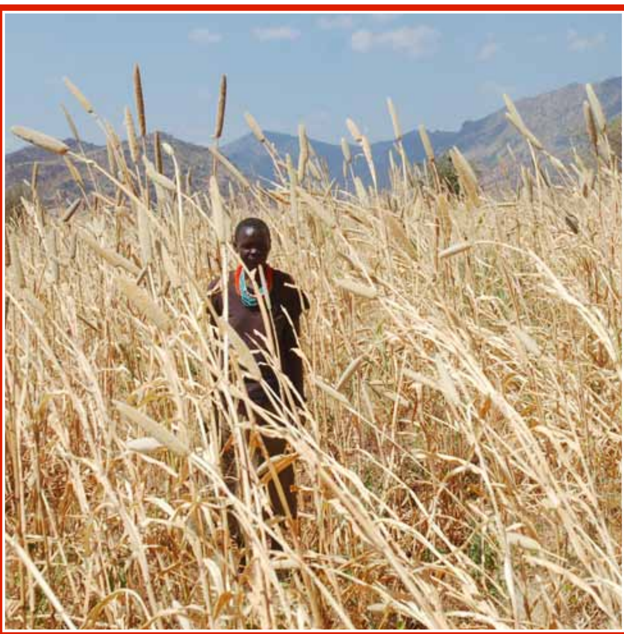
Pearl Millet

From-a-distance | **Close-up**

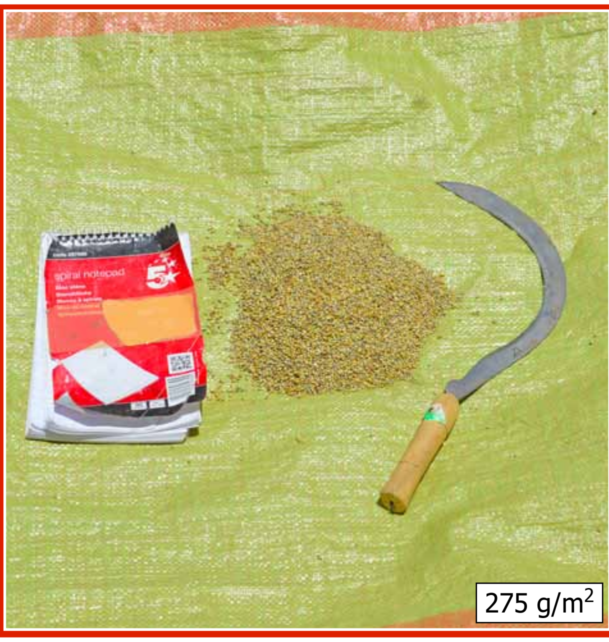
- Local landrace - own seeds
- 3 plants/m^2
- 23 heads/m^2
- 6-8 tillers/plant
- Weeded three times
- Not yet field dry - grain required drying

- Local landrace - own seeds
- 4 plants/m^2
- 34 heads/m^2
- 8-9 tillers/ plant
- Weeded once only
- Harvested when dry

- Local landrace - own seeds
- 3 plants/m^2
- 15 heads/m^2
- 5 tillers/plant
- Harvested when dry



Pearl Millet

Harvest from $1m^2$	Grain from $1m^2$	Yield
		Fresh weight 275 g/m^2 **Air-dry 89%** Dry Matter 246 g/m^2 **2.46 t/ha** **1.00 t/acre**
		Fresh weight 200 g/m^2 **Air-dry 100%** Dry Matter 200 g/m^2 **2.00 t/ha** **0.81 t/acre**
		Fresh weight 165 g/m^2 **Air-dry 100%** Dry Matter 165 g/m^2 **1.65 t/ha** **0.67 t/acre**

Pearl Millet

From-a-distance | **Close-up**

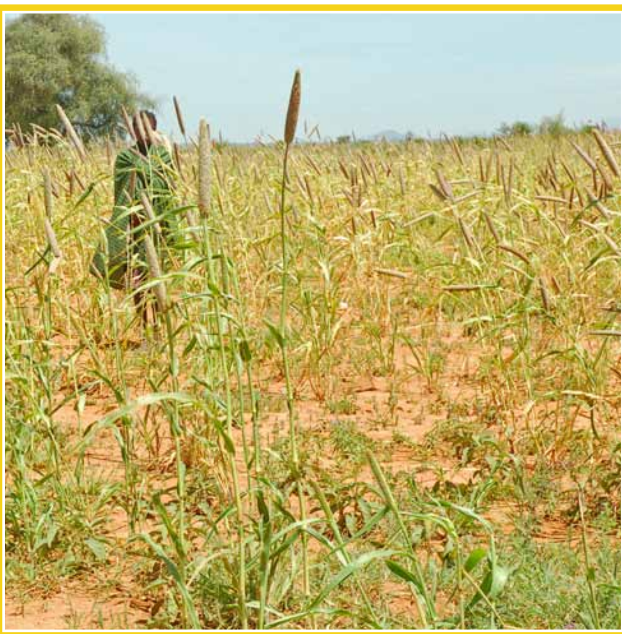
- Local landrace - own seeds
- 3 plants/m^2
- 7-8 tillers/plant
- Weeded three times
- Harvested dry - grain dry to bite
- Harvesting ongoing

3 plants/m^2

- Local landrace - own seeds
- 4 plants/m^2
- 5-6 tillers/plant
- Weeded once only
- Harvested dry - grain dry to bite
- Harvesting ongoing

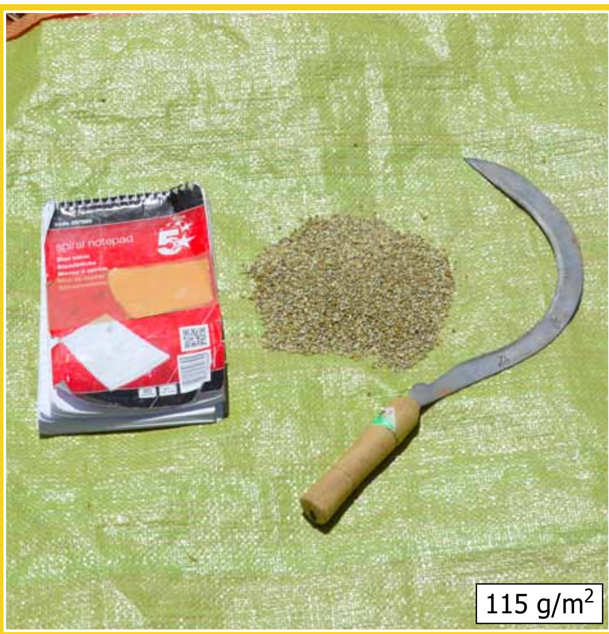
4 plants/m^2

- Local landrace - own seeds
- 2 plants/m^2
- 5-6 tillers/plant
- Weeded three times
- Not yet field dry - required drying



2 plants/m^2

Pearl Millet

Harvest from $1m^2$	Grain from $1m^2$	Yield
		Fresh weight 145 g/m^2 **Air-dry 100%** Dry Matter 145 g/m^2 **1.45 t/ha** **0.58 t/acre**
		Fresh weight 125 g/m^2 **Air-dry 100%** Dry Matter 125 g/m^2 **1.25 t/ha** **0.51 t/acre**
		Fresh weight 115 g/m^2 **Air-dry 95%** Dry Matter 110 g/m^2 **1.10 t/ha** **0.45 t/acre**

Pearl Millet

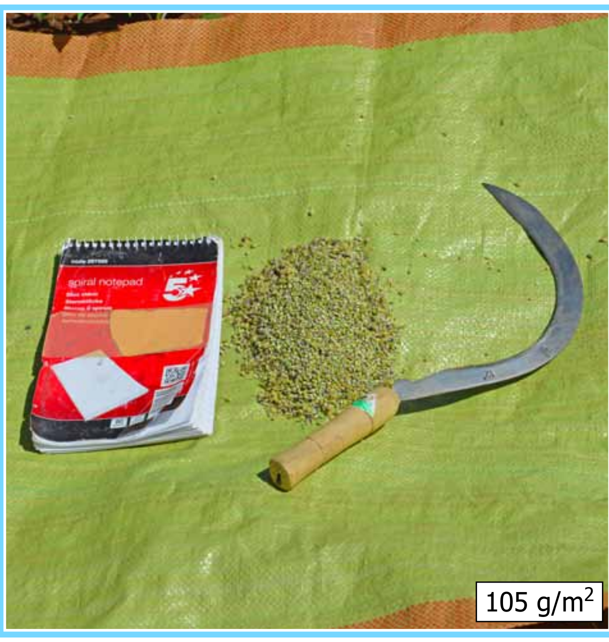
From-a-distance | Close-up

- Local landrace
- 2 plants/m^2
- 9 heads/m^2
- 4-5 tillers/plant

- Local landrace
- 3 plants/m^2
- 17 heads/m^2
- 5-6 tillers/plant

- Local landrace
- 1 plant/m^2
- 5 heads/m^2
- Variable sized heads

Pearl Millet

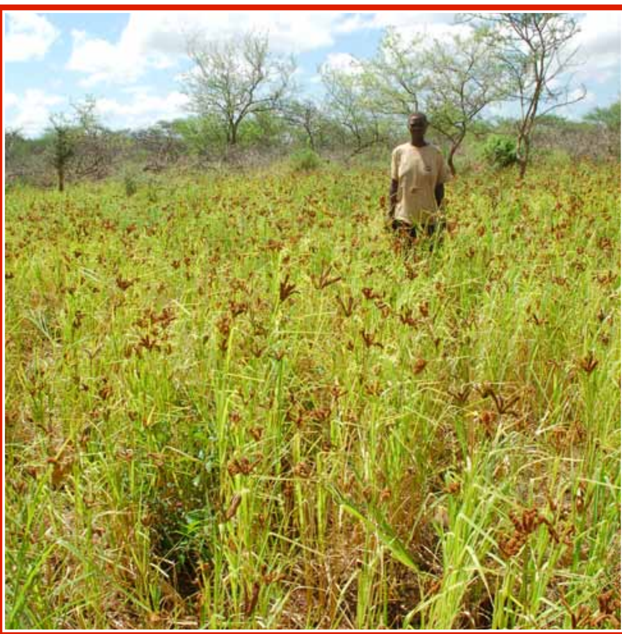
Harvest from 1m^2	Grain from 1m^2	Yield
 9 heads/m^2	 105 g/m^2	Fresh weight 105 g/m^2 **Air-dry 100%** Dry Matter 105 g/m^2 **1.05 t/ha** **0.43 t/acre**
 17 heads/m^2	 105 g/m^2	Fresh weight 105 g/m^2 **Air-dry 71%** Dry Matter 75 g/m^2 **0.75 t/ha** **0.30 t/acre**
 5 heads/m^2	 27 g/m^2	Fresh weight 27 g/m^2 **Air-dry 100%** Dry Matter 27 g/m^2 **0.27 t/ha** **0.11 t/acre**

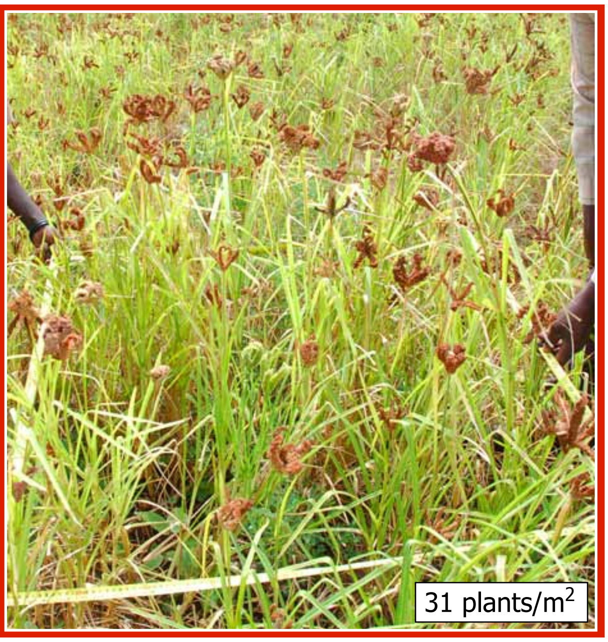
Finger Millet

From-a-distance | **Close-up**

- Local landrace - own seeds
- 13 well spaced plants/m^2
- 60 heads/m^2 - many tillers
- Well weeded field
- Harvested when dry - grain dry to bite
- Harvesting nearly over

