AFRICA soil health consortium

# Nutrient management

# Sorghum & millet

### Sorghum and millet nutrient management

Both sorghum and millet do better in poor soils than maize. Even without fertilizer application, their deep rooting systems help them to produce harvests in situations where maize will fail: sorghum and millet roots can penetrate up to 2 metres to reach moisture and nutrients while maize reaches down no more than about one metre. Sorghum and millet are often grown on lighter soils (sandy to loamy sandy) than maize.

Current yields of sorghum and millet achieved by smallholders in Africa are about 1 tonne and 0.5 tonnes per hectare, respectively. There is, however, large annual variability as they are grown in areas prone to dry spells which can severely affect yields.

These low yields can, however, be doubled and annual variability reduced by use of good seed, dry spells mitigation technologies and good agronomic practices (timely planting at optimum spacing, timely weeding, timely and appropriate application of organic matter and mineral fertilizer, and use of soil amendments to correct soil acidity and other problems) – that is an integrated soil fertility management (ISFM) approach.

Sorghum responds better to improved soil conditions than millet, although millet is more resilient and better able to deal with stress, such as dry spells and low nutrient content of the soils.

Sorghum and millet respond differently to fertilizer application: if a farmer grows both crops, it will often make more sense to apply available fertilizer to sorghum rather than millet, but there are exceptions - see box *If you have to choose to microdose either sorghum or millet, which crop should you choose?*

Before the decision is taken to apply fertilizer, farmers need to be guided through simple cost-benefit calculations to make sure the additional expenditure is justified (see box, Will fertilizer application be profitable?).

**Will fertilizer application be profitable?**

In *Some examples of fertilizer types, rate of application and timing for sustainable cropping, Table 3* (page x), in the first example of a suitable fertilizer for sorghum, 2 bags of DAP and 2 bags of urea were used per hectare of sorghum to give a grain yield of 2000 kg per hectare and a stover yield of 4000 kg per hectare.

The yield would have been just 600 kg per hectare of grains and 1100 kg per hectare of stover without fertilizer application.

But how beneficial is using fertilizer in this example?

Below is a worked example of how to calculate the financial benefit using some estimates of prices for grain, stover and fertilizer. When extension workers and farmers repeat these calculations they should, of course, use prevailing local prices.

**Without fertiliser**:

Value of grains: 600 kg @ $0.30 per kg = $180

Value of stover: 1100 kg @ $0.05 per kg = $55

Total value of sorghum harvest per hectare = $235

**With fertiliser**:

Value of grains: 2000 kg @ $0.30 per kg = $600

Value of stover: 4000 kg @ $0.05 per kg = $200

Total value of sorghum harvest per hectare= $800

Cost of fertilizer:

2 bags of DAP @ $30 each = $60

2 bags of urea @ $30 each = $60

Total cost of fertilizer per hectare = $120

To calculate if it was profitable to use fertilizer: (total value of sorghum with fertilizer-total value of sorghum without fertilizer) -total cost of fertilizer) = ($800-$235) = $565 - $120 = $445 per hectare.

So, here the farmer recovered the $120 invested in fertilizer and made an additional $445 per hectare by using fertilizer. In this case the investment in fertilizer was very worthwhile, but with lower prices for grain and stover, and/or higher prices for fertilizer this may not be the case. For an investment in fertilizer to be worthwhile, the profit needs to be at least twice the amount invested; so, for an investment of $100, the anticipated additional profit needs to be at least $200.

## Types of fertilizer

As they grow and develop, sorghum and millet take their nutrients from the soil.

The three major nutrients plants obtain from the soil are nitrogen, phosphorus and potassium. For sorghum and millet grown in most soils in sub-Saharan Africa, nitrogen (N) and phosphorus (P) are the two that farmers need to focus on, especially if crop residues are well managed to sustain potassium (K) in the soil. Most K taken up from the soil is stored in the stover and so can be recycled in the system if crop residues are returned to the soil.

Soils already contain some N and P but not at the levels required by sorghum and millet to produce higher yields. To ensure economic, sustainable millet and/or sorghum production on the same piece of land, nutrients need to be added through application of mineral fertilizer and organic matter at a level that will complement what the soil already contains.

Depending on the circumstances, farmers may also need to take measures to address dry-spells (see Box: *Zai pits*) and acidity (see *Soil amendments other than organic matter*), both of which can cause yield reductions.

