AFRICA soil health consortium

Nutrient management

Cassava

Fertilizer use

By applying mineral fertilizers to their cassava, smallholder farmers can increase their yields from about 10 tonnes to as much as 16 tonnes of fresh roots per hectare.
The application of nutrients helps to replace the lost nutrients and maintain soil fertility to enable continuing good yields in subsequent farming seasons.

Determining the exact quantity of fertilizers to apply on a given plot depends on many factors and can vary from one soil type to another. However, a simple way to determine the fertilizer requirement is linked to the cassava root yield.

Let's assume that the natural soil nutrient reserves are sufficient to produce around 10 tonnes per hectare of fresh cassava roots. For every one tonne of fresh cassava roots harvested, including leaves and stems, about 10 kg of nitrogen (N), 1 kg of phosphorus (P) and 7 kg of potassium (K) are removed from the soil. So, the additional nutrients removed from the soil to achieve 16 tonnes per hectare compared to 10 tonnes are 60 kg N, 6 kg P and 42 kg K per hectare.

Not all fertilizer applied to the soil is taken up by the target crop: on average only about half is taken up by the plant. So, to supply 60 kg N, 6 kg P and 42 kg K (to enable production of 16 tonnes fresh roots per hectare), the farmer needs to apply twice as much, that is 120 kg N, 12 kg P and 84 kg K per hectare.

In the sections that follow, examples are given showing how these amounts of nutrients can be supplied by the application of different types of fertilizers.

NPK fertilizers

There are two main types of fertilizers, compound fertilizers that supply several nutrients together and straight fertilizers that supply just a single nutrient. This section deals with NPK fertilizers, which are good examples of the first type.
Standard compound fertilizers, known as N-P-K, supply nitrogen (N), phosphorus (P) and potassium (K).

Most of the N-P-K products show the combination of these three nutrients in ratio form, for example N-P-K 15-15-15, which contains 15% N, 15% P_2O_5 and 15% K_2O[1].

[1] The convention with fertilizers is that the amount of nitrogen is given as elemental nitrogen (N) but the amount of P and K is shown as the equivalent amount of salts of these elements, P_2O_5 in the case of P and K_2O in the case of K. P_2O_5 contains about 44% P. K_2O contains about 83% K.

Other N-P-K formulations are available that provide other relative proportions of nutrients; for example, N-P-K 17-17-17 contains 17% N, 17% P_2O_5 and 17% K_2O.

If a farmer, who currently achieves a yield of around 10 tonnes per hectare without the use of any fertilizer, wishes to increase their yield to 16 tonnes per hectare, they can do so by applying NPK fertilizer – as well as following the other recommendations provided in this guide. The table below shows the amount of either NPK 15-15-15 or NPK 17-17-17 that should be applied.

Fertilizer	kg per hectare	g per cassava plant
NPK 15-15-15	800 (16 bags)	80
NPK 17-17-17	700 (14 bags)	70

In case a farmer cannot afford to buy enough fertilizer to support a yield of 16 tonnes per hectare, the following table shows the amount of NPK fertilizer needed to achieve a range of yields from 10 to 16 tonnes fresh roots per hectare.

Target yield tonnes fresh roots per hectare	NPK 15-15-15		NPK 17-17-17	
	Total kg per hectare (number 50 kg bags)	Total g per plant	Total kg per hectare (number 50 kg bags)	Total g per plant
10	0	0	0	0
11	133 (2.7)	13	117 (2.3)	12
12	266 (5.3)	27	234 (4.7)	23
13	400 (8)	40	350 (7)	35
14	533 (10.7)	53	468 (9.4)	47
15	666 (13.3)	67	585 (11.7)	59
16	800 (16)	80	700 (14)	70

The total quantity of NPK fertilizer required should be applied in three phases (also called splits):

One-third of the total quantity required should be applied 4-6 weeks after

planting; for example, if the target yield is 13 tonnes per hectare, the total of 400 kg NPK 15-15-15 should be applied in three equal splits, each of about 133 kg – that is a bit more than two and a half standard 50 kg bags; per plant each split should be about 13 g NPK 15-15-15.