- Local landrace - own seeds
- 31 plants/m^2
- 84 heads/m^2
- Approx 2-3 tillers/plant
- No weeding needed
- 2 tiers of heads
- High density of plants
- Not yet field dry - required drying
- Ongoing harvest of dry heads only





- Local landrace - own seeds
- 12 well spaced plants/m^2
- 54 heads/m^2
- Approx 4-5 tillers/plant
- Well weeded field
- Grain nearly dry to bite
- Ongoing harvest

Finger Millet

Harvest from 1m² | **Grain from 1m²** | **Yield**

60 heads/m^2

330 g/m^2

Fresh weight
330 g/m^2

Air-dry 100%

Dry Matter
330 g/m^2

3.30 t/ha

1.34 t/acre

84 heads/m^2

365 g/m^2

Fresh weight
365 g/m^2

Air-dry 82%

Dry Matter
299 g/m^2

2.99 t/ha

1.21 t/acre

54 heads/m^2

275 g/m^2

Fresh weight
275 g/m^2

Air-dry 92%

Dry Matter
252 g/m^2

2.52 t/ha

1.02 t/acre

Finger Millet

From-a-distance	Close-up

- Local landrace - own seeds
- 16 well spaced plants/m^2
- 70 heads/m^2
- Approx 4 tillers/ plant
- Well weeded
- Grain nearly ready
- Harvesting of all heads started

- Local landrace - own seeds
- Dense sowing
- 44 plants/m^2
- 92 heads/m^2
- Approx 2 tillers/ plant
- Well weeded field
- Not yet field dry - grain required drying
- Harvesting started by trimming dry heads

- Local landrace - own seeds
- 18 plants/m^2
- 37 heads/m^2
- Approx 2 tillers/ plant
- No weeds
- Not yet field dry - grain required drying, nearly dry to bite
- Harvesting started by trimming dry heads

Finger Millet

Harvest from 1m^2	Grain from 1m^2	Yield

Fresh weight
235 g/m^2

Air-dry 91%

Dry Matter
215 g/m^2

2.15 t/ha

0.87 t/acre

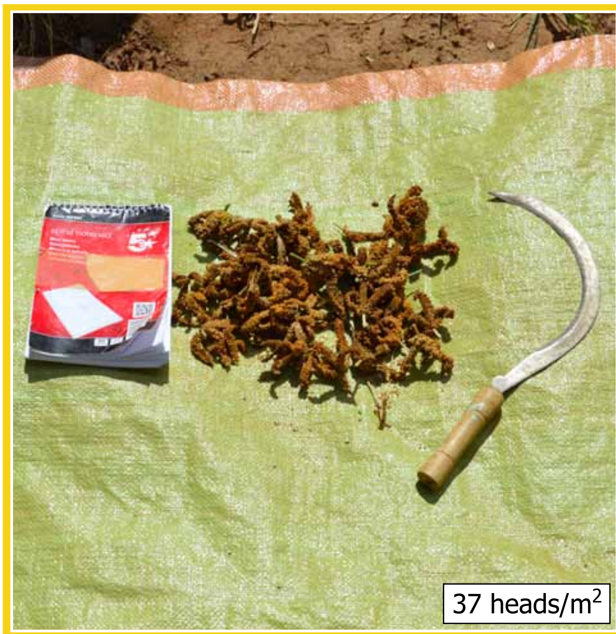
Fresh weight
185 g/m^2

Air-dry 82%

Dry Matter
151 g/m^2

1.51 t/ha

0.61 t/acre



Fresh weight
130 g/m^2

Air-dry 85%

Dry Matter
111 g/m^2

1.11 t/ha

0.45 t/acre

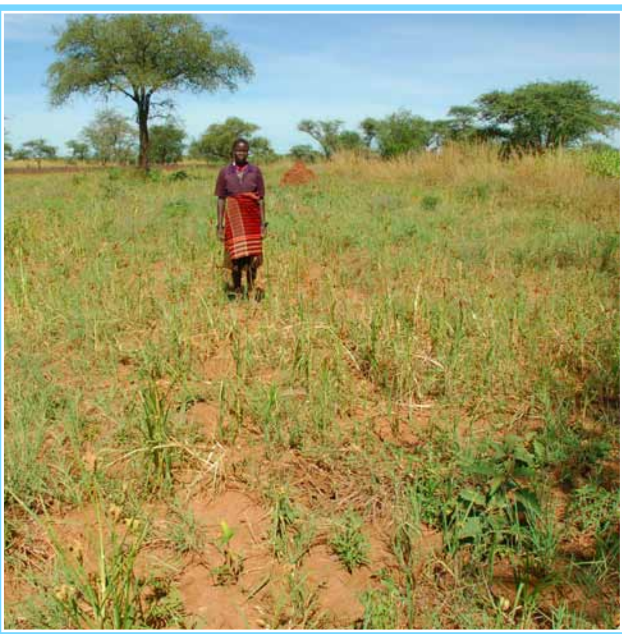
Finger Millet

From-a-distance | **Close-up**

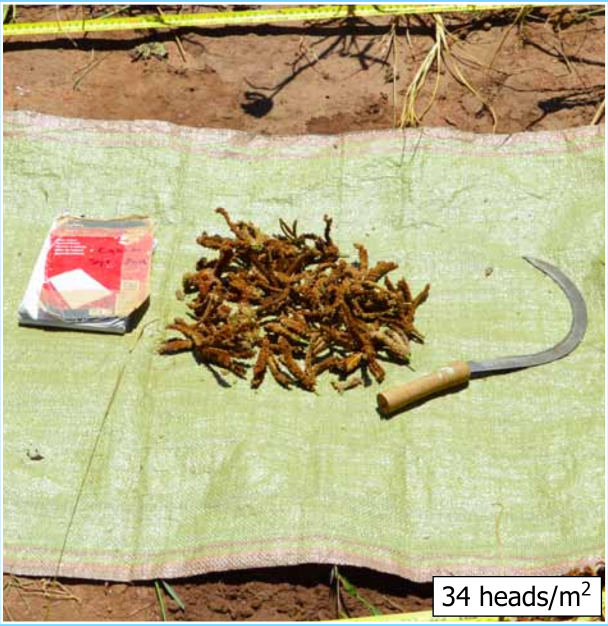
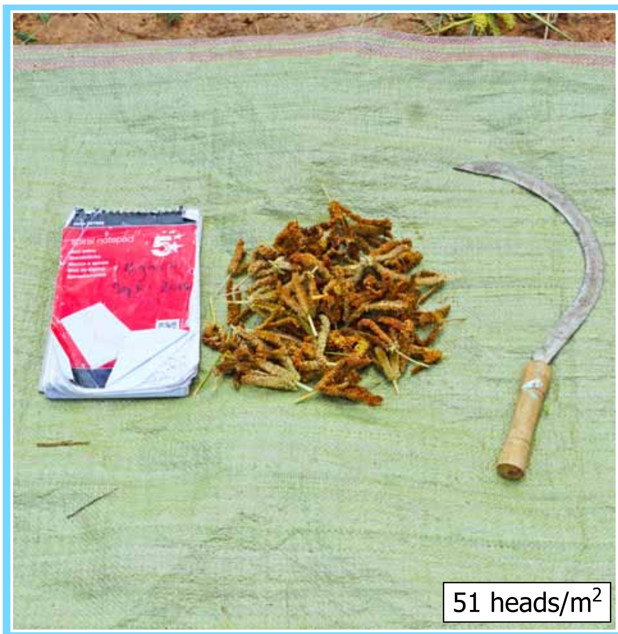
- Local landrace - own seeds
- 26 plants/m^2
- 34 heads/m^2
- Approx 1-2 tillers/plant
- Weedy crop
- Not yet field dry - grain required drying, nearly dry to bite
- Harvesting starting by trimming dry heads

- Local landrace - own seeds
- 35 plants/m^2
- Heavy sowing
- 51 heads/m^2
- Approx 1-2 tillers/plant
- Spaces in cover
- Weedy
- Not yet field dry - grain required drying, nearly dry to bite
- Harvesting starting by trimming dry heads

- Local landrace - own seeds
- 15 plants/m^2
- 26 heads/m^2
- Approx 1-2 tillers/plant
- Spaces in cover
- Weedy crop
- Harvested when dry - grain dry to bite
- Harvesting finishing



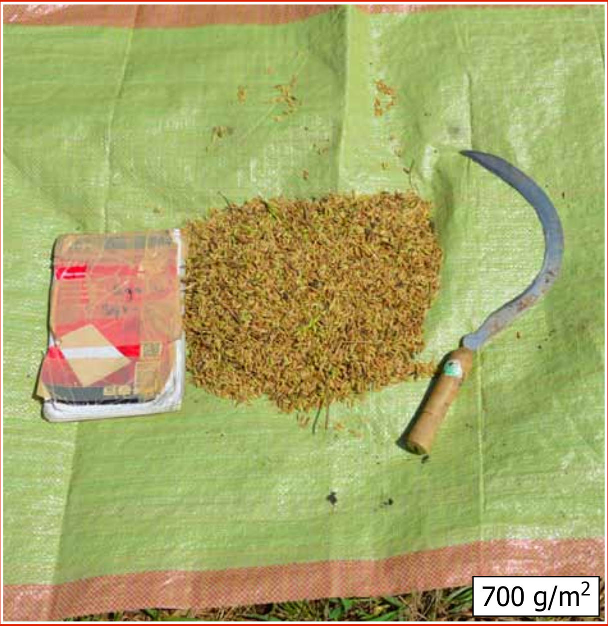
Finger Millet

Harvest from $1m^2$	Grain from $1m^2$	Yield
		Fresh weight 110 g/m^2 **Air-dry 85%** Dry Matter 94 g/m^2 **0.94 t/ha** **0.38 t/acre**
		Fresh weight 90 g/m^2 **Air-dry 80%** Dry Matter 72 g/m^2 **0.72 t/ha** **0.29 t/acre**
		Fresh weight 50 g/m^2 **Air-dry 100%** Dry Matter 50 g/m^2 **0.50 t/ha** **0.20 t/acre**

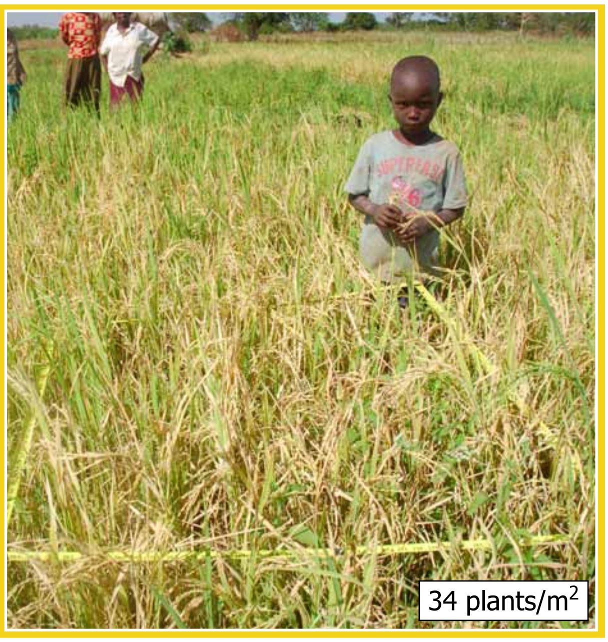
Rice

	From-a-distance	Close-up
• Landrace *Kaiso* • Seeds from local market • Dense, even crop • Well formed heads • Many tillers		
• Landrace *Kaiso* • Mbale seed • Tall, well developed plants • Well formed heads • Variable tillers		
• *Nerica 4 type* • Good vegetational growth • Good even crop • Good seed set • Long heads • No weeds		