There are two main types of nutrient sources relevant for sorghum and millet crops: mineral fertilizers and organic matter.

**Mineral fertilizers**, also known as inorganic or chemical fertilizers, are manufactured and sold for use by farmers. They only supply nutrients and do not help maintain soil health and structure in the same way that organic matter does.

There are many different kinds of mineral fertilizer but they all fall into two main types: those that supply two or more nutrients and those that supply only or mainly a single nutrient.

NPK fertilizers supply the three major plant nutrients - N, P and potassium (K, also known as potash).

Different NPK fertilizers are often available which contain different proportions of N, P and K. These are labelled, for example NPK 15-15-15. The first number is the percentage of the fertilizer that is N; the second number is the percentage of the fertilizer than supplies P; the third number is the percentage of the fertilizer that supplies K[1]. So, the higher the number, the more of that nutrient the fertilizer supplies: for example, NPK 17-17-17 will supply more N, P and K per kg of fertilizer applied than NPK 15-15-15: NPK 15-15-15 will supply 150 g N while NPK 17-17-17 will supply 170 g N per kg of fertilizer.

Diammonium phosphate (DAP) supplies two of the three major plant

1 The figure for P and K actually refers to the percentage of the salts $P_2O_5$and $K_20$. $P_2O_5$ contains 43.7% P. $K_20$ contains 83% K.

nutrients, N and P. DAP contains 18% N and 20% P (equivalent to 46% $P_2O_5$): one kg of DAP supplies 180 g of N and 200 g phosphorus (equivalent to 460 g of $P_2O_5$).

Urea is a good example of a single nutrient, or straight fertilizer – urea only supplies the nutrient nitrogen (often abbreviated to N). Urea contains 46% nitrogen (N): one kg of urea therefore supplies 460 g of N but no phosphorus (P) or potassium (K).

Other examples of single nutrient fertilizers are single superphosphate (SSP; 20% $P_20_5$) and triple superphosphate (TSP; 46% $P_20_5$), both of which supply the nutrient phosphorus (P).

**Organic matter** includes manure, agro-forestry and leguminous organic inputs, compost and crop residues.

As well as providing nutrients for plants, including N, P and K, organic matter also helps to maintain good soil health and structure: improving water retention and maintaining beneficial soil organisms such as bacteria, fungi and earthworms, amongst others.

Farmers usually produce their own organic matter from their crops and livestock, but some may also buy them from neighbours or obtain them when neighbours' cattle, sheep and goats are allowed to graze their fields after harvest and deposit dung. Some farmers can harvest organic matter in the sylvo-pastoral lands (where there is open grassland and also trees and shrubs) or produce it through fallow systems.

**Mineral fertilizers**

Currently, many small-scale farmers who grow sorghum and millet use no mineral fertilizer. Mineral fertilizers are relatively expensive. Many farmers do not know how to use fertilizers properly and some believe, incorrectly, that they can 'poison' the soil.

This manual includes a two-stage approach to introducing farmers to using fertilizer on their sorghum and millet crops:

1. Microdosing
2. Fertilizer application at conventional recommended rates

In both cases, to derive the most benefit, the '4Rs' of fertilizer management should be followed:

- use the right fertilizer product for the crop
- apply the right amount

- apply at the right time in relation to the crop's growing cycle
- and place the fertilizer

*Microdosing*

Strategic application of fertilizer, also known as microdosing, involves applying relatively small amounts of fertilizer in the planting hole (also called hills or stands) of sorghum or millet at planting time rather than the conventional approach of broadcasting larger amounts of fertilizer all over the plot.

Microdosing is especially appropriate for poor and small-scale farmers: less fertilizer is used compared to broadcasting so the investment cost is lower. Placing the fertilizer close to the plant also means the fertilizer is better targeted at the sorghum or millet crop and so is less likely to encourage weeds.

For microdosing either sorghum or millet, the small amount of fertilizer should be applied to each hill when the seeds are sown:

- First a hole should be made with a stick, hoe or machete at the appropriate spacing.
- Next the fertilizer should be placed in the hole and covered with a little soil.
- Finally the seeds are sown and covered with soil – taking care to ensure the seeds and fertilizer do not touch: the sorghum or millet seed should be planted at a depth of 2-4 cm.

