Assessing soil fertility and improving fertilization

Rolando Ureña
Commercial and Technical Manager
Emerging Markets
Why Fertilize?
Integrated Nutrition Program .......

Short term
Ensuring the availability of nutrients in each plant physiological event.

In the medium and long term
Control the evolution of soil fertility.
"Soil fertility is a dynamic process"

"Plants respond to the condition where they grow"

"Nutrition must adjust to changes Fertility"

"Excellent management programs may become obsolete"
Integrated Nutrition Program .......

It is based on the scientific analysis of thousands of historical data from the agricultural area crop.

Historical review of soil analysis, leaf and fruit of different production areas in the agricultural area of the country and the selected crop.

Morphological data generating during a long term based on observation plots established in different farms of the crop in the country.

Quantification and statistics of performance of each harvest and the quality associated with nutrition.
Integrated Nutrition Soil, Crops and Ambient.

Crop Solutions
Precision Farming: It must be the future standard and must be commercially integrated to our solutions.

Digital tools and services:
- Nutrient and Water Sensors
- Soil, leaves and fruit analysis

Data Collection

Interpretation

Recommendation

KNOWLEDGE DEVELOPMENT
Data capture – Innovation and R&D – Partnerships – Compatibility
Tissue

- Foliar Analysis
- Stem Analysis
- Root Analysis
- Grain Analysis
- Fruit Analysis
# Leaf analysis of cocoa – nutrient contents in leaves of productive trees

<table>
<thead>
<tr>
<th></th>
<th>N [%]</th>
<th>P [%]</th>
<th>K [%]</th>
<th>Ca [%]</th>
<th>Mg [%]</th>
<th>S [%]</th>
<th>source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2,0 – 2,5</td>
<td>0,1 – 0,3</td>
<td>1,3 – 2,2</td>
<td>0,3 – 0,6</td>
<td>0,2 – 0,5</td>
<td>Noordiana, 2007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,8 – 2,2</td>
<td>0,1 – 0,12</td>
<td>0,4 – 1,3</td>
<td>1,7 – 2,2</td>
<td>0,6 – 0,9</td>
<td>0,14 – 0,2</td>
<td>Abreu, 1996</td>
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<tr>
<td></td>
<td>2,0 – 2,3</td>
<td>0,2 – 0,23</td>
<td>2,1 – 2,4</td>
<td>0,5 – 0,8</td>
<td>0,4 – 0,6</td>
<td>0,2 – 0,22</td>
<td>Malavolta,</td>
</tr>
<tr>
<td></td>
<td>2,34 – 2,4</td>
<td>0,21 – 0,23</td>
<td>1,6 – 1,7</td>
<td>0,8 – 0,9</td>
<td>0,4 – 0,45</td>
<td>Sodré, 2001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,9 – 2,2</td>
<td>0,15 – 0,18</td>
<td>1,70 – 2,0</td>
<td>0,9 – 1,2</td>
<td>0,4 – 0,7</td>
<td>Bergmann, 1992</td>
<td></td>
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</tbody>
</table>

<table>
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</thead>
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<tr>
<td></td>
<td>60 - 200</td>
<td>50 - 300</td>
<td>25 - 70</td>
<td>8 – 12</td>
<td>20 - 100</td>
<td>Noordiana, 2007</td>
</tr>
<tr>
<td></td>
<td>150 – 250</td>
<td>80 – 110</td>
<td>40 – 55</td>
<td>20 – 25</td>
<td>55 – 70</td>
<td>Malavolta,</td>
</tr>
</tbody>
</table>
Soil Analysis
Chemical Soil Analysis

- Content evaluation of SOLUBLE nutrients

- Different extractive solutions:
  - Acidity:
    - KCl
    - Calcium Acetate pH 7
    - Aluminium
  - Calcium, Magnesium, Potassium, Phosphorus:
    - KCI – Olsen Modified Melich 3
    - Interchangeable ion resins
    - Saturated paste
    - EDTA
    - DTPA
    - Warm water
  - Micronutrients:

- Relationship with variety analysis - weather - soil - harvest tissue - quality
GPS farms are sampled and maps of soil fertility are built.
Fruit Analysis: Translucensy “water blow”
Why Production is Affected?

- Low Radiation
- Water Stress
- Reduction of Leaf Area
- High Temperature
- Low Availability Oxygen
- Ground Pathogens
- Compacted Soils
- Weed Competition
- AI Toxicity
- High Salinity
- Low Soil Fertility
- Nematodes
Fertile soil is needed for growth

- Leaves develop on cacao as groups or ‘flushes’.

- Leaves from one flush will mature before the next flush occurs.

- Nutrients for a flush of growth are drawn from the older leaves.

- If soil fertility is low, flush growth can cause major defoliation of the tree.

- Therefore the degree of defoliation during flush growth is often used as a guide to the soil fertility status.
Majority of the lateral roots are concentrated around the soil surface.