Rice

Harvest from 1m^2	Grain from 1m^2	Yield
 28 plants/m^2	 700 g/m^2	Fresh weight 700 g/m^2 **Air-dry 87%** Dry Matter 612 g/m^2 **6.12 t/ha** **2.48 t/acre**
 24 plants/m^2	 525 g/m^2	Fresh weight 525 g/m^2 **Air-dry 90%** Dry Matter 475 g/m^2 **4.75 t/ha** **1.92 t/acre**
 38 plants/m^2	 380 g/m^2	Fresh weight 380 g/m^2 **Air-dry 100%** Dry Matter 380 g/m^2 **3.80 t/ha** **1.54 t/acre**

Rice

	From-a-distance	Close-up
• Landrace *Kaiso* • Dense stand • Weedy		 34 plants/m^2
• Landrace *Kaiso* • Variable stand • Weedy		 16 plants/m^2
• Landrace *Kaiso* • Variable stand		 16 plants/m^2

Rice

Harvest from 1m^2	Grain from 1m^2	Yield


34 plants/m^2


305 g/m^2

Fresh weight
305 g/m^2

Air-dry 100%

Dry Matter
305 g/m^2

3.05 t/ha

1.23 t/acre


16 plants/m^2


220 g/m^2

Fresh weight
220 g/m^2

Air-dry 100%

Dry Matter
220 g/m^2

2.20 t/ha

0.89 t/acre


16 plants/m^2


150 g/m^2

Fresh weight
150 g/m^2

Air-dry 100%

Dry Matter
150 g/m^2

1.50 t/ha

0.61 t/acre

Rice

	From-a-distance	Close-up

- Local seed
- Even crop
- Mixed heads
- Many tillers
- Variable establishment of plants
- No bird damage
- No disease

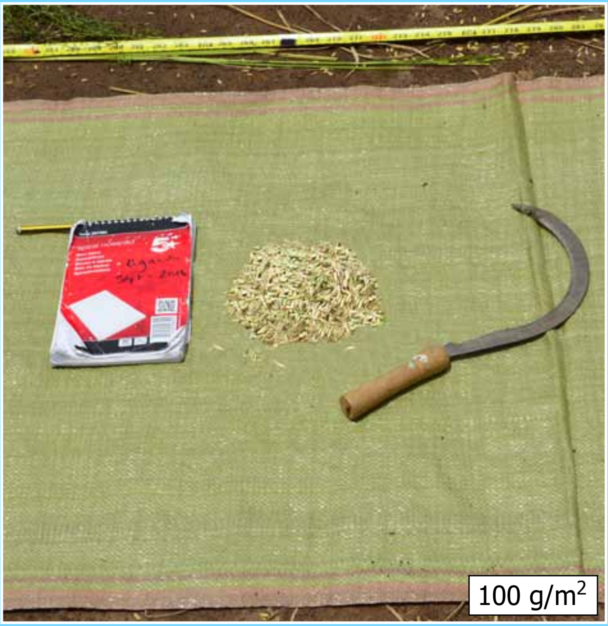
- Landrace *Kaiso*
- Low density
- Poor plant establishment
- Poor seed set

- Local seed
- Poor crop
- Almost no seed set
- Few tillers
- Poor establishment of plants
- Bird damage
- Some plants may have disease

Rice

Harvest from 1m²	Grain from 1m²	Yield


23 plants/m²


100 g/m²

Fresh weight 100 g/m²

Air-dry 100%

Dry Matter 100 g/m²

1.00 t/ha

0.40 t/acre


13 plants/m²


50 g/m²

Fresh weight 50 g/m²

Air-dry 100%

Dry Matter 50 g/m²

0.50 t/ha

0.20 t/acre


13 plants/m²


10 g/m²

Fresh weight 10 g/m²

Air-dry 100%

Dry Matter 10 g/m²

0.10 t/ha

0.04 t/acre

Cassava

	From-a-distance	Close-up
• Variety *Migyera (NASE 3)* • Type - bitter approx. 2 year; actual age 29 months, harvesting now • Point-to-Plant 5 plant circle radius is 2.85 m Area/plant = 5.10 m^2 • 1959 plants/ha • 21.19 kg tuber per plant - fresh weight		
• Variety *Migyera (NASE 3)* • Type - bitter approx. 2 year; actual age 27 months, harvesting now • Point-to-Plant 5 plant circle radius is 2.40 m Area/plant = 3.62 m^2 • 2763 plants/ha • 13.60 kg tuber per plant - fresh weight		
• Variety *Morulea (TME 14)* • Type - sweet but approx. 2 year; actual age 17 months, harvesting now • Point-to-Plant 5 plant circle radius is 2 m Area/plant = 2.51 m^2 • 3978 plants/ha • 6.32 kg tuber per plant - fresh weight		

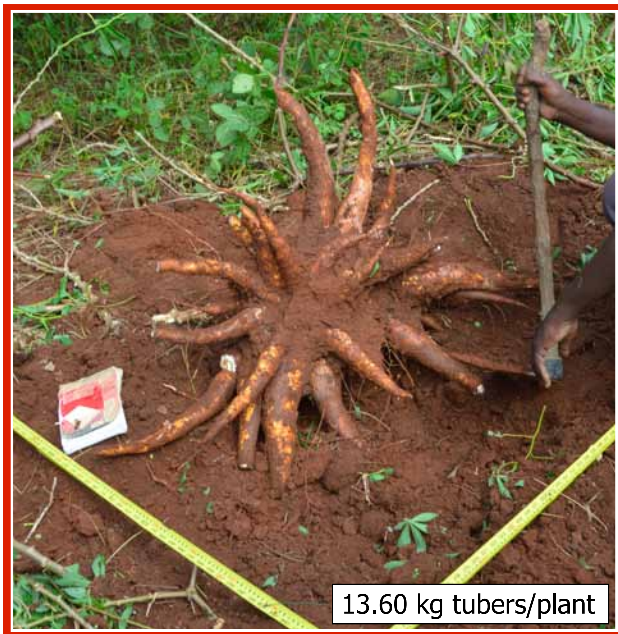
Cassava

Product of a single plant | **Yield of a single plant** | **Yield**

Fresh weight 4.15 kg/m^2

41.52 t/ha fresh

16.77 t/acre fresh



Fresh weight 3.76 kg/m^2

37.60 t/ha fresh

15.22 t/acre fresh

Fresh weight 2.51 kg/m^2

25.14 t/ha fresh

10.16 t/acre fresh

Cassava

From-a-distance | **Close-up**

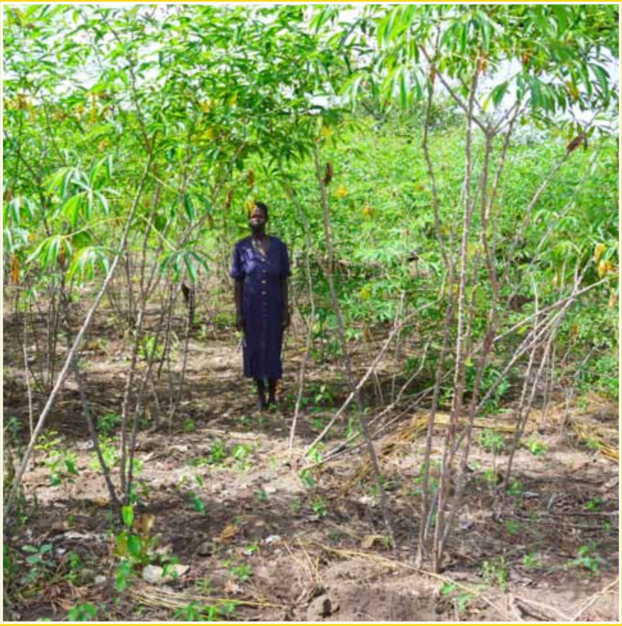
- Variety *Morulea (TME 14)*
- Type - sweet but approx. 2 year; actual age 17 months, harvesting now
- Point-to-Plant 5 plant circle radius is 2.12 m
- Area/plant = 2.82 m^2
- 3541 plants/ha
- 5.69 kg tuber per plant - fresh weight

1 plant/2.82 m^2

- Variety *Morulea (TME 14)*
- Type - bitter approx. 2 year; actual age 26 months, harvesting now
- Point-to-Plant 5 plant circle radius is 2.17 m
- Area/plant = 2.96 m^2
- 3379 plants/ha
- 5.46 kg tuber per plant - fresh weight

1 plant/2.96 m^2

- Variety *Mogomogo*
- Type - sweet approx. 2 year; actual age 24 months, harvesting now
- Point-to-Plant 5 plant circle radius is 1.55 m
- Area/plant = 1.51 m^2
- 6624 plants/ha
- 2.30 kg tuber per plant - fresh weight



1 plant/1.51 m^2

Cassava

Product of single plant	Yield of single plant	Yield

Fresh weight
2.01 kg/m^2

20.15 t/ha fresh

8.14 t/acre fresh

Fresh weight
1.84 kg/m^2

18.45 t/ha fresh

7.45 t/acre fresh

Fresh weight
1.52 kg/m^2

15.23 t/ha fresh

6.15 t/acre fresh

Cassava

	From-a-distance	Close-up

- Variety *Morulea (TME 14)*
- Type - sweet approx. 2 year; actual age 26 months, harvesting now
- Point-to-Plant 5 plant circle radius is 2.25 m
- Area/plant = 3.18 m^2
- 3143 plants/ha
- 2.80 kg tuber per plant - fresh weight

- Type - approx. 2 year; actual age 24 months, harvesting now
- Point-to-Plant 5 plant circle radius is 2.57 m
- Area/plant = 4.15 m^2
- 2409 plants/ha
- 2.90 kg tuber per plant - fresh weight

- Variety *Migyera (NASE 3)*
- Type - bitter approx. 2 year; actual age 28 months, harvesting now
- Point-to-Plant 5 plant circle radius is 1.98 m
- Area/plant = 2.46 m^2
- 4061 plants/ha
- 0.80 kg tuber per plant - fresh weight