**A common recommendation for microdosing millet is to apply 4 kg P per hectare** (equivalent to 9.2 kg $P_2O_5$). Three examples of how this can be achieved are:

**Example 1**: Apply 6 g NPK 15-15-15 per hill of millet. This is equivalent to 60 kg NPK 15-15-15 per hectare, assuming a planting density of 10,000 hills per hectare (1 metre spacing between rows and 1 metre between plants within a row). This is about one-fifth the amount of P fertilizer recommended for sustainable millet production – see *Fertilizer for sustainable cropping*, page 31.

**Example 2**: Apply 2 g DAP per hill of millet. This is equivalent to 20 kg DAP per hectare, assuming a planting density of 10,000 hills per hectare. This is about one-fifth of the amount of P fertilizer recommended for sustainable millet production for which additional nitrogen fertilizer, such as urea, is also recommended – see *Fertilizer for sustainable cropping*, page 31.

**Example 3**: Apply 5 g single superphosphate (SSP) per hill of millet. This is equivalent to 50 kg SSP per hectare, assuming a planting density of 10,000 hills per hectare. This is about one-fifth the amount of P fertilizer recommended for sustainable millet production for which additional nitrogen fertilizer, such as urea, is also recommended – see *Fertilizer for sustainable cropping*, page 31.

Trials have shown that, in the short term, microdosing can increase millet yields by around 50% or more: for example, if a farmer obtained a yield of 400 kg per hectare with no fertilizer, a yield of around 600 kg per hectare could be expected with microdosing.

**A common recommendation for microdosing sorghum is to apply 4 kg P per hectare** (equivalent to 9.2 kg $P_2O_5$). Three examples of how this can be achieved are:

**Example 1**: Apply 6 g NPK 15-15-15 per hill of sorghum. This is equivalent to 240 kg per hectare, assuming a planting density of 40,000 hills per hectare (0.6 metre spacing between rows and 0.4 metre spacing within row). This is about half the amount of NPK recommended for sustainable sorghum production – see *Fertilizer for sustainable cropping*, page 31.

**Example 2**: Applying 2 g DAP per hill of sorghum. This is equivalent to 80 kg per hectare, assuming a planting density of 40,000 per hectare. This is about 80% of the amount of DAP recommended for sustainable sorghum productionfor which additional nitrogen fertilizer, such as urea, is also recommended – see *Fertilizer for sustainable cropping*, page 31.

**Example 3**: Apply 5 g single superphosphate (SSP). This is equivalent to 200 kg SSP per hectare, assuming a planting density of 40,000 hills per hectare. This is about half the amount of fertilizer recommended for sustainable sorghum production for which additional nitrogen fertilizer, such as urea, is also recommended – see *Fertilizer for sustainable cropping*, page 31.

Trials have shown that, in the short term, microdosing can double sorghum yields: if a farmer obtained a yield of 600 kg per hectare with no fertilizer, a yield of around 1200 kg per hectare could be expected with microdosing.

**If you have to choose to microdose either sorghum or millet, which crop should you choose?**

If a farmer is growing both sorghum and millet, is microdosing with only P, as suggested above, but cannot afford to apply fertilizer to both crops it probably makes most sense to apply the available P to the millet.

This is because millet is better able to cope with a shortage of N than sorghum. This means, in this situation, millet will respond better to the added P than sorghum would.

**Farmer friendly fertilizer measurements**

It is difficult for farmers to know what 2 g of DAP or 6 g NPK fertilizer looks like and they will not 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[1]. The bottle-top can then be used as a scoop for measuring fertilizer.

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 filled with a range of fertilizers.

See the table below for other fertilizers: values in this table have been calculated using the OFRAtool.

To apply 2 g of DAP per planting hole, 2 bottle-top measures are needed for every 5 holes.

To apply 6 g of NPK 15-15-15, two bottle-top measures are needed per hole.

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 a 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 |

In addition to the microdosing fertilizer recommendations outlined above for millet and sorghum, it is recommended that farmers also improve the organic matter status of their soil by applying manure or compost (see *Organic matter*, page 34). This will increase the use efficiency of the nutrients in the mineral fertilizer.

In countries where phosphate rock is available, it is recommended to apply phosphate rock in order to prevent soil mining. See *Soil amendments other than organic matter*, page 35.