- 56% between 0-10 cm
- 26% between 11-20 cm
- 14% between 20-30 cm
- 4% between >30 cm

Source: Himme
Soil types

- Cacao prefers deep (at least 1.5m), well drained soils
  - Short term waterlogging is OK, but the roots must dry quickly
  - High water tables will limit root development

- Sandy clay loam to clay loam soils are highly productive

- Good organic levels are important
  - At least 3% organic matter

- Soil pH should be 5.0 to 7.0

- Production is severely limited below pH4.0 and above 8.0

- Cacao has low tolerance of Al toxicity
Soil Nutrition

Salinity
Salinity

- Cacao has a low tolerance of Chloride.
- Care is needed when planting close to the seashore:
  - Wind breaks are used to reduce wind blown seas spray from contacting the leaves.
- Areas where the water table becomes seasonally saline (parts of Mekong Delta in Vietnam) can cause leaf burn during periods of higher salinity.
- Sulfate of potash fertilizers should be used in areas where chlorine levels are high.
Salinity lowers production
Soil Nutrition

Soil Acidity
Evolution of Soil Acidity in Costa Rica

Regular applications for 700-800 kg N / ha / year, based on raw materials with high acidifying power for more than 30 years, have generated soil acidity. The subsequent formulation with more noble materials such as Nitrabor have allowed the reversal of malnutrition.

1970’s sources:
(NH₄)₂SO₄
Urea
Effect of Soil Acidity on Root Growth

For its genesis tropical soils over time they tend to generate acidity. Years of using acidifying nitrogen sources have accentuated the problems of soil acidity.

Excess soil acidity accelerate the process of root mortality, favoring foliar deficiencies of Ca and Mg and the presence of physiological and nutritional disorders.
Banana: Problem on acid soils (low soil pH)
Al toxicity reduces water and nutrient uptake by 50%

Grand Naine – Pot experiment (- and + Aluminium [2.2 ppm])

**Nutrient uptake [mg/plant] - Cumulative (until 40 days)**

**Water uptake [L]**
- AL: 18.7
+ AL: 9.2

REF: Rufyikiri et al. (2000)
Effect of Soil Acidity in Weight and Quality Fruit

Exchangeable acidity facilitates the loss of roots in banana plant, one of the main effects is to reduce the weight of the bunch, due to lack of absorption sites of Ca, Mg and other nutrients.

There is a direct relationship between excess acidity and % of non-exportable fruit, because of nutrient deficiency as Ca.
Relationship between pH and Soil Acidity in Coffee Farms in Costa Rica

Acidity Problems

Healthy Soil

S.A. = 21%

%S.A. = 8%
Soil pH Evolution in a Coffee Farm. Naranjo, Costa Rica

Decrease of 1,05 units of pH
Acidity [H+] has increased 10 times = 900%
Relation of Soil Acidity and Production, coffee farm. Costa Rica
Relationship between the aluminum content in the leaf and the “cuerpo de tasa”, Costa Rica
Relationship between the concentration of aluminum in the coffee bean and the “resabio de la tasa”, Costa Rica
Effect of leaf aluminum concentration on growth of cocoa seedlings - Malaysia

source: Shamshuddin, 2004
Effect of aluminum concentration in soil solution on growth of cocoa - Malaysia

source: Shamshuddin, 2011
Effect of acidity saturation in the yield of Sugarcane
Effect of soil aluminum saturation on cocoa nutrient uptake - Brazil

source: Baligar, 2005b
## Acid Equivalent or Basicity of some Nitrogen Fertilizers

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>% of N</th>
<th>kg CaCO₃/kg N</th>
<th>kg CaCO₃/100 kg mat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Sulphate</td>
<td>21</td>
<td>5,35 A</td>
<td>112 A</td>
</tr>
<tr>
<td>Urea</td>
<td>46</td>
<td>1,80 A</td>
<td>84 A</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>33,5</td>
<td>1,80 A</td>
<td>63 A</td>
</tr>
<tr>
<td>MAP</td>
<td>10</td>
<td>6,5 A</td>
<td>65 A</td>
</tr>
<tr>
<td>DAP</td>
<td>18</td>
<td>4,1 A</td>
<td>74 A</td>
</tr>
<tr>
<td>Nitromag</td>
<td>21</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Calcibor</td>
<td>15,5</td>
<td>1,7 B</td>
<td>27 B</td>
</tr>
<tr>
<td>Potassium Nitrate 13,5-0-44</td>
<td>13,5</td>
<td>1,9 B</td>
<td>26 B</td>
</tr>
<tr>
<td>Potassium Nitrate15-0-14</td>
<td>15</td>
<td>1,9 B</td>
<td>28 B</td>
</tr>
</tbody>
</table>

Adapted from Tisdale et al, 1993
Effect of Nitrogen Source in Soil pH

NH₄

H⁺

NO₃

OH⁻
HCO₃⁻

pH decreases

++ Acidity

pH increases

- - Acidity
Effect of the Nitrate in Soil pH

Nitrate-N increases root zone pH

16.6 mg NO$_3$-N

Ammonium-N decreases root zone pH

16.6 mg NH$_4$-N

Ammoniac Nitrogen acidifies the rhizosphere: NH$_4^+$ enters, H$^+$ leaves

Nitric Nitrogen increases the pH in the rhizosphere: NO$_3^-$ enters, OH$^-$ leaves

Marschner & Romheld, 1983
Synergisms and antagonisms between Nutrients

- Nitrates carry cations to be absorbed.
- Ammonium absorption competes with the absorption of other cations
Soil Nutrition

Nutrients Balance
The law of least

La producción de una planta se verá limitada por el nutriente disponible en menor cantidad.