Cassava

Product of single plant	Yield from single plant	Yield

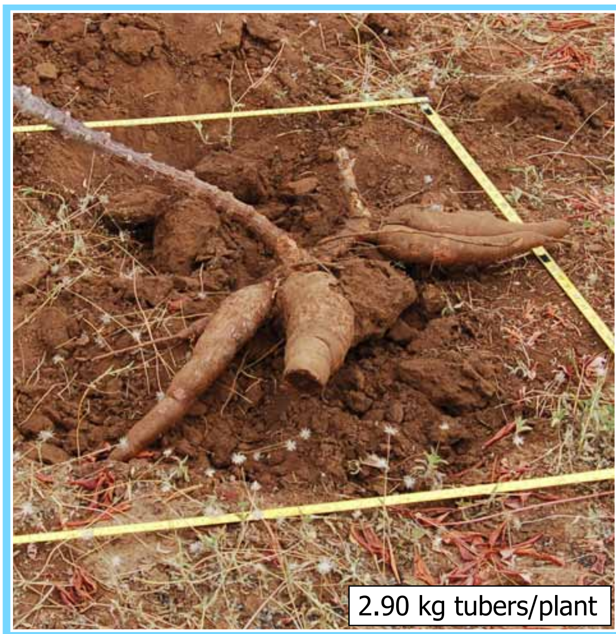
2.80 kg tubers/plant

0.88 kg/m^2

Fresh weight 0.88 kg/m^2

8.80 t/ha fresh

3.56 t/acre fresh



2.90 kg tubers/plant

0.69 kg/m^2

Fresh weight 0.69 kg/m^2

6.99 t/ha fresh

2.82 t/acre fresh

0.80 kg tubers/plant

0.32 kg/m^2

Fresh weight 0.32 kg/m^2

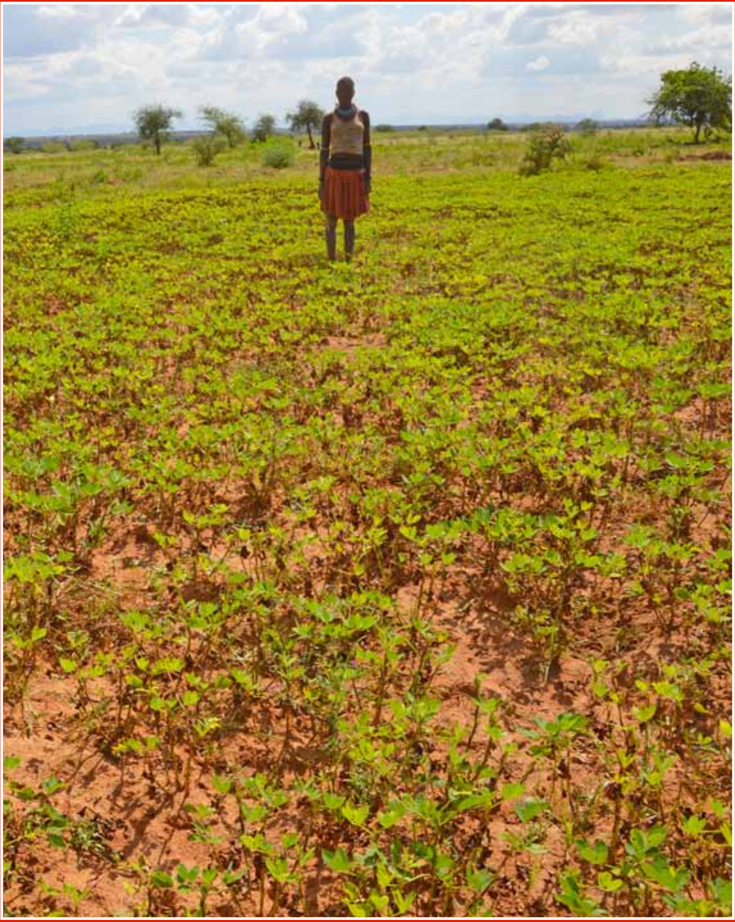
3.25 t/ha fresh

1.31 t/acre fresh

Groundnut

From-a-distance | **Close-up**

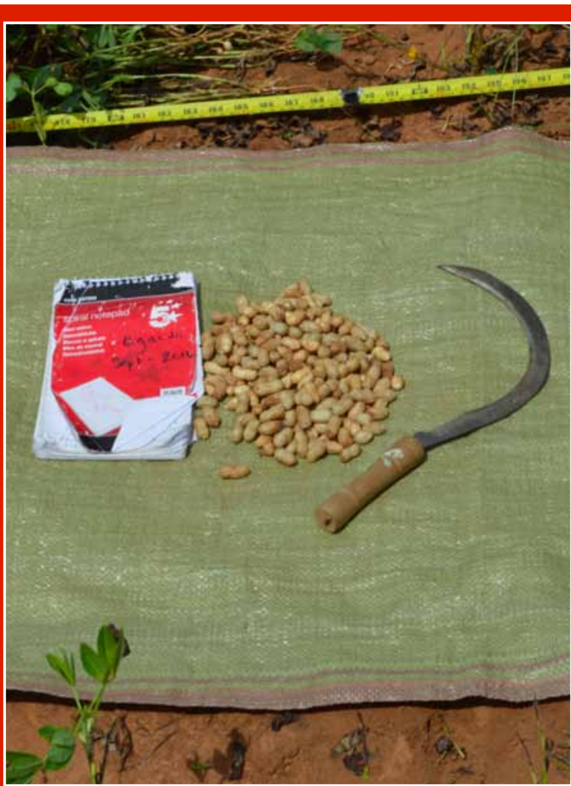
- Erect local variety
- Approx. 15 plants/m^2
- Well weeded
- Disease free
- Even stand
- 1.75:1 pod:stem/plant ratio



- Erect local variety
- Approx. 13 plants/m^2
- Well weeded
- Disease free
- Variable stand
- 1.5:1 pod:stem/plant ratio

Groundnut

Harvest from 1m²	Produce from 1m²	Yield



Freshly dug weight (unshelled)

300 g/m²

3.00 t/ha **1.21 t/acre**

Freshly dug weight (unshelled)

260 g/m²

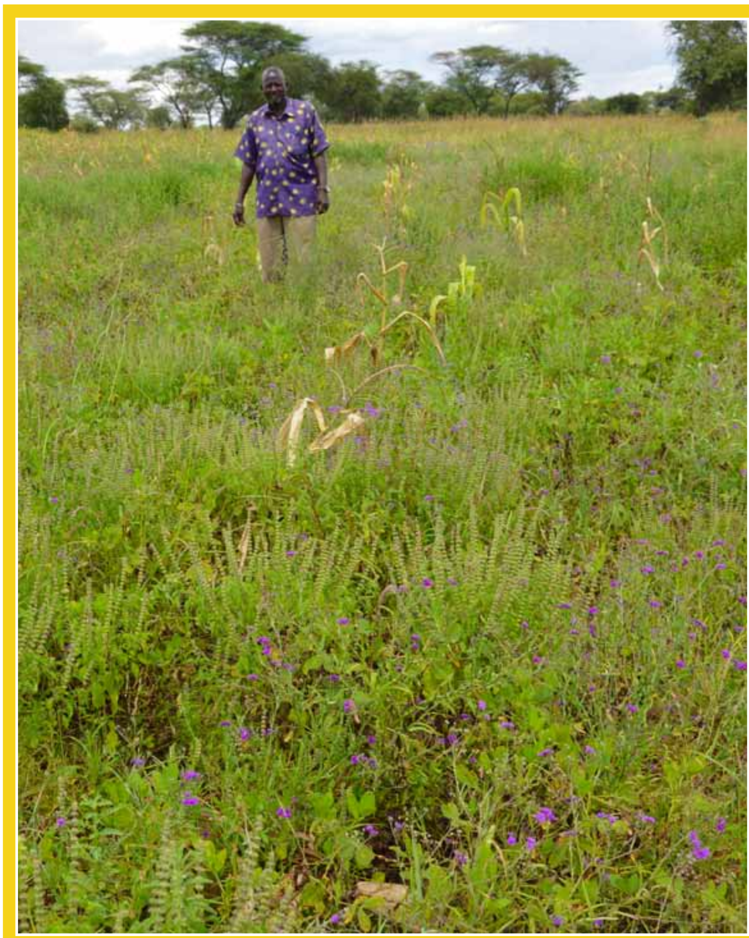
2.60 t/ha **1.05 t/acre**

Groundnut

From-a-distance

Close-up

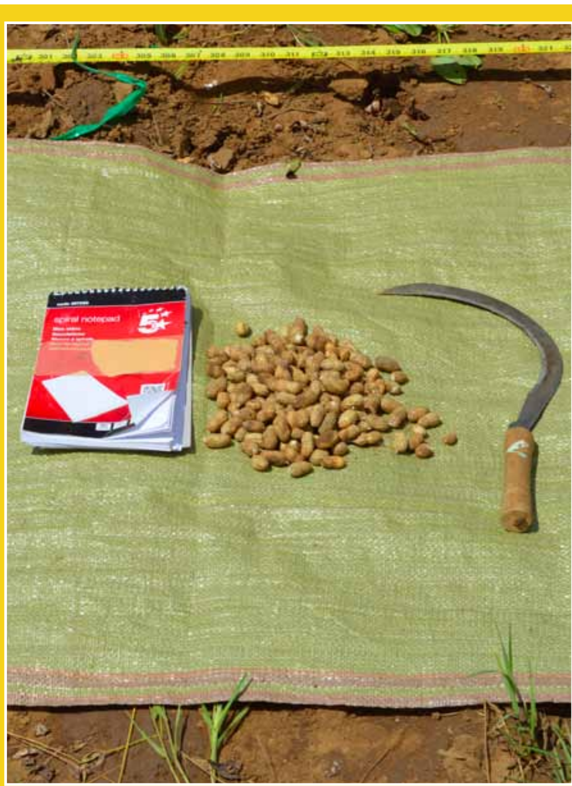
- Erect local variety
- Approx. 14 plants/m^2
- Well weeded
- Disease free
- 2.5:1 pod:stem/plant ratio



- Erect local variety
- Approx. 10 plants/m^2
- No weeding
- Weed infested
- Too much top growth
- 6:1 pod:stem/plant ratio

Groundnut

Harvest from 1m² | **Produce from 1m²** | **Yield**



Freshly dug weight (unshelled)

240 g/m²

2.40 t/ha **0.97 t/acre**

Freshly dug weight (unshelled)

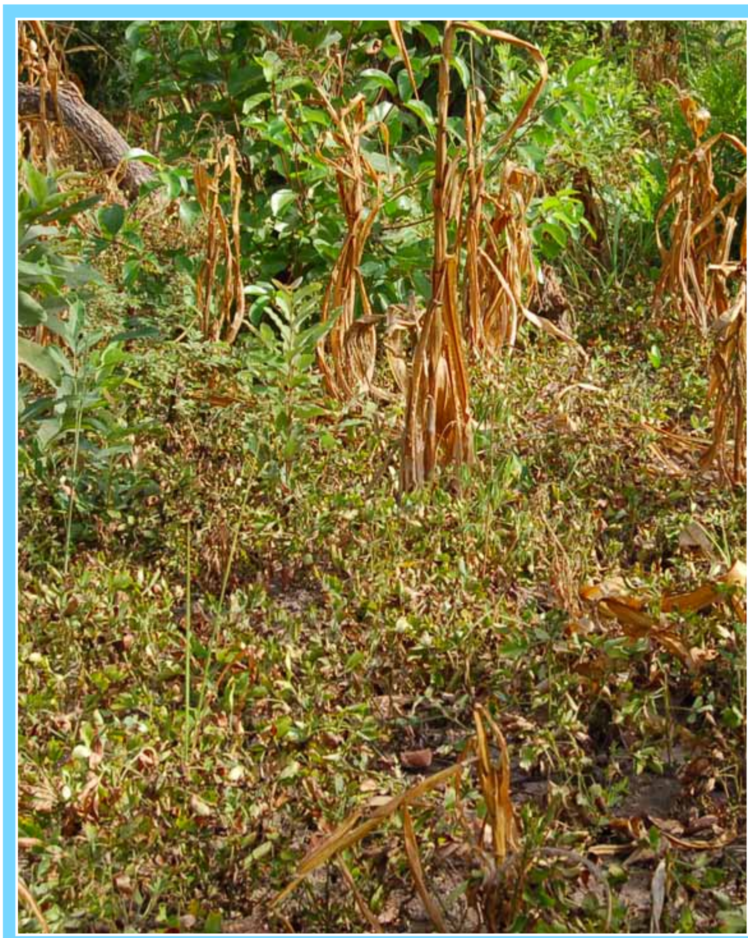
150 g/m²

1.50 t/ha **0.61 t/acre**

Groundnut

From-a-distance | **Close-up**

- Erect local variety
- Approx. 9 plants/m^2
- Medium plant density
- Weeded once only
- Disease free
- Poor crop growth
- 1.3:1 pod:stem/plant ratio



- Intercrop with maize
- Approx. 11 groundnut plants/m^2
- Very low maize plant density
- Drier crop
- Poor peg development
- 5:1 pod:stem/plant ratio

Groundnut

Harvest from 1m²	Produce from 1m²	Yield

Freshly dug weight (unshelled)

125 g/m²

1.25 t/ha **0.51 t/acre**

Freshly dug weight (unshelled)

60 g/m²

0.60 t/ha **0.24 t/acre**

Sunflowers

From-a-distance | **Close-up**

- Local seed
- Even crop stand
- Tall, well developed plants
- Full seed set
- Large heads
- Few weeds

- Market seed
- Even crop stand
- Tall, well developed plants
- Variable seed set
- Large heads
- Few weeds