It is also recommended that farmers increase the legume component in the cropping system. Legume crops used as rotations or intercropping benefit the soil due to biological nitrogen fixation from the atmosphere. See *Legumes rotations and intercrops,* page 20-21.

Microdosing is a relatively low-cost way of boosting yields <u>in the short term</u> – a good first step from using no fertilizer towards sustainable intensification. By increasing production, perhaps producing a surplus for sale, this cash income (or money saved from buying food) can be used to buy more fertilizer next season. In this way farmers graduate from using little or no fertilizer, to low-cost microdosing and finally to sustainable intensification in which the soil nutrient balance is maintained by the application of higher level of fertilizers.

Microdosing can be more effective if it is combined with simple complementary technologies (see box, *Zai pits*).

**Box : Zai pits**

Zai pits are simple hand-dug holes which help to conserve water and contain higher levels of organic matter and nutrients that the surrounding soil. They are particularly useful for degraded soils and in regions where rainfall is poor and erratic. Zai pits improve infiltration of rain water and also capture runoff – in doing so they reduce soil erosion and importantly mitigate dry spells or drought.

The planting pits are about 20-40 cm in diameter and 10-15 cm deep, with 12,000 to 25,000 pits per hectare.

The pits are dug during the dry season and available organic matter, such as leaves, stems and manure, is added. After the first rainfall, the pits are covered with a thin layer of soil and the seeds placed in the middle of the pit and covered. Mineral fertilizer can also be applied in the pits at planting – following the guidelines, above, for microdosing.

The major disadvantage of this approach is the labour required: it takes between 300 and 450 hours to dig zai pits on a hectare of land.

**Fertilizer for sustainable cropping**

After practicing microdosing for a few seasons, and seeing for themselves the benefits, farmers should be encouraged to graduate to using the full recommended amount of fertilizer to support sustainable cropping in the long term. Although this will require the use of more fertilizer than in microdosing, and so will be more expensive, this approach will help to ensure higher yields are achieved in this and future years.

For sustainable cropping, mineral fertilizer is usually applied as basal fertilizer and top dressing.

*Basal fertilizer*

Basal fertilizers are applied before or at planting. These fertilizers contain the nutrients that crops need for early growth or those that are not easily lost from the soil in the root zone.

For sorghum and millet, the main types of fertilizer which should be applied before planting are phosphorus (P) fertilizers as well as organic matter. Most soils (over 80%) in the sorghum and millet belt are deficient in P.

*Top dressing*

Top dressing refers to mineral fertilizer, especially nitrogen, that is applied at some time after planting.

Nitrogen (N) should be applied as a top-dressing to sorghum and millet <u>before the panicles (flowers) emerge</u> (see Photo 2): a common mistake is to apply N when the grain is filling out, which is too late.

The most commonly available N fertilizers available to farmers are urea, diammonium phosphate (DAP) and sulphate of ammonia (SA).

**Photo 2: Sorghum before and after panicle emergence**

*Application of fertilizer*

The three main ways that fertilizers can be applied to the soil are:

i) broadcast

ii) in bands

iii) placed in the hole where the seed will be or is planted (spot application).

Each method has its advantages and disadvantages, summarised in Table 1.

**Table 1: Advantages and disadvantages of three methods of applying fertilizers**

| Advantages | Disadvantages |
|---|---|
| **Broadcast**<br>Improves the fertility of the whole field, not just fertilizing the crop<br>Less labour needed than banding or spot application | Needs to be ploughed in or incorporated to be effective<br>Nutrients, e.g. P, more in contact in soil and therefore fixed more<br>More weeds will grow and compete with the crop |
| **Banding**<br>Targets the crop - fertilizer is more available to plants and less available to weeds<br>P and K fixed is less as contact with soil is reduced<br>Saves time and labour by applying when preparing ridges | Needs to be worked into the soil to be effective<br>Requires more labour than broadcasting<br>Can scorch the plant if applied too close to young seedlings |
| **Spot application, e.g. microdosing (see above)**<br>More precise targeting<br>P and K fixed is less as contact with soil is reduced | Needs to be incorporated to be effective<br>Can harm the seed if it comes into contact with the fertilizer |

*Some examples of fertilizer types, rate of application and timing for sustainable cropping*

The overall aim is to apply fertilizer at rates which are most profitable for the farmer, not to maximise yields, and also to maintain soil fertility in the long term.