A second dressing (the same amount of fertilizer as the first split) should be applied 10–12 weeks after planting.

The third dressing (again, the same amount of fertilizer as the first and second splits) is recommended 16–20 weeks after planting. However, this depends on the rainy season: it should not be applied just before the rain stops.

Farmers should use gloves to protect their hands; if gloves are not available they could use plastic bags instead.

To apply fertilizer:

1. Using a small weeding hoe (10–15 cm across) or similar tool, scrape a half-moon shaped furrow 20 cm from the base of the cassava plant (Figure 1).
2. Apply the correct measure of fertilizer into the furrow.
3. Cover the applied fertilizer with soil.

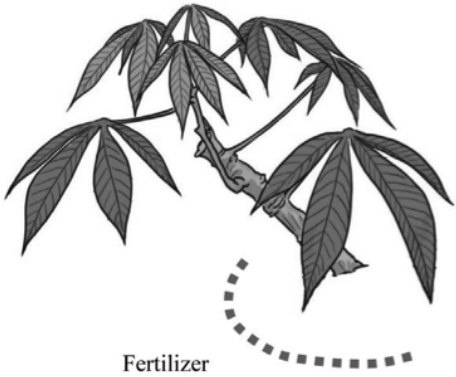

Figure 1: Fertilizer applied in half-moon.

If the second rainy season is short and unreliable then the three dressings should be scheduled in closer intervals so as to supply all fertilizer in the first season.

If second season rains are reliable then the last dressing could be applied

once the second season rains have established.

For later dressings the use of a hoe may not be appropriate as cassava roots near the surface could be damaged. In this case the fertilizer should be applied in a circle or semi-circle around the cassava at 10–20 cm distance. If the cassava is planted in wider rows and closer distances within the rows, the fertilizer may also be banded along the cassava row at 10-15 cm from the cassava row.

Some regions have a bimodal rainfall which allows cassava planting at either the first or the second rains. For such regions, fertilizer application needs to be scheduled according to the length of the rains in each season. For example, if planted at the start of a long rainy season that will be followed by a shorter one, then two dressings should be scheduled in the first season and one in the second. If cassava is planted at the start of a short rainy season, only one dressing should be applied and the others be given in the following longer season. However, farmers should avoid application of fertilizer too late because under dry conditions nutrient uptake is limited or can cause damage.

Single nutrient fertilizers

In some places farmers may only have access to NPK fertilizers. If they do have a wider choice of fertilizers available, however, it is likely to be more cost effective to use a combination of single nutrient fertilizers.

NPK fertilizers are not ideal for cassava crops because the relative proportion of the three main nutrients, N, P and K, are fixed. In both the examples above, using either NPK 15-15-15 or NPK 17-17-17, although the amount of N and K being supplied is correct, almost 5-times more P is being supplied than is needed – so, the farmer is wasting money by providing too much P.

A more cost-effective way of supplying the required nutrients would be to replace N-P-K with single nutrient sources such as urea, single superphosphate (SSP) or triple superphosphate (TSP), diammonium phosphate (DAP) and potassium chloride, which is also called muriate of potash (MOP).

Urea supplies only N (no P or K).

Triple superphosphate supplies only P.

Potassium chloride supplies only K.

DAP supplies mostly P but also some N.

By using a combination of several single nutrient fertilizers, the exact amount of N, P and K needed can be applied - unlike with N-P-K where the ratios of the different nutrients are fixed. Use of single nutrient fertilizers requires more calculations but may be less expensive and more efficient.

Example 1: Using TSP, urea and MOP: If a farmer who currently achieves a yield of around 10 tonnes per hectare without the use of any fertilizer wishes to increase their yield to 16 tonnes per hectare, they can do so by applying various combinations of single nutrient fertilizer – as well as following the other recommendations provided in this guide.

The table below gives some examples of suitable combinations of single nutrient fertilizers which together supply the correct amount of nutrients: in each example all three types of fertilizer (P, N and K fertilizer) need to be applied.