Sunflowers

Harvest from 1m²	Seeds from 1m²	Yield

Fresh weight 285 g/m^2

Air-dry 100%

Dry Matter 285 g/m^2

2.85 t/ha **1.15 t/acre**

Fresh weight 415 g/m^2

Air-dry 64%

Dry Matter 266 g/m^2

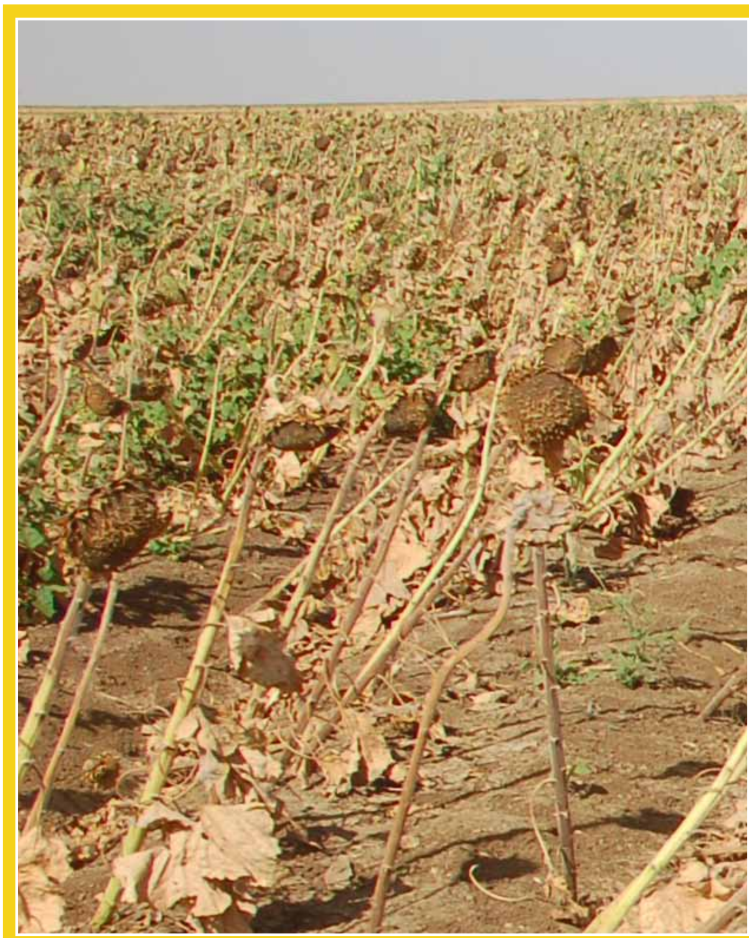
2.66 t/ha **1.08 t/acre**

Sunflowers

From-a-distance

Close-up

- Local seed
- Even crop stand
- Differing sized heads
- Few weeds
- Variable seed set



- Medium sized heads
- Low plant density
- Full seed set
- Some seeds lost (birds)
- Some weeds

Sunflowers

Harvest from $1m^2$	Seeds from $1m^2$	Yield

Fresh weight
210 g/m^2

Air-dry 100%

Dry Matter
210 g/m^2

2.10 t/ha **0.85 t/acre**

Fresh weight
125 g/m^2

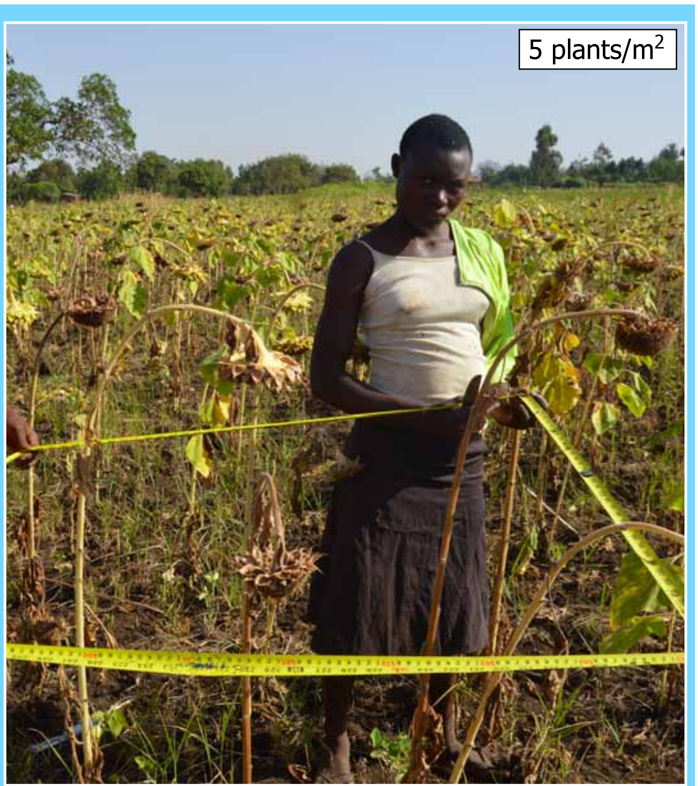
Air-dry 100%

Dry Matter
125 g/m^2

1.25 t/ha **0.51 t/acre**

Sunflowers

From-a-distance | **Close-up**



- Local seed
- Medium and small heads
- Variable plant development
- Very weedy

- Local seed
- Crop stand uneven
- Poorly developed plants
- Small sized heads
- Few weeds
- Variable seed set

Sunflowers

Harvest from 1m²	Seeds from 1m²	Yield

Fresh weight
100 g/m²

Air-dry 100%

Dry Matter
100 g/m²

1.00 t/ha **0.40 t/acre**

Fresh weight
45 g/m²

Air-dry 93%

Dry Matter
42 g/m²

0.42 t/ha **0.17 t/acre**

ANNEX 1

Estimating yield of each crop in an intercrop

To estimate the yield from an area of land in an intercrop you will need to consider each crop separately and estimate its density. This is because farmers plant their crops at different densities in intercrops compared to sole crops and this needs taking into consideration when estimating crop yield.

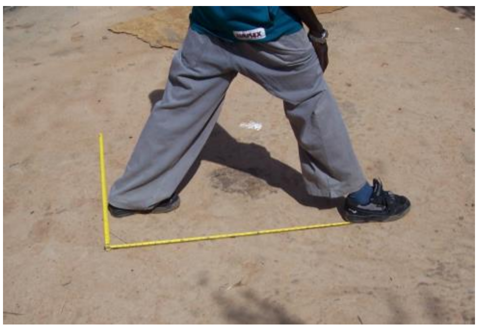
Remember, an intercrop is any field that has two or more crops grown together as a mixture on the same piece of land. If your crop is an intercrop, consider each crop separately and decide which one you will estimate.

Locating the crops ready for harvest in an intercrop: Look at your intercrop, identify those plants that are crops and those that are weeds. Disregard the weeds. **Remember**, the farmer may have planted the crops at different times and so some of the crops may be immature and are not ready for harvest.

For these immature crops there are two options;

i) you can make a note in your field book of the location of the field and which crops are immature so that the field can be revisited later or,
ii) if the crops are close to maturity then you can continue with a crop assessment and estimate the yield the crop may give when it reaches maturity.

Estimating the density: To do this, count the number of plants of each chosen crop in a known area of the field. For well-spaced crops, use an area of **four** square metres (**4 m^2**) which means an area that is a square in shape with each side measuring **two** metres in length. As a general guide, one stride of a person of medium height is equal to one metre (measuring from the back of the foot to the back of the next foot). By using a measuring tape or ruler, you can measure your own stride and adjust it so that it is as close to 1 metre in length as possible, shown in the following photo.

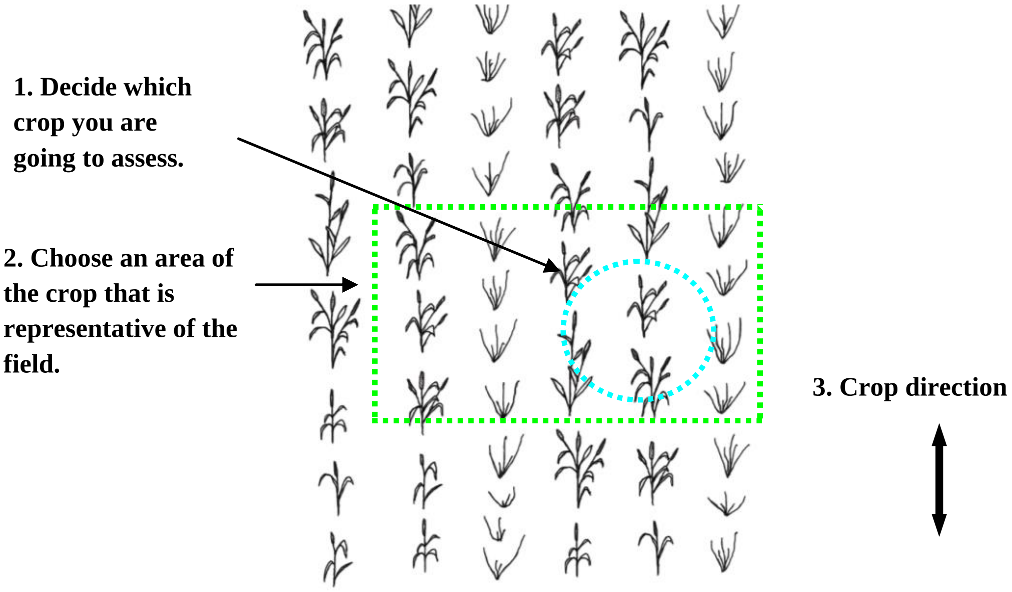


Procedure for measuring population density:

1. Decide which crop in the intercrop you are going to assess.

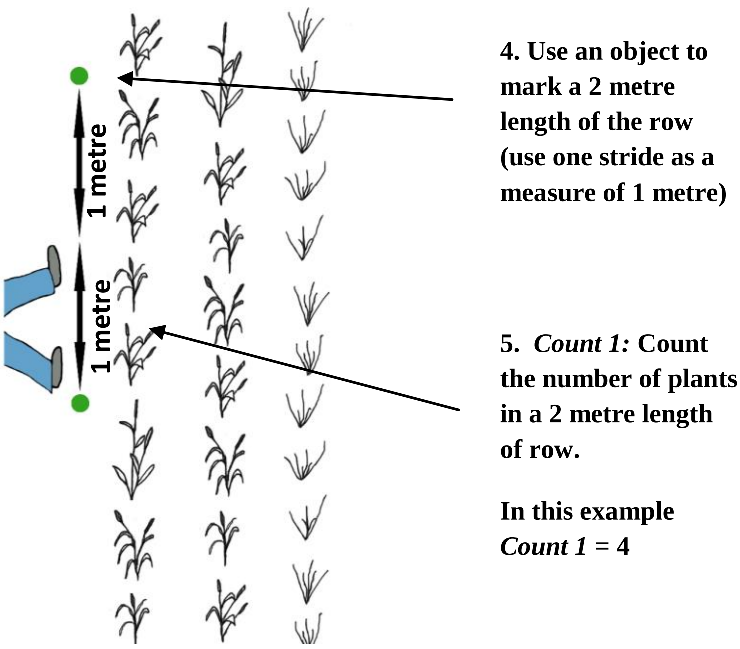
2. Choose an area of the field where the crop is neither very good nor very poor (i.e. it is representative of the field as a whole).

3. Look at the crop and decide in which direction the rows are planted.



4. Use an object to mark the start of your **2 m** length and then take two good strides along the row and use another object to mark the end of the **2 m** length.

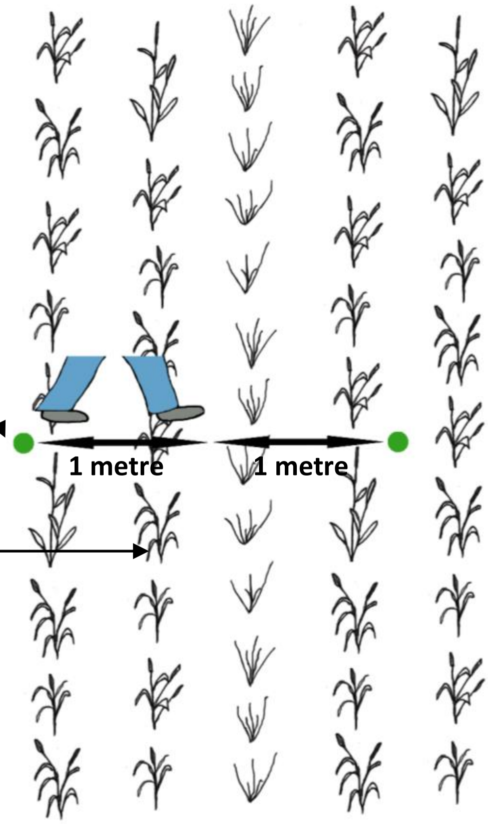
5. Count the number of plants along this **2 m** length (*Count 1*).



