Nutrition aspects and fertilizer recommendations on BANANA (Musa spp.)

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1.1 General features

The cultivation of banana is widely spread in a large number of countries in tropical and subtropical regions in South and Central America, Africa, Middle East and Asia as shown in figure 1: in 2010 world banana production averaged 102,000,000 MT and the country that produced the highest quantity of banana was India, followed by China, Philippines, Ecuador, Brazil and Indonesia (FAO data, 2010).

![World banana production in 2010](image)

Fig. 1 – World banana production in 2010 (FAO data, 2010).

Actually the major group of banana is represented by the group of Cavendish (genome AAA of *Musa acuminata*), including Dwarf Cavendish, Giant Cavendish (Williams), Grande Naine, Dacca, Robusta (Plant Names Database).

Due to its widespread area of cultivation, it is not possible to define an unique model of fertilization, depending mainly on climatic (rainfall) and agronomic (plant density, crop cycle length, yield) factors. However it is possible to delineate some common key aspects referred to the published technical literature.

1.2 Main factors affecting banana production

Banana is cultivated on many soil types but preferred pH averages about 5.5 and 6.5 (IFA, 1992). Optimal mean temperature is 27°C and a range between 16 and 38°C is ideal for a good growth. Yields can vary greatly depending on environmental and agronomic aspects. Generally crops from the ratoon are more productive than mother plant crops. Good commercial yields vary from 40 to 60 MT/ha (FAO Water).

Banana is a fast-growing plant that requires high and continuous nutrient and water supplies to sustain a year-long cycle and ensure economically convenient yields. Banana needs high amounts of nutrients, especially Nitrogen and Potassium: part of them can be supplied by the residues of the previous crop; however a good fertilizer management is fundamental, as it will be explained afterwards.

Banana has a crop coefficient ($K_c$) varying in a range between 0.5 (initial stage during the 1st year) and 1.2 (middle stage during the 2nd year) as shown in figure 2 (FAO, 1998). It is possible to obtain the crop evapotranspiration ($ET_c$) using the formula:

$$ET_c = K_c \times ET_0$$
where ET₀ = reference evapotranspiration.

It was estimated that maximum evapotranspiration (ETₘ) of banana is 5-6 mm/day (FAO, 1998). Then water requirement per year is about 1800-2200 mm that should be cover through rainfall or irrigation.

Water requirement is continuous during the crop cycle and water deficits in the different stages can affect the production. In particular water deficits:
- in the vegetative period can affect leaf development,
- in the flowering period can limit leaf growth and number of fruits,
- in the fruit development and ripening period can influence both the fruit size and quality.

![Banana crop coefficients (Kc)](source)

**Fig. 2** – Banana crop coefficient variations during its cycle: its average crop coefficient is 1 (FAO, 1998).

Water and nutrient deficits can also interact with each other: it was demonstrated that the fate of Potassium in the soil-plant system is influenced by water supply as its availability is characterized by soil diffusion and mass flow (Teixeira et al., 2002; Martins et al., 2011).

### 1.3 Plant nutrition

Generally the crop of banana has a length of about one year. In the group of Cavendish the time from planting (or ratoon start) to shooting is about 7-9 months, the time from flowering to harvest is about 90-180 days and the time between two harvest is about 7-15 months (IFA, 1992). Variability depends on temperature, rainfall and crop type (mother plant or ratoon crop).

Nitrogen and Potassium requirements are very high and continuous during the cycle. Nutrient uptake reported in literature varies enormously, being referred to different climatic area. Average nutrient uptake has been estimated (per metric ton of whole bunches) as 7.8 kg of N, 2.4 kg of P₂O₅, 34.5 kg of P₂O₅. Considering that the residues of the crop are not removed by the plantation, only the nutrients removed through the fruits must be successively introduced in the system with the fertilization program. The nutrients removed are reported in figure 3 and the ratio N:P:K of the removal nutrients corresponds to 1:0.35:4.9 (Tandon et al., 2010).
Fig. 3 – Average nutrient uptake (Tandon et al., 2010): the nutrients removed by the bunch must be introduced with the fertilization program.

Other macro- and micronutrients are important for banana, especially Calcium, Magnesium and Sulphur. Average nutrient uptake and removal are reported in the table 1.

Nitrogen and Phosphorus uptake is continuous during the whole cycle, but higher from planting (or ratoon start) to bunch emergence, while Potassium uptake begins slowly at the initial stages and reaches its peak during bunch growth (IFA, 1992). Magnesium uptake follows the same trend of Phosphorus, main Calcium and Sulphur uptake occurs until shooting, then the rate is reduced.

Leaf analysis represents an important tool to verify if the crop suffers some nutrient deficits or if the crop health status is good. Nutritional status must be optimal especially at two stages, at flower initiation and at the initially fully expanded bunch: at this time leaf analysis would be done. Nutrient values are reported in the table 2.