Generally, sorghum responds better to fertilizer than millet – so if growing sorghum and millet, more fertilizer should be applied on sorghum than on millet.

As a rule of thumb:

- **Not more than 40 kg of N and 20 kg of P per hectare should be applied to millet.**
- **For sorghum, the maximum N should be 60 kg and maximum P should be 20 kg per hectare.**

The amount of mineral fertilizer required to supply 40 or 60 kg of N will vary depending on the fertilizer used: different types of fertilizer contain different amounts of N. Similarly, the amount of fertilizer required to supply 20 kg P will vary depending on the fertilizer being used.

In the tables below, some examples are given which show how the required nutrients can be supplied using different types and combinations of fertilizer. The tables focus on the two main nutrients, N and P, and aims to supply the maximum amounts of N and P recommended in the above rule of thumb.

**Table 2: Millet.** Various fertilizer options to supply 40 kg N and 20 kg P per hectare; 10,000 stands per hectare. If yield is up to 1 tonne per hectare, this should maintain soil nutrients to support sustainable farming.

| Fertilizer options | kg per hectare | g (bottle-tops[3]) per stand |
|---|---|---|
| DAP (basal) and urea (top dressing) | 100kg (2 bags) DAP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>50kg (1 bag) urea as top dressing | 10 g (2 bottle-tops per hole) DAP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>5 g (5 bottle-tops per 4 holes) urea as top dressing |
| SSP (basal) and urea (top dressing) | 220 kg (4.5 bags) SSP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>90kg (1 bag) urea as top dressing | 22 g (6 bottle-tops per hole) SSP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>9 g (2 bottle-tops per hole) urea as top dressing |
| NPK15-15-15 | 305 kg at land preparation | 30 g (10 bottle-tops per hole) at planting |
| Manure[4] and TSP and urea | 2 tonnes manure and 40kg (1 bag) TSP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>50kg (1 bag) urea as top dressing | 70g manure and 4 g (half a bottle-topper hole) TSP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>5 g (5 bottle-tops per 4 holes) urea as top dressing |

[3] Metal beer or soda crown bottle-tops – level not heaped full.
[4] It is assumed here that only half the nutrients in the manure will be available in the first season

**Table 3: Sorghum.** Various fertilizer options to supply 60 kg N and 20 kg P per hectare; 40,000 stands per hectare. If yield is up to 2 tonne per hectare and all the stover is returned to the soil (see *Soil fertility and residue management*) this will maintain soil nutrients to support sustainable farming.

| Fertilizer options | kg per hectare | g per stand |
|---|---|---|
| DAP (basal) and urea (top dressing) | 100kg (2 bags) DAP at land preparation<br>AND LATER, BEFORE PANICLES EMERGE<br>100kg (2 bags) urea as top dressing | 2.5g (one bottle-tops per 2 holes) DAP at planting<br>AND LATER, BEFORE PANICLES EMERGE<br>2.5g (3 bottle-tops per 5 holes) urea as top-dressing |
| SSP (basal) and urea (top dressing) | 220 kg (4.5 bags) SSP at land preparation<br>AND LATER,BEFORE PANICLES EMERGE<br>130 kg (2.6 bags) urea as top dessing | 5.5 g (3 bottle-tops per 2 holes) urea as top-dressing |
| NPK15-15-15 | 400 kg (8 bags) at land preparation | 10 g at planting |

**Table 4: Legume sole crop.** Various nutrient sources to supply 20 kg P per hectare when legumes are grown as a sole crop in a millet or sorghum and legume rotation. Legume spacing 50 cm between rows and 20 cm between stands (100,000 stands per hectare).

| Nutrients | kg per hectare | g per stand |
|---|---|---|
| DAP basal<br>No top-dressing required | 100kg (2 bags) DAP at land preparation | 1g DAP (one bottle-top per 5 holes) at land preparation |
| SSP<br>No top-dressing re-quired | 220 kg (4.5 bags) SSP at land preparation | 2.2 g SSP (2 bottle-tops per 3 holes) |
| TSP basal<br>No top-dressing re-quired | 100kg (2 bags) TSP at land preparation | 1g TSP(one bottle-top per 7 holes) at land preparation |

In intercrops, the legume is not given any additional mineral fertilizer as the focus is mainly on the cereals – so the above rules of thumb and fertilizer recommendations for millet and sorghum still apply.