6. Repeat the process described in 4. but at a 90° angle to the row.

7. Count the number of plants along this **2 m** length (*Count 2*).

6. Repeat the process but at a 90° angle to the first count.



7. *Count 2*: Count the number of plants of one crop in a 2 metre cross-section of the intercrop.

***Count 2* = 3 in this example.**

8. Calculate the total plant population for a 4 m^2 area by multiplying *Count 1* by *Count 2*. In the example above:

Total population density of **ONE** crop in the intercrop

= *(Count 1)* x (*Count 2*) = 4 x 3 = 12 = **12** plants in **4** m^2

9. Calculate the total plant population for 1 m^2 by dividing the answer above by **4**. Plant density in **1** m^2 = **12**/**4** = **3** plants per sq m

10. Record the density of each crop in your notebook and then continue to **STEP 2**.

ANNEX 2
Converting grams per m^2 to tonnes per hectare

To convert the weight, in grams, of your grain sample harvested from one square metre (m^2), to yield in kilograms per hectare, you only have to change the units and multiply by 10, as shown in the example below:-

***e. g.* 175 g/m^2 = 1 750 kg/hectare**

To convert the weight from kg per hectare to tonnes per hectare, change the units and divide by 1 000:-

***e. g.* 1 750 kg/hectare = 1.75 t/ha**

Calculations explained:

- To scale up from one square metre to one hectare, multiply by 10 000 (10 000 m^2 = 1 hectare)
- To convert your sample weight from grams to kilograms divide by 1 000 (1 000 g = 1 kg)
- To convert your sample weight from kilograms to tonnes divide by 1 000 (1 000 kg = 1 tonne)

Example: If the grain harvested from one square metre weighs 250 g, then to scale up to t/ha use the equations below.

250 g x 10 000 (change 1 m^2 to hectares) = 2 500 000 g/hectare = 2 500 kg/ha= 2.5 t/ha

The area of land which is more familiar to local farmers and administrators in Karamoja is an 'acre' comprising 4 840 square yards or 4 046 square metres (= 0.4046 ha).

Consequently, there are 10 000/4 046 = 2.47 acres in a hectare.

ANNEX 3

PET-Crops, Karamoja

An example of a self-checking sheet

Region: **Assessor's Name:** **Date:**

Crop name/Location/ Farmer/ Sample number/ GPS coordinate	PET score allocated before weighing by assessor	Measured yield g/m^2				Comments
		Wf	W1	W2	W3 (*in this case W3= Wc, a constant weight which may be achieved at W1, W2, W3 etc...*)	
Late Sorghum, Kotido, Farmer Akello, Sample 1, 03 41N, 34 09E	Top yellow	235	225	220	220	Actual: Bottom red

ANNEX 4

Some definitions of terms used in PET manuals

What does estimate mean?

An estimate is an approximate or rough calculation. Good estimates, based on a sound knowledge of a situation, will help you reach a good decision within the resources that are available. For example, if you are asked how much crop is harvested from a farmer's field, you could measure the whole crop to get a true value of yield or you could estimate the yield **by eye** with the help of PET-Crops, Karamoja. In most situations, it is not practical to measure the harvested crop and so a good estimate is important.

What is a crop assessment?

When you estimate the amount of crop in a village, a district or a region at harvest time, you are doing what is called a crop assessment. A crop assessment involves a collection of on-farm estimates of each crop provided by each farmer after harvest; or an assessment made by multiplying the weight of samples of crop yield taken per unit area by the number of units in your area of interest.

What is crop yield (or yield per unit area)?

The yield of a crop is the weight of that part of the crop that can be eaten, or used in any way, and is harvested by the farmer (for example, maize grain). The yield per unit area is the weight of the harvested parts produced from a known area of land (usually a hectare). For example, you can say that the farmer's field produced 1 000 kilograms per hectare (1 000 kg/ha) or one tonne per hectare (1 t/ha).

If you are measuring the weight of your crop from one square metre (1 m^2) you would weigh your crop in grams (g). If you weigh your crop from one square metre, and it weighs 100 grams (100g), you can say your yield is 100 grams per square metre (100 g/m^2). This may then be converted to a more usable/quotable yield in kg or tonnes per ha.

Remember: One tonne (t) is the same as 1 000 kilograms (kg).
One kilogram (kg) is the same as 1 000 grams (g).

What is plant density (or crop density)?

By plant (or crop) density, we mean the number of plants in a known area of land. In PET-Crops, Karamoja plant density usually refers to the number of plants inside the square frame (or quadrat), whose sides measure one metre in length (that is, the number of plants per 1 m^2). If you have a crop with many plants inside the square metre then the plant density is high. You can also say that it is a very dense crop. If you have few plants inside your square metre then the plant density is low. You can also say it is not a dense crop, or it is a thin crop. Some fields have mixed stands, where some areas may have a high density and others may have a low density. You will have to estimate the proportions of each high area and each low area to arrive at the average plant density of the field.

What is one square metre?

One square metre is a measurement of area often used as a standard sample area for counting plants or weighing the harvest. Using the PET approach, you will be working with a square frame (a quadrat) and each of the four sides will be one metre. The area inside your square frame is one square metre (1 m x 1 m = 1 m^2).

If you have an area which you can cover with the equivalent of 4 quadrats, your land will measure four square metres (4 m^2). This will be equivalent to a square with sides 2 m long (2 m x 2 m= 4 m^2).

If you have a bigger area which you can cover with 100 quadrats, then your field is 100 square metres (100 m^2 =10 m x 10 m).

What is one acre?

An acre is a unit of land area measurement equivalent to 4 840 square yards (Imperial scale) or 4046 square metres (metric scale). Yields of crops are usually quoted by local agriculturalists and farmers in tonnes per acre.

What is one hectare?

One hectare (ha) is a measurement of area 10 000 times larger than 1 m^2. It is equivalent to an area 100 m x 100 m (10 000 m^2). It is the most used international measure of land area; and used most often for the value of crop yields.

One hectare is 2.47 acres.

What is a tonne per hectare?

A tonne per hectare is a measure of the weight of crop harvested from an area of one hectare. If you have one tonne per hectare (1 t/ha) it means that a field which measures one hectare produced 1 tonne or 1 000 kilograms of crop. If a field which measures one hectare produced 2 000 kilograms, you would say that the crop quantity was two tonnes per hectare (2 t/ha).

When you weigh your crop from one square metre, you will obtain the yield in grams per square metre (g/m^2). Normally you do not give the yield from a field in g/m^2, because the area is so small, instead you would convert your measures to tonnes per hectare (t/ha). NB: Annex 2 explains how to do this.

What does cross-check mean?

When you cross-check your data, it means that you compare your estimate of crop yield with a measured value of crop yield to make sure that your estimates are good and accurate.

What is a quadrat?

A quadrat is a square frame, which can be made of most materials such as wood, plastic or wire. A quadrat is used to mark an area of land from where you will take your crop cuttings or counts. The quadrat you will use will usually measure one metre (1 m) each side, and therefore the size of the land inside the quadrat will measure one square metre (1 m^2).

What is a spring balance scale?

The spring balance is a simple weighing instrument, which you can see in the photograph in the PET manual. It is used to measure the weight of small quantities of crop. You need to have something to hold the crop, in this case a clean plastic bag. The plastic bag has a weight, so in order to measure the weight of the crop you first need to set the spring balance to zero with the empty plastic bag attached. This is known as calibrating the spring balance, setting to zero, or *taring* the balance. Do not use a plastic bag for storing your grain. Use a cotton bag or a thick paper envelope, reinforced on the joins and corners.

What does drying to a constant weight (Wc) mean?

When the sampled crop is not fully dry, you must dry it in the sun to obtain an estimate of the weight of the mature crop. It may take a long time to bring down the *water content* to the usual level at harvest time, which is usually lower than 15%, leaving dry matter (DM) greater than 85%. After drying for several hours, weigh the crop on the spring balance and dry again. You will know the harvested parts are fully dry when the measurement you take is the same as the one before. When two consecutive measurements are the same, the sample is said to be dried to a constant weight and is, for purposes of crop assessment, 'completely' dry. Speeding-up the natural process using a microwave oven needs care not to cook the sample.

Therefore, if using a microwave oven:-

- Use only medium intensity in 2-minute bursts.
- Cool and weigh after each burst until the weight stays the same.
- Bite the grain. If soft, continue to dry in 2 minute bursts until the grain is too hard to bite, or it snaps when bitten.

ANNEX 5
Post-harvest yield assessment

On some occasions, assessment teams arrive after harvest. Rather than relying totally on the hearsay of the farmer regarding crop performance, assessors may wish to conduct: a) forensic assessment on the field; or b) estimate the crop in-store to obtain a rough estimate of production.

a) Forensic Assessing

This technique is applicable to stover crops such as maize, sorghum or millet crops, where the harvest is in **un-threshed** heaps in the field and is assumed to have had **one head or cob per stem**.

i) Use the PET quadrat to count the number of stems in a square metre (as described earlier) and so to estimate the **mean number of heads or cobs per square metre**, as shown below.

ii) Take a sub-sample of heads or cobs from a heap already harvested. To ensure that your sample is random, divide (by eye) the heap into four and choose (by lottery) which quarter to sample. Next, divide this quarter into three equal sized segments and remove one of these entirely from the heap. Count the number of harvested parts (heads, cobs etc.) it contains, then thresh and weigh the grain. By dividing the weight of threshed grain by the number of harvested parts included in the segment, you can find the **average weight of grain per head or cob**.

A heap of heads divided into 4 quarters

A quarter divided into 3 with sub-sample segment removed

iii) Multiply the average weight of grain per head or cob from (ii) by the average number of heads or cobs per square metre (i) to get **grain weight per m^2** (g/m^2), which may then be converted to **yield per hectare or acre**, as shown in Annex 2.

<u>For example:</u>

A small maize field has been harvested. It looks quite uniform, so the assessor takes two sample quadrats to estimate the mean number of stems or cobs per m^2. These samples indicate that there would have been 4 and 3 cobs per m^2 respectively.

Therefore, the estimated average number of cobs per m^2 is (4+3)/2 = 3.5.

Now the assessor studies the large heap of air dry cobs already harvested and divides this, by eye, into quarters. The farmer draws lottery ticket number 3, so this is the quarter of the heap that is sampled – an entire third of this quarter segment is removed and sampled. It consists of 16 cobs which are then carefully threshed and their grain weighed - the product weighs 1660 grams.

Therefore, 16 cobs yield 1 660 grams of grain.

1 cob therefore yields 1 660/16 = 104 g of grain.

Going back to the original samples, the mean cob number per quadrat was 3.5 per m^2.

Therefore, the average yield of grain per m^2 is estimated to be 3.5 x 104 = 364 g/m^2 or 3.64 t/ha.

This most closely matches the middle yellow *photo-indicator.*

b) Estimating yield from threshed grain in-store

This technique may be used for any cereal crop where the whole field has been harvested and **threshed**, but not yet bagged.

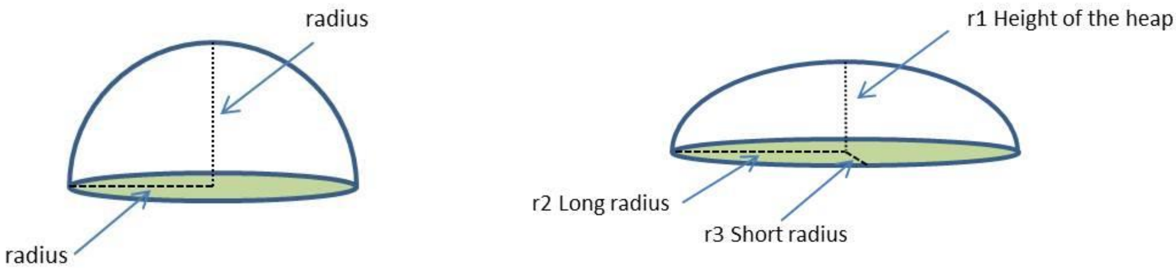
i) Measure the area of the field that has been harvested in square metres (*e.g.* for rectangular fields this is length x width).

ii) Study the shape of the heap: A hemisphere is half of a sphere (a completely round circle shape). Hemispheroids are flatter than hemispheres so have different dimensions in different directions (an example of a hemispheroid heap is the photo of pearl millet shown above).