Table 1 – Average nutrient uptake of the plant and removal through bunch (Tandon et al., 2010)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Nutrient uptake (kg/t of fruits)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>N</td>
<td>7.76</td>
</tr>
<tr>
<td>P(_2)O(_5)</td>
<td>2.38</td>
</tr>
<tr>
<td>K(_2)O</td>
<td>34.52</td>
</tr>
<tr>
<td>S</td>
<td>1.46</td>
</tr>
<tr>
<td>CaO</td>
<td>4.54</td>
</tr>
<tr>
<td>MgO</td>
<td>2.50</td>
</tr>
<tr>
<td>Cl</td>
<td>10.5</td>
</tr>
<tr>
<td>B</td>
<td>0.026</td>
</tr>
<tr>
<td>Cu</td>
<td>0.008</td>
</tr>
<tr>
<td>Fe</td>
<td>0.12</td>
</tr>
<tr>
<td>Mn</td>
<td>0.24</td>
</tr>
<tr>
<td>Zn</td>
<td>0.094</td>
</tr>
</tbody>
</table>
Table 2 – Leaf analysis values (IFA, 1992)

<table>
<thead>
<tr>
<th>Plant growth stage</th>
<th>Nutritional status</th>
<th>% of dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Flower initiation</td>
<td>Deficient</td>
<td>&lt; 2.3</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2.3-3.3</td>
</tr>
<tr>
<td></td>
<td>Optimum</td>
<td>3.3-3.7</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>&gt; 3.7</td>
</tr>
<tr>
<td>Initial fully expanded bunch</td>
<td>Deficient</td>
<td>1.6-2.1</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2.0-2.5</td>
</tr>
<tr>
<td></td>
<td>Optimum</td>
<td>2.7-3.6</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>-</td>
</tr>
</tbody>
</table>

1.4 Fertilizer recommendations

A reasonable fertilizer program is fundamental to ensure to the crop the adequate level of nutrients. Nitrogen and potassium fertilization is indispensable but some cautions should be taken. It was demonstrated that nitrogen application can decrease soil pH level and base saturation (Teixeira et al., 2002): fertilization should maintain a sufficient soil cationic balance that means, in a soil with sub-acid pH, about 80% CEC saturation by K, Mg and Ca in the ratio of 1:3:6 (IFA, 1992).

The amounts of nutrients that are introduced through fertilization must be calculated basing on the expected yield and the total removal per metric ton of whole bunches. It was found a “break even point” in Nitrogen rate: in average conditions it was estimated that the maximum yield response (about 57 MT/ha/crop) was obtained with a nitrogen application of about 240 kg/ha/crop, equivalent to about 4.2 kg of N/ton of fruits: if this rate is overcome, increasing Nitrogen dose, yield increases lowly and it can also decrease at very high rates (Irizarry et al., 2002). Consequently excessive high rate of Nitrogen is not required to support high yield and, on the contrary, cause environmental and agronomic problems, such as Nitrogen leaching, soil acidification, crop cycle elongation.

Phosphorus can be applied in a single application incorporated before the transplant. Nitrogen and Potassium should be distributed with split applications in order to ensure a continuous supply to the plant. Nitrogen can be split in 4-6 applications each 2-3 months. In humid area applications should be repeated each 2-4 weeks. Potassium can be split as Nitrogen, but the rate should be lower at the initial stages and reach its maximum immediately before and after flowering (IFA, 1992). Calcium, magnesium and sulphur fertilization, if necessary, should cover the period until shooting.

Ilsa fertilizer program differs depending on conventional or organic crop management.

Conventional fertilization includes the use of the organic nitrogen fertilizer Fertorganico (N=11) splitted in 6 applications every other month. The total N amount must be calculated according to the expected yield and using the values in table 1 referred to the bunch nitrogen removal. Phosphorus and Potassium can be applied following the suitable farmer practice.

Organic fertilization includes the use of two organic fertilizers, Fertorganico (N=11) and Ennekappa 7.0.21 (N=7, K₂O=21). Applications are splitted and alternated in 6 applications every other month. The total amount of Nitrogen and Potassium must be calculated as explained above.

In case of little organic plantations, fertilizer program can follow the productive cycle of the single plant:
- two applications of Fertorganico (N=11) during the vegetative stage;
- three applications of Ennekappa 7.0.21 (N=7, K₂O=21) immediately before, during and after flowering;
- one application of Fertorganico during the bunch development stage.

The doses can be calculated as explained above.

Fertorganico is an organic nitrogen fertilizer that, thanks to its formulation in scale, ensures a slow nitrogen release. Its maximum efficiency can be obtained if application is localized around the plant at a soil depth of 5-10 cm. Ennekappa 7.0.21 is an organic fertilizer that follows the same ratio N:K of bunch removal.

Ilrsa nitrogen fertilizers are characterized by a slow release of the organic nitrogen, as shown in figure 4: nitrogen is released mainly in the first period, then its release is lower but constant; periodical applications ensure a constant availability of nitrogen, covering the period when the release of nitrogen of the last application is decreasing.

**Fig. 4** – Sequential release of total nitrogen (NH₄⁺ and NO₃⁻) contained in Fertorganico. The amount of Fertorganico corresponds to 100 mg of N/kg of dry matter. The test was carried out in Ilrsa laboratory: temperature was always maintained at 23°C and the WHC at 50%. Samples were leached every 2 weeks for six times. In normal conditions of application the first period of high release lasts more time, depending on variable temperatures, water availability and intensity of leaching events.
1.5 References


FAO (Water Development and Management Unit), www.fao.org/nr/water/