**Organic matter**

Organic inputs come in different forms such as compost, farmyard manure (FYM), green manure from cover crops and crop residues. Some farmers construct temporary overnight pens for their cattle, sheep and goats in their fields during the dry season. The pens are moved from time to time to new areas on the field thereby leaving the urine, droppings and left-over food spread across the field ready to be ploughed in during land preparation. Some pastoralists keep their cattle in farmers' fields in the evenings in exchange for grains and other foodstuff.

In addition, dry crop residues, such as sorghum or millet stover, can be returned to the field after harvesting. If all the sorghum stover is returned to the field, then at least half of the N and P, and around 80% of the potassium taken up by the plants is returned to the soil.

If available, organic inputs should be applied at a rate of 2 to 5 tonnes every two years. Since these inputs are rarely available in large enough quantities, application can be localised. For example, applying animal manure in zai pits or in selected area of the farm to address specific constraints diagnosed by the farmer or to enhance efficiency of input in target areas.

**Soil amendments other than organic matter**

Soil amendments are either non-nutritive materials or materials that build up nutrients in the long term, over years, rather than supplying nutrients primarily for one cropping season.

Most soil amendments used to correct soil acidity are also applied before planting. They include lime, rock phosphate and gypsum, and also various sources of organic matter.

Apart from correcting acidity, lime ($CaCO_3$) also corrects calcium (Ca) deficiency. Although highly acidic soils are not common in the sorghum and millet growing belt, where they occur soil acidity results in stunted roots of crops (see Photo 3).

**Photo 3: Maize and many other crops are affected by high acidity in soils. Normal and stunted roots of maize shown in this photo – stunted roots of millet and sorghum would look similar**

Gypsum ($CaSO_4 \cdot 2H_2O$) act as a source of both calcium (Ca) and sulphur (S).It improves alkaline soils and treats aluminium toxicity. It is also used to improve soil structure by improving particle aggregation and inhibiting or overcoming dispersion (cracking) in clayey, saline and sodic (sodium laden) soils.

Sodic soils are alkaline soils with a high pH (above 9) due to the presence of excessive sodium carbonate ($Na_2CO_3$). They are mostly found in arid and semi-arid areas and are poor in drainage because their structure impedes water infiltration thus increasing run-offs and erosion thereby reducing water availability for plant growth.

Rock phosphate is good for building long-term soil capital as it slowly releases P.

Rock phosphate should be applied to soils every 3 years at a rate of 60 kg $P_2O_5$ per hectare. The rock phosphate can also be applied to compost which is then applied to the soil.

Rock phosphates from different sources contain different amounts of P: to supply the required amount of P, the amount of rock phosphate applied needs to be based on its P content. For example, if using Tilemsi rock phosphate from West Africa, which contains 30% $P_2O_5$, to supply 60 kg P per hectare requires about 450 kg Tilemsi rock phosphate[2].

On very light soils (sandy soil) that are suitable for millet, lime should be applied every 5 years at a rate of about 2 tonnes per hectare. Higher rates, up to about 10 tonnes per hectare, should be applied on heavier soils where sorghum dominates. If in doubt of the rate to apply, seek advice from an agricultural specialist.

Gypsum should be applied every 3 years on alkaline soils as a soil conditioner at a rate of 2-4 tonnes per hectare.

Gypsum is particularly good in promoting nitrogen fixation in legumes (groundnuts, cowpea and soybeans) at low rates of 100-300kg per hectare to supply the needed sulphur. However, that sulphur could be got more cheaply from single superphosphate (SSP). In sandy soils, groundnut pods may not fill due to calcium deficiency: gypsum should be applied at a rate of 200-400 kg per hectare just before the groundnut crop flowers to prevent this problem.

### Legumes rotations and intercrops

*Rotations*

Legumes are sometimes planted as monocrops in rotation with sorghum and millet.

Rotation of cereals and legumes can be used as means of improving soil fertility and productivity due to the ability of the preceding legumes to fix nitrogen. They also enhance fertilizer use efficiency.