	P fertilizer		**and N fertilizer**			
	Total kg per hectare (number 50 kg bags)	**Total g per plant**	**Total kg per hectare (number 50 kg bags)**	**Total g per plant**	**Total kg per hectare (number 50 kg bags)**	**Total g per plant**
Example 1: TSP, urea and MOP	TSP 54 (1 bag)	TSP 5	Urea 260 (5.2 bags)	Urea 26	MOP 173 (3.5 bags)	MOP 17
Example 2: DAP, urea and MOP	DAP 54 (1 bag)	DAP 5	Urea 240 (4.8 bags)	Urea 24	MOP 173 (3.5 bags)	MOP 17

The application of the single nutrient fertilizers is different from that of N-P-K: it allows the different nutrients (N, P and K) to be applied when they are most needed.

TSP or DAP, supplying the P, should be applied at planting in a single dressing.

The urea (N) and the KCl (K) should be applied in three splits at 4-6, 10-12 and 16-20 weeks after planting, with the same technique and the same considerations as for N-P-K fertilizer, avoiding application when heavy rains are imminent and not applying in or before dry phases.

Practical considerations: One additional matter to observe when applying fertilizer is the canopy development of the cassava: a lush dark green and dense canopy indicates that the N supply is sufficient, so if this is observed by farmers they may reduce or eliminate N (urea) application. This is particularly advisable for dressings close to the start of dry phases.

For efficient use of labour, a 'production line' approach should be used when applying fertilizer. For example, 3 people working together in a well-organised system should be able to apply fertilizer to 10,000 plants, i.e. 1 hectare, in 1-2 days.

Factors to consider when applying fertilizer are:

Labour requirement – do you have the required number of people for your farm size?

Weather conditions – do not apply fertilizer just before heavy rain is expected, or when the soil is too wet or waterlogged, because the nutrients could be washed off or leached into inaccessible soil layers. Do not apply fertilizer during dry conditions because the high salt concentrations in a soil with low water content can damage the crop (commonly called 'burn').

Fertilizer type – do you have the right type of fertilizer for your crop? Have you considered the crop requirements and the status of your soil? Note that nutrients can be supplied by straight or compound fertilizers. The decision on the type of fertilizer to use should depend both on availability and cost.

Fertilizer availability – do you have enough fertilizer for your farm to achieve the target yield? It is recommended that, if the quantity of fertilizer is not enough for the entire plot, the farmer should apply the recommended amount to the portion of the farm for which the available quantity is enough, and to leave the remaining section of the farm without any fertilizer. This enables farmers to see for themselves the benefit of fertilizer application in terms of yield increases – the farmers are actually doing a mini with/without trial on their own farms.

Farmer friendly fertilizer measurements

It is difficult for farmers to know what small amounts of fertilizer, such as 13 g of urea, looks like and very few will have access to weighing scales.

The solution to this problem is to identify a locally available container, such as metal crown cork bottle-top for beer or soda[2]. The bottle-top can then be used as a scoop for measuring fertilizer.

For larger amounts, discarded water bottles with the top cut off make useful containers.

Different fertilizers have different densities, so while a bottle-top full (level, not heaped) of NPK 15-15-15 will weigh 3 g, a bottle-top full of DAP will weigh just under 5 g.

For those with access to the internet, a tool (the OFRA fertilizer calibration tool) is available at CABI-ASHC website (www. africasoilhealth.cabi.org). This tool enables the user to calibrate any circular or rectangular container that can be filled with a range of different fertilizers. The user inputs the diameter, or length and width, and height of the container being used and selects the fertilizer type; the tool then calculates how much the container will hold of the specified fertilizer.

The table, below, shows the weight of a standard crown cork bottle-top full of various fertilizers: values in this table have been calculated using the CABI tool.