Figure 4: Hemispheres and hemispheroid shapes

Hemisphere **Hemispheroid**

iii) Next, measure the radius of the hemisphere shaped heap in metres; or the three radii of the hemispheroid heap.



Radius of a Hemisphere **Radii of a Hemispheroid**

iv) Calculate the volume of threshed grain in the heap in cubic metres using the most suitable formula:

For heaps which are a hemisphere in shape:

Volume = 2/3 pi r^3 = 2/3 pi x r x r x r (where r = single radius of the sphere);

For heaps which are hemi-spheroid in shape:

Volume =2/3 pi x r_1 x r_2 x r_3 (where r_1 x r_2 x r_3 = the three radii of the spheroid).

Convert this volume to litres by multiplying it by 1 000.

v) Multiply the volume of grain in litres by the appropriate **bulk density value** (see Annex 10), which is the standard weight per unit volume for a specific type of grain, expressed in kg/litre (this can be checked by weighing a litre of grain from the heap using the PET balance). This provides the weight of grain (in kg) in the heap.

vi) Divide the weight of grain in kg by the area of the field in square metres, to work out your estimated yield in kg/m^2. This figure may then be converted to yield per hectare or acre, as shown in Annex 2.

For example:

A pearl millet field measuring 80 m x 108 m has been harvested by the time an assessor arrives. Its product has been threshed and is being stored in a large hemispheroid heap which measures 50 cm high x 4 m long x 3.2 m wide.

This means that the 3 radii of the heap in m are: 0.5 x 4/2 x 3.2/2 = 0.5 m x 2 m x 1.6 m.

The assessor works out the volume of the heap in m^3 using the formula:

Volume = 2/3 pi x r_1 x r_2 x r_3

= 2/3 x 3.14 x 0.5 x 2 x 1.6 = approximately 3.3 m^3

He converts this to litres by multiplying this volume by 1 000 = 3.3 x 1 000 = 3 300 litres.

The grain density value for millet (0.63 kg/litre) can now be used to estimate the weight of the heap of grain in kg:

3 300 x 0.63 = 2 079 kg

To estimate the yield of grain as tonnes/ha, this weight of grain is divided by the area of the field in m^2. The area of the field is 80 m x 108 m = 8 640 m^2

Therefore, the yield is 2 079/ 8 640 = 0.24 kg/m^2

This is 1 000 x 0.24 = 240 g/m^2 or 2.40 tonnes per hectare.

This matches the top red *photo-indicator.*

ANNEX 6

Crop yield assessment using the PET approach

1.1 Any crop assessment aims to produce figures describing the harvest of the main staples of a specified location for a particular season. Production estimates are derived by multiplying area harvested by an estimated yield per unit area. Both parameters are measurable at harvest time when the assessments should occur.

1.2 To be convincing, the estimated levels of production recorded must be plausible. Plausibility is a very important consideration in acceptability, without which crop assessments become worthless exercises. Therefore, data presented should be rational, justifiable and defendable in debate; and, should come from a source as close as possible to the farming community.

1.3 In countries/states where active administrations exist, the best *entry-points* for any crop assessment mission are agricultural sector offices of administrative units that are a) in day-to-day contact with their farming community[6]; and b) may be visited throughout the country within *the time and budget* allocated to assessments. So, usually, the best *entry-points* are district level Ministry of Agriculture offices but may also be, depending on circumstances, irrigation schemes, area development projects, private estates or zones under temporary administrations. During the course of an assessment mission, *entry-points* will be visited in sequence to provide the background, quantitative information required to create the area per crop framework upon which the results are built.

1.4 With these points in mind, the *golden* rules regarding quantitative data collection are:

- Assessment mission teams must never leave an *entry-point* without the area[7] data for the season's crops of interest.
- If time is short and data are not compiled, teams should concentrate on the compilation of the data for the main staples rather than a plethora of areas of minor field crops and vegetables.
- Do not accept that data will be sent/faxed/e-mailed later. The road to incomplete files is paved with such broken promises.
-

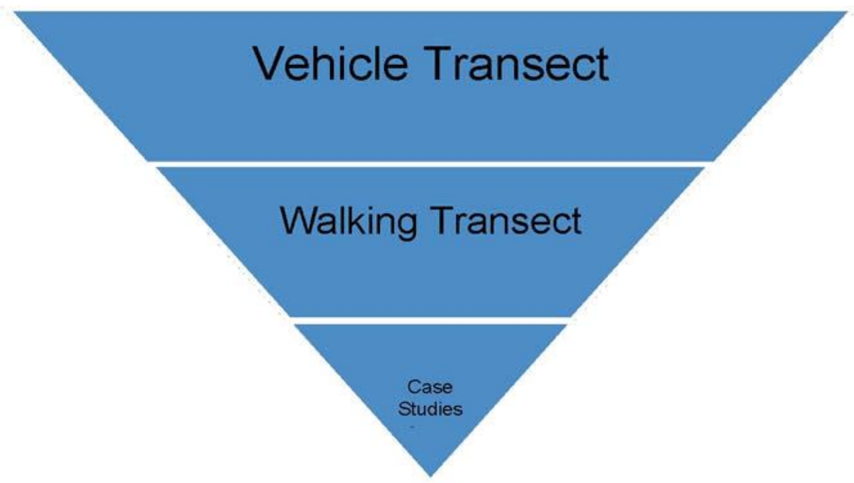
[6] The staff are in daily contact with farmers and are not office-bound.
[7] Sometimes yield estimates will also be available. These yields will need auditing using PET as described in the manual.

2.0 PET- Crop yield assessing

2.1 The PET manual as presented above describes a rapid, objective way of estimating yield in every field you see in passing. The PET Approach below explains how to use the manual to best effect in transects, *i.e.* in journeys when the item of interest is noted regularly and in a similar manner.

2.2 The PET protocol to estimate crop performance, by identifying yields at harvest time, comprises the application of increasing intensities of observation, best described diagrammatically as an inverted triangle, as shown in Figure 5. The observations begin from the vehicle, are continued during transects walked slowly through the fields and, finally, are made within fields during discussions with farmers.

Figure 5: Observation Levels - decreasing in number; increasing in detail



2.3 During **vehicle transects**, two observers sit either side of a vehicle, travelling at a slow, steady speed. They identify the approximate yield of all fields seen on their respective sides of the road by using the **from-a-distance** *photo-indicators* (on the appropriate page in the PET manual for the crop in question) to fit the fields passed on the journey into the 4 broad clusters of yield noted earlier *viz.* **RED, YELLOW, BLUE and ZERO** (zero means crop present but absolutely no production). Scores for every field seen are recorded on a specific 'A4' transect sheet. Each transect sheet represents 30 minutes of driving, and consists of 30 rows (1 row per minute), with observations further sub-divided into 20 second 'cells'. A typical vehicle transect recording sheet is shown below in Table 1 below.

2.4 The three colour categories are present to ease rapid approximation of yields during driving transects. The colour bands provide a *convenient initial grouping.* However, the range of yields should be regarded as contiguous - NOT as zero plus three discontinuous clusters, into one of which all crops must fall. They should not prevent assessments of levels between each band (*i.e.* red-yellow; yellow-blue; blue-zero) if necessary.

2.5 In some years it is possible, although unlikely, that there will be no crops in the red band. In other years, there may be no crops in the blue band, the lowest yields being found in the yellow band. When they occur, such instances should be recorded fully within the system described.

2.6 For every 20 second cell, **small fields** are classified as **zero**, **blue**, **yellow** and **red** or in combinations. This information is noted on the prepared A4 transect sheets, using symbols (**z**, **b**, **y** or **r**) entered in the appropriate row, under the corresponding crop headings. Large, industrial crops may take up more than one 20 second cell. These are scored using symbols (**Z**, **B**, **Y** or **R**).

2.7 For small fields, each lower-case symbol represents a value scored of 0.1. Up to 5 x 0.1 points may be entered for a 20 second cell, as aggregations of peasant farms are always associated with significant areas of fallow, buildings, paths and clearings alongside cropped areas. For large *industrial*[8] fields, each upper case symbol scores 1 whole point, representing the whole area noted during 20 seconds of travel.

2.8 There are two yield estimates (one for each side of the vehicle) for each 30 minute transect sheet for every journey. These data are eventually combined to calculate average yield for all crops in each district.

2.9 At the end of the 30-minute transect, the scores represented by each symbol for each crop are added-up. These individual totals are multiplied by a **yield factor** (expressed in tonnes/hectare), which is specific to each yield level for each crop (see below), enabling **weighted average yields** of each crop to be calculated.

2.10 **Yield factors** are determined when observers leave the vehicle, at predefined regular intervals[9], and switch to **walking transects**, an action which enables fields to be observed more closely. Using the **close-up** *photo-indicators* from the PET manual, crops are categorised and recorded at **low, medium or high** levels **within the three colour bands;** or at levels **between, below or above** the colour category already determined during the driving transect; or as **zero**.

- The appropriate **yield factor** for the selected colour category is read off (or, for levels falling between categories, is calculated) in tonnes per hectare.
- A typical walking transect sheet is given in Table 2 below.

2.11 The sequence of actions is completed by conducting detailed case-studies of a small number of available farmers involving:

[8] These are large fields of PET crops that are being farmed by commercial enterprises.
[9] Or on arrival at an area of specific interest as determined by the results of the initial observations.

- Semi-structured interviews in his/her field using a common pre-tested/proven checklist and;
- Occasionally, taking representative samples of the field then threshing, winnowing, weighing and, if necessary, drying the product to cross-check use[10] of the *photo-indicators* (see **Steps 6 and 7**, starting on page 20).

2.12 At the end of each day, each team summarises the returns for the vehicular and walking transects and calculates **weighted averages** for each crop, using the appropriate yield factors. Finally, the day's data are cross-referenced with the previous day's data to check for inconsistencies[11].

2.13 In the PET Methodology, emphasis is placed on the facts that:

- PET-Crops manuals are tools for rapid assessment, applying optimal levels of accuracy (OLA).
- As such, speed of application must be matched by speed of analysis and speed of reporting or the value is lost.
- The PET manual provides the formula to be applied to assess yields, but it is the rigour, consistency and stamina of the teams using the manual that make the approach successful.
- PET provides estimates of yields per acre or per hectare at harvest time; *it does not provide forecasts for immature crops*, therefore the timing of assessment missions applying PET needs careful planning.
- As well as cross-checking by sampling and against previous days' data (described above), PET yield data should also be cross-checked against a) estimates from previous surveys; b) direct data from well-positioned and involved key informants including regional/district extension workers, elders, tractor drivers, tractor owner/ managers, threshing-machine operators and grain traders and combine drivers.
- Combining the yield estimates from PET with the best-fit area estimates provides a rapid and direct estimate of production with which to identify food-security, strategy options at an early stage in the marketing year in prospect. In the example transect recording sheet below, you will note that the columns on the left refer to the minute the records are noted, followed by three columns of 20 second cells, where 1 has been entered in each. These are the full *"industrial"* scores for the general vegetation of the area, which may be bush, forest, savannah, swamp or in some cases, widespread *industrial* fallow. These matrix or background scores may be considered as the natural position. The crop scores are subtracted from the background scores during the process of estimating the weighted average of each transect that are then summarised as district or regional averages.

[10] The assessor should adjust their choice of *photo-indicator* to correct their bias if necessary.
[11] Other tasks that should be completed at the end of each day include summarising the semi-structured interviews, and filing data retrieved from entry point sources.

Table 1: Example of Vehicle (Driving) Transect Sheet

Team							State						District						Sub-County								
Date							Time						Transect No.						Sheet No.								
Min.	Bush/Forest/Sav.			Sorghum			Maize			Pearl Millet			Finger Millet			Rice			Cassava			Groundnut			Sunflower		
				rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz	rybz
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Small fields: r=red, y=yellow, b=blue, z=zero; Large fields: R=red, Y=yellow, B=blue, Z=zero

Small farms will have max. of 5 scores=0.5 points/cell; Large farms a max. of 1 score = 1 point/cell
z= zero ; in other words - crop planted but no yield

Table 2: Example of Walking Transect Sheet

Date District Sub- County Assessor

Time	Location	Crop	PET Score (divided colours or zero)	Estimated Yield (t/ha)	Comment

ANNEX 7

Preparing PET-Crops, Karamoja: Locations of samples and *photo-indicators*

The methods used to prepare PET-Crops, Karamoja are summarised below:

1. Preliminary discussions with specialists identified the crops to be included as sorghum (early maturing; late maturing); maize; finger millet; pearl millet; rice; groundnuts; sunflowers; and cassava.