Short duration legumes can sometimes be grown early in the season, preceding the main crop if the rainy season is long. For example, short duration cowpea that matures in about 2 months can be planted at the beginning of the rainy season, harvested and the stover slashed down, and sorghum or millet then planted immediately after in the same season.

For cowpeas, the seed rate is about 12-25 kg per hectare. Erect varieties can be planted at inter-row spacing of 50cm and within-row spacing of 20cm. Semi-erect and creeping varieties can be planted at inter-row spacing of 75cm; within row spacing can be 30cm for semi-erect types and 50cm for creeping types. For all types, 3 seeds should be planted per hole if germination percentage is good, or 4 seeds per hole if germination

2 60 kg P is equivalent to 60 kg x100/43.7 = 137 kg P2O5. If rock phosphate contains 30% P2O5, then 137 kg x 100/30 = 458 kg

percentage is poor. Thin to 2 seedlings two weeks after planting.

*Intercrops*
In intercrops, the distance between sorghum rows (inter-row spacing) can be between 60 and 90 cm to make room for the intercrop (a legume or millet or both). The within-row spacing can be 40-60 cm if no other crop will be planted between the sorghum stands in the row (see example presented in Figure 3). If another crop will be planted between the sorghum stands in the row then the within-row spacing of sorghum can be between 60 and 80 cm as the inter-row spacing.

Legumes are the main intercrop partners in the sorghum and millet cropping systems, although other crops such as okra and sesame also feature.

Often farmers either mix cereal and legume seeds together, planting them in no particular pattern, or plant them separately and at different times. In an intercrop situation it is best to plant the legumes and the cereals in different holes in an ordered pattern to maximize yield. For example, two rows of cowpea spaced at 20 cm x 20 cm are alternated with a row of sorghum/ millet.

Factors to consider when choosing spacing pattern for intercrops include:

- the maturity period of the crop (short, medium, long duration)
- the farmer's objective: plant at higher densities if the objective is to get more fodder.
- The priority crop, e.g. the farmer might be more interested in cowpea than sorghum; in such a case the cowpea stands will be more than those of sorghum.

The creeping types of cowpea are normally preferred in intercrops as they are more adapted to shading than the erect types used in sole cropping. Another reason why farmers prefer the creeping types in intercrops is that the erect types have fewer leaves; the creeping ones have more leaves which also can serve as a green vegetable for the household, which is useful for dietary diversity. Creeping type are also effective moisture and soil conservation tools as they cover the soil.

Due to the numerous benefits derived from growing legumes in association with sorghum and millet (see Table 5, below), it is good to increase the legume component in intercrops.

### Table 5: Why combine sorghum/millet with legumes?

| Advantages | Disadvantages |
|---|---|
| • Reduces use of mineral fertilizer<br>• Legume as a cash crop, increases ability to buy inputs, e.g. fertilizer<br>• Nutrition – legumes are a good protein source<br>• Better crop-livestock integration – enhanced fodder quality<br>• Better soil conservation (soil cover by legume)<br>• More efficient use of land<br>• Biodiversity improved in the field<br>• Reduced risk of pests and diseases<br>• Root exudates from legumes increases phosphate rock solubility/uptake of N<br>• Improved physical, chemical and biological properties of the soil<br>• Better weed control<br>• Flexibility, profit<br>• Resource maximization,<br>• Risk minimization<br>• Soil conservation and maintenance<br>• Weed control<br>• Affordable source of protein for farming household | • More labour intensive<br>• Increased pesticide use – if cowpea is introduced<br>• High cost of legume seed compared to the cereals<br>• Potential reduction in yield of cereal |

**Africa Soil Health Consortium – improving soil fertility, improving food production, improving livelihoods**

ASHC works with initiatives in sub-Saharan Africa to encourage the uptake of integrated soil fertility management (ISFM) practices. It does this primarily by supporting the development of down to earth information and materials designed to improve understanding of ISFM approaches.

ASHC works through multidisciplinary teams including soil scientists and experts on cropping systems; communication specialists, technical writers and editors; economists; monitoring and evaluation and gender specialists. This approach is helping the ASHC to facilitate the production of innovative, practical information resources.

ASHC defines ISFM as: A set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic and economic principles.

**This nutrient management guide series is part of the wider cropping systems guide series and is an output of the Africa Soil Health Consortium (ASHC), which is coordinated by CABI.**

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