So, for example, to apply 13 g of NPK 15-15-15 per cassava plant, just over 4 (actually 4 and 1/3rd) bottle-tops level full of NPK fertilizer are needed: 4.3 x 3 g = 13 g

To apply 5 g of TSP per cassava plant, about three-quarters of a bottle-top are needed: 0.75 x 7g = 5g

Once farmers have some experience of using the measure they will know what the appropriate amount of a given fertilizer looks like. They can then stop using the measure and apply, for example, a three-finger pinch of fertilizer which corresponds to the right amount. From time to time it would be advisable to check that their pinch is delivering the right amount of fertilizer.

Fertilizer type	Weight of fertilizer (g) per metal beer or soda bottle-top full
CAN	3
DAP	5
MOP	6
NPK 15-15-15	3
SSP	3.5
TSP	7
Urea	4

[2] The standard metal crown cork bottle-top has a 2.8 cm diameter and a depth of 0.5 cm, giving a volume of 3 ml (3 cm^3). It has 21 'teeth'.

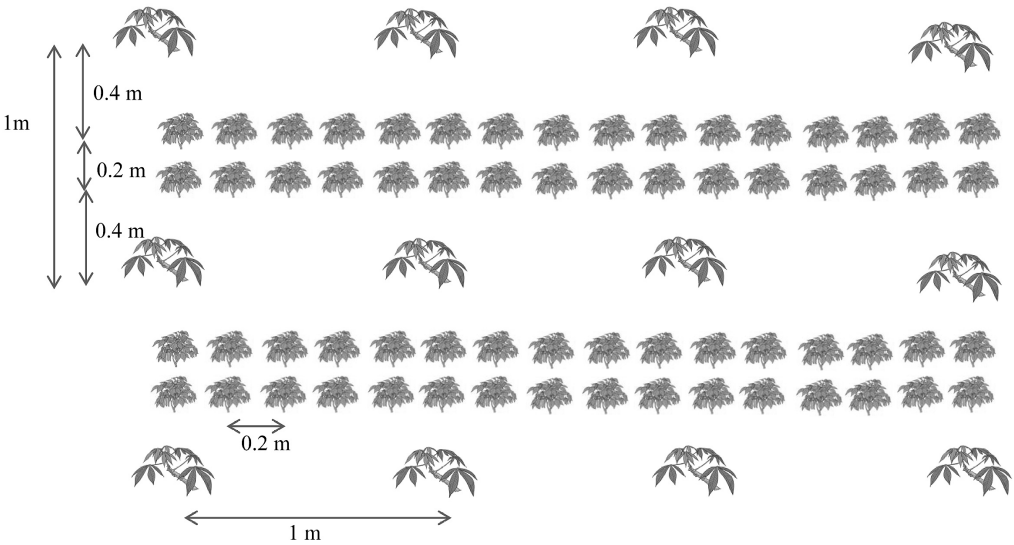

Figure 2: Suggested spacing for cassava –maize intercrop.

200 kg of urea per hectare needs to be applied in three equal splits, each of about 67 kg (or 0.7 g urea per maize plant).

The urea is applied by banding 10-15 cm from the base of the maize stand (i.e. applying in a narrow band along the row of maize: 3.5 g urea is needed for every 5 maize plants, that is about one metal soda or beer bottle top level full.

However, the amount of urea applied should be adjusted based on the observed colour of leaves of the maize: if the leaves are pale green-yellow this indicates nitrogen deficiency, therefore add more N.

Cassava intercropped with legumes: In this intercrop arrangement, the most likely deficient soil nutrient is phosphorus (P). Low P supply reduces the ability of legumes to fix nitrogen. This limits the grain yield and the legume's contribution to soil fertility restoration.

So, in addition to the fertilizer recommended for cassava grown as a monocrop, additional P is needed: this can be supplied by the application of 50 kg TSP as a basal fertilizer when the legume seed is sown.

Cassava intercropped with vegetables: Like maize, this intercrop requires more nitrogen (N) than cassava grown as a monocrop. The N needed will

vary depending on the vegetables being grown: green leafy vegetables are nitrogen-hungry, therefore, more N should be applied. A good starting point would be to add, in addition to the fertilizer recommended for the cassava intercrop, an additional 130 kg urea per hectare (13 g per square metre).