2. Reconnaissance surveys in each district in Karamoja identified both the scope and range of performance of all crops at all locations within the Districts.

3. Stratified sampling, to cover the range identified, was undertaken in specific locations selected jointly by the FAO PET team, with the support of local MoA and NGO office subject matter specialists.

4. Representative fields were identified within those selected locations. 1 m^2 plots were sub-sampled from these fields to provide the most informative *photo-indicators* for the range of productivity identified.

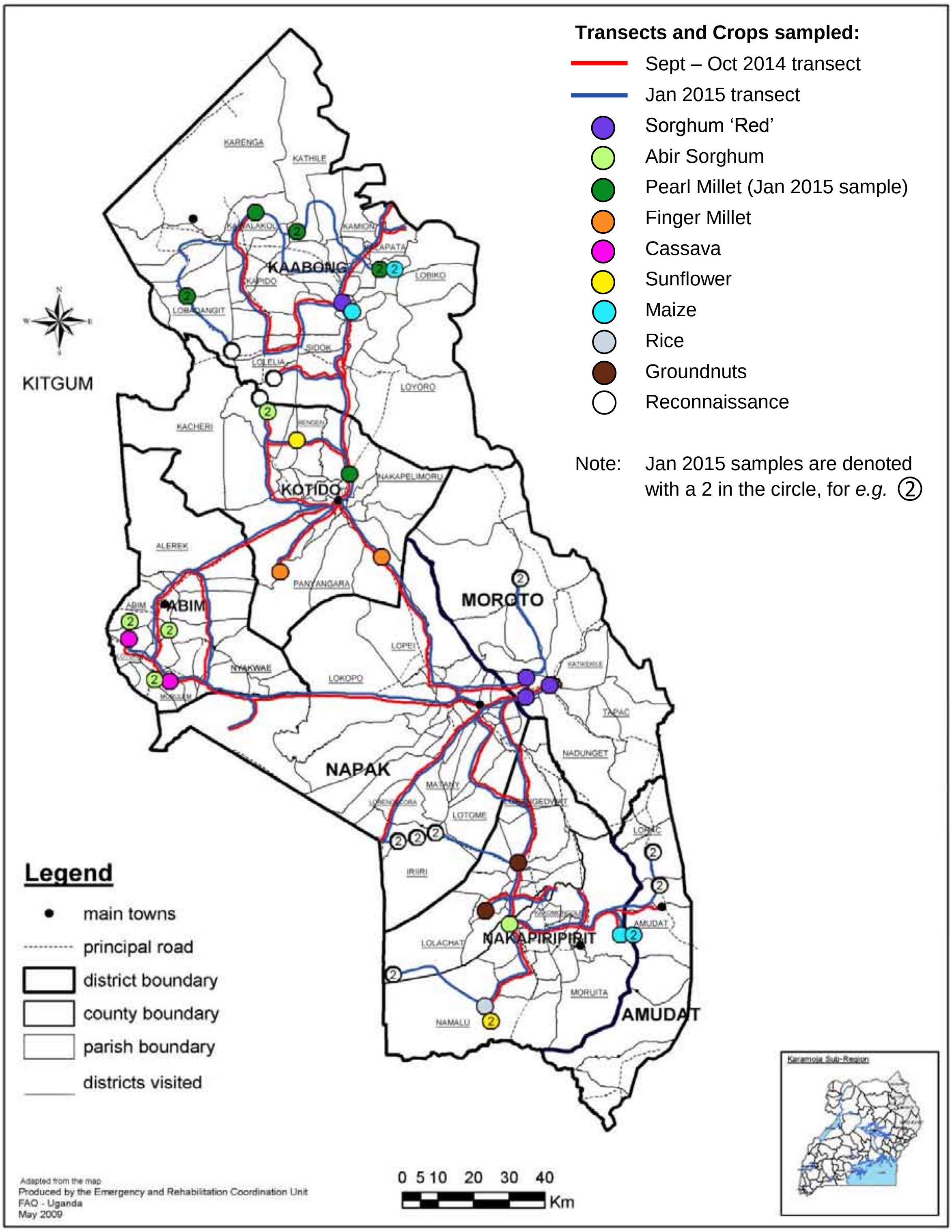
5. *Photo-indicators* of standing crops were prepared at each site to include photos and data:

- From-a-distance.
- From the 1 m^2 plots which were harvested and threshed.
- Products after harvest from the 1 m^2 plots.

6. Where possible, **samples** of crops at the normal *moisture content* for harvest were selected and then weighed. If still moist however, samples were weighed at harvest and later dried and weighed until a constant weight (Wc) was reached in order to determine the exact air-dry matter production obtained from 1 m^2, for extrapolation to 1 ha.

7. All **weights** were recorded and entered into the appropriate column in the PET manual alongside the *photo-indicators* from the same plots.

Figure 6: The locations from which samples and *photo-indicators* were taken in preparing PET-Crops, Karamoja.



ANNEX 8
Crop area estimates

1. The timing of assessment missions means that, in most cases, harvesting is underway. Therefore, harvested area data will always be incomplete. Consequently, final planted area data may provide the best crop area statistics with which to estimate production.

2. It is easier for visiting assessment teams to estimate yield, as noted in Annex 6, than to estimate area. Regarding area, assessment missions may only ensure that the figures provided to them by the *entry-point* administrations are plausible and that they are within the historically-accepted land available for cultivation. To achieve this, assessment missions with access to *entry-point* data should:

- Watch out for double counting due to administrative boundary changes, which may change the status of villages or even whole districts.
- Be aware of changes in numbers of farming households.
- Be sure to check the units used i) at the point of data collection from administrators and ii) when transcribed into the records.
- If local units are used, check that the conversion factors are consistent and plausible.
- Remember that at most *entry-points*, most data are summated by hand and entered/copied by hand.
- Mistakes invariably occur, so check the calculations.

3. Mission teams should request final planted area data at each *entry-point* for each crop. This means that each crop has a separately recorded area. Complications arise when:

- Two crops are planted in series in the same season, *i.e.* the second one is planted after the harvest of first one. This doubles the occupancy of the area under production whether the two crops are the same or different (relay cropping).
- Two or more crops are grown together in same field during the same season. When planted and harvested at different times, this doubles the occupancy of the field and, therefore, doubles the harvested area (intercropping). Plant densities are likely to be lower in an intercropped field than when each crop is a planted separately in monoculture, so yields/unit area are likely to be lower.

4. In both the circumstances noted above the actual *production* area is twice the *geographical* area. Where data allows, the extent of the increase for the individual crop areas should be noted in the text and identified in tables. A different approach is necessary when:

- Two crops are sown together and the mixed products are harvested together. In such cases (for instance wheat and barley), the area is not doubled and only the area of the dominant crop should be recorded (mixed cropping).

5. Total planted area data received should be:

- Collected at each *entry-point* in their original form. An electronic copy on a memory stick is preferred, or a photocopy or carbon copy; but if neither are available the data should be transcribed from original on to assessment mission sheets.
- Cross-checked for year-to-year and place-to-place consistency in transformation from local measures to international units.
- Compared with the known total agricultural/cultivated area of each *entry-point*.
- Cross-checked against any known changes to numbers of households farming in each *entry-point*.
- Cross-checked against any known boundary changes to eliminate double counting.
- Compared with last year's main season harvested area in each *entry-point*.
- Cross-checked with any changes to the planted area of any preceding minor season in each *entry-point*.
- Compared with any known changes to area of industrial crops, tree crops, pasture land, forestry areas or fallowing practices.

6. Individual staple-food crop planted areas should be:

- Compared with the last 5 years' annual national, regional and *entry-point* estimates.
- Intercropped areas noted in each *entry-point*.

7. The final database will be achieved through combining information received and adjustments made following the team's field audits, particularly with regard to yield. Remember, by virtue of the facilities placed at their disposal, assessment missions are invariably in a far better position to estimate *actual yields* than the local MoA officers or any other assessing groups. When sure of the overall accuracy, enter the data into a hierarchically-linked, excel spreadsheet using figures rounded-up to an appropriate level.

ANNEX 9

PET approach vs conventional statistics survey

IMPORTANT ASPECTS	PET APPROACH WITH PET MANUAL	Conventional STATISTICAL APPROACH
The purposes of the two methods are entirely different, though both are based on objective approaches[12].	Used for Rapid Appraisals only, when results are required immediately.	Used for national archives and experimental comparisons, when results are not expected immediately.
	Used when only approximate estimates are needed to determine trends for immediate decision making - including, but not limited to, identifying areas of surplus and areas of deficit.	Used to detect the fine differences required for a) retrospective understanding of events and b) making choices between similarly performing varieties/farming techniques.
	Provides an Optimal Level of Accuracy (OLA) that is determined by time and funds available.	Highest level of accuracy expected, which is determined by the statistical techniques adopted.
PET is easily explained to non-specialists.	Can be planned, organised and implemented by non-specialists following short training.	Planning, organising, implementing and controlling require highly trained specialists.
The PET approach does not demand a high level of mathematical/statistical expertise.	Analysis can be done through simple mathematical calculations, no more complicated than weighted averages.	Analysis requires high degree of statistical training.

[12] As opposed to crop production and food security assessments based on post-harvest interviews, which the author notes (having conducted assessments of various types in more than 70 countries) are too easily influenced by vested interests: a) particularly in countries with long histories of institutionalised food aid and b) where crop assessments are known to be used to generate taxable income levels.

PET is an accessible approach.	Every single field can be scored in seconds and quantified in a matter of a few minutes. Missing a few fields does not alter the spatial consistency of what is, at best, a rough estimate.	System accurately describes yield from a few sampled fields only, and disregards all the others. Must be conducted according to the plan or the results are null and void. Sticking to the plan is difficult where there is no proper supervision.
The PET approach provides flexibility.	Allows for cross-checking and correction/adjustments. All fields seen may be scored into main categories. Scoring is then refined and quantified during walking transects, to fine-tune selected levels of performance in specific representative areas.	Inflexible, no adjustments allowed. Without the full rigour of a supervised, statistically valid approach of sampling randomly selected plots within fields, the method can lead to misleading errors, as so few fields are involved; and is open to abuse when only the lowest performing areas are chosen deliberately as the sample.
Farmers can participate in the PET approach.	Farmers can join in PET and select their choice of *photo-indicator* with the assessors.	No participation possible except at labouring level.
PET teams can be easily checked by their supervisors.	PET is non-destructive. Sample sites are observed and compared to *photo-indicators* as standing crops. Crop cutting is used for fine tuning observational skills only. Therefore sites can be revisited and checked.	All samples are cut. Exact sites cannot be revisited or checked.

ANNEX 10

Grain bulk density factors

The bulk density is the weight per unit volume of a loose material, such as grain. Different grains have different bulk densities, some being "heavier" (more dense) than others. By multiplying the standard *bulk density factor* of your grain type by the volume that you have, you can estimate weight, and therefore yield.

Table 3: Standard Bulk Density Factors for commonly grown crops:

Crop	**Bulk Density in kg/litre (or tonnes/m^3)**
Barley grain	0.62
Chickpea	0.74
Cowpea	0.75
Groundnuts in shell	0.30
Groundnuts, shelled	0.64
Maize (grain)	0.72
Millet	0.63
Navy beans	0.76
Sesame seed	0.59
Sorghum	0.73
Sunflower	0.42
Wheat (grain)	0.77

These values will vary slightly with moisture content, variety, quality, contamination levels etc. so are not exact, but are still useful when used as a tool for estimating crop yield.

For example, using its bulk density factor, an 800 litre heap of maize is estimated to weigh 800 x 0.72 = 576 kg.

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