Micronutrients

Micronutrient deficiencies are hard to diagnose in cassava because the signs may be mistaken for disease symptoms. If a farmer has followed all the tips offered on nutrient application of N, P and K in this handbook and the cassava yield remains below 16 tonnes per hectare, or the appropriate target yield, in a good rainfall year, the problem might be micronutrient deficiencies. For example, zinc deficiency, whose symptoms are yellow or white spots between veins, can sometimes be observed in young cassava plants. Symptoms, such as rotting stem or root, may indicate boron deficiency.

Many of the nutrients can be supplied by applying fertilizers. Multi-micronutrient products exist (including in spray formulations), but the farmer should seek advice before acquiring and using these products. In general, advice should be sought on how to address problems caused by micronutrient deficiencies in cassava.

Organic matter

Cassava tends to be grown in non-cattle areas, limiting access to cattle and farmyard manure. In these areas small ruminants usually run free making manure collection difficult. Livestock markets can, however, be a source of manure. Industrial poultry and pig farms co-exist in some regions with cassava producing areas and they too can be a source of manure. Organic matter – including poultry manure, cow dung, household waste and compost - provides both nutrients and organic carbon, which improves the soil's physical properties, water retention and microbial activity, all leading to a 'healthy soil' with fewer pests and diseases.

For land under continuous cultivation, the recommendation is to apply as much organic matter as possible before tillage. Often manure is used closer to the homestead (where livestock are housed) and on high-value crops, and also because this limits labour and costs of transporting bulky organic matter.

Organic matter is often a scarce resource which should be applied to the crops which will result in greatest economic return. In many cases, this will not be cassava.

Organic matter from crop or household residues should be composted for

4-6 months before application on the farm.

In terms of nutrients, manure mostly supplies N, which may not be the most limiting nutrient for cassava. However, it also contains other nutrients, which help to improve the soil nutrient status.

The key challenges regarding organic fertilizer use include:

1. Limited quantity of suitable organic matter for composting or conversion available.
2. Bulkiness, which increases the cost of handling, as well as transportation over long distances.
3. High variability in nutrient content.
4. High variability in nutrient availability and release to the crop.

Due to these challenges, farmers using organic inputs need to observe their cassava crops more intensively than if they rely only on inorganic fertilizer.

As a general rule, phosphorus (P) in organic materials is not very easily available. The full amount of P-containing mineral fertilizer should therefore be applied with no reduction made for the organic matter supplied.

Potassium (K) content in manures and composted materials is usually low. The full amount of K containing mineral fertilizer should therefore be applied with no reduction made for the organic matter supplied.

Nitrogen (N) availability depends on the type of organic material and may be rapidly or slowly released to the crop. Farmers therefore need to carefully observe cassava canopy development and colour – if it looks sparse and pale, then N should be applied as urea. Such N application often triggers decomposition of organic matter and leads to accelerated release of N, so N rates from fertilizer should be small to avoid excess N supply.

Residue management under intercrop arrangements

It is recommended that the maximum amount of crop residue should be left in the field where it was grown. This is easier for maize, where only the cobs are carried out of the field, but more difficult for legumes. For example, groundnuts and soybean plants are usually cut or pulled and carried from the field to pick the pods, while cowpea plants remain in the field in some regions and pods are continuously picked from the still growing crop.
In regions with intense competition for crop residues as livestock feeds, cooking fuel, thatching or fencing materials, it is likely that all biomass of the

intercrop is removed. In some regions, cowpea fodder can fetch the farmer more income than the grain.

If possible, cassava leaves and peels should be left in the field and incorporated into the soil.

Where livestock is fed crop residues, manure may be brought back to the field – especially if the farmland is near the homestead.

Generally, avoid burning of crop residues: carbon (C), nitrogen (N) and sulphur (S) will be lost to the atmosphere: it is much better to leave the crop residues as mulch on the surface. The ash left is a poor fertilizer and tends to be blown away or leached into deep soil layers. Burning also exposes the soil to erosion.