The law of least

[Diagram showing various nutrients such as S, N, P, K, etc., with water flowing out to represent the law of least.]
Nutrient removal with 1 t/ha dry cocoa bean (incl. husks equivalent to 1 t of bean)

<table>
<thead>
<tr>
<th>Country</th>
<th>Beans kg nutrient</th>
<th>Husks kg nutrient</th>
<th>Total kg nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P₂O₅</td>
<td>K₂O</td>
</tr>
<tr>
<td>Cameroon</td>
<td>19,2</td>
<td>10,1</td>
<td>12,8</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>22,1</td>
<td>6,8</td>
<td>9,0</td>
</tr>
<tr>
<td>Nigeria</td>
<td>22,7</td>
<td>9,2</td>
<td>10,1</td>
</tr>
<tr>
<td>Malaysia</td>
<td>20,4</td>
<td>8,2</td>
<td>12,6</td>
</tr>
<tr>
<td>SE Asia</td>
<td>20,0</td>
<td>4,7</td>
<td>11,3</td>
</tr>
<tr>
<td>Philippines</td>
<td>21,3</td>
<td>9,2</td>
<td>11,4</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>21,3</td>
<td>9,6</td>
<td>12,7</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>19,3</td>
<td>10,5</td>
<td>13,1</td>
</tr>
<tr>
<td>Brazil</td>
<td>22,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia (QL)</td>
<td>22,8</td>
<td>10,9</td>
<td>8,3</td>
</tr>
<tr>
<td>Average</td>
<td>21,1</td>
<td>8,8</td>
<td>11,3</td>
</tr>
</tbody>
</table>

### Average nutrient requirements of Cacao
*(kg/ha, based on 1075 trees/ha)*

<table>
<thead>
<tr>
<th>Stages of development</th>
<th>Crop age (Month)</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedling (nursery)</td>
<td>5-12</td>
<td>2.4</td>
<td>0.6</td>
<td>2.4</td>
<td>2.3</td>
<td>1.1</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>Immature</td>
<td>28</td>
<td>128</td>
<td>13.6</td>
<td>114</td>
<td>151</td>
<td>113</td>
<td>3.9</td>
<td>0.5</td>
</tr>
<tr>
<td>1st year of production</td>
<td>39</td>
<td>212</td>
<td>23</td>
<td>321</td>
<td>140</td>
<td>71</td>
<td>7.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Mature crop</td>
<td>50-87</td>
<td>438</td>
<td>48</td>
<td>633</td>
<td>373</td>
<td>129</td>
<td>6.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Source: Panduan budaya Kakao
Nutrient uptake – whole plant

Mature Cacao plantation, 7 years old, 1100 trees/ha

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>CaO</th>
<th>MgO</th>
<th>Mn</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average nutrient requirement (whole plant) kg/ha</td>
<td>453</td>
<td>114</td>
<td>788</td>
<td>540</td>
<td>221</td>
<td>7</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Source: Modified after Thong & Ng (1978)
The (possible) role of Nutrition in Cocoa
- adopted from Coffee Plantmaster

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
<th>B</th>
<th>Cu</th>
<th>Fe</th>
<th>Mn</th>
<th>Mo</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOWERING AND BERRY SET</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>BEAN SIZE</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>YIELD</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
<td>⬆️</td>
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<td>DISEASES</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CAFFEINE CONTENT</td>
<td></td>
<td></td>
<td></td>
<td>⬆️</td>
<td></td>
<td>⬆️</td>
<td></td>
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</tbody>
</table>

INCREASE ⬆️  REDUCTION ⬇️

Adapted from Coffee Plantmaster
Nutrient demand (uptake & removal)
1000kg/ha/year dried beans - Malaysia
Nutrient balance is important

Seeds in pod from low K application fail to fill completely

Farmer fertilizer application in Vietnam

Nutrient uptake ratio from previous slide
Balanced Nutrition is important
Colombia-Cacao

Yield (t/ha)

kg/ha (average of 5 years)

Ref. Uribe et al. (1998)
Impact of different N forms on growth and N uptake of cocoa seedlings - Brazil

**Source:** Santana, 1980
Impact of different nitrogen rates on cocoa yield - Ghana. 3-year avg.

- N application of 90 kg N/ha resulted in highest yield.
- No further yield increase with increase in N rates, because of unbalanced nutrition (low K).
- Base dressing with 115 kg P2O5 and 76.5 kg K2O/ha; N as ammonium sulphate

source: Ofori-Frimpong. 2003
Relationship between the content of foliar Nitrogen and TM Sugar/ha
Foliar Nitrogen and Sugar Cane Yield, according to the phosphorus level in the soil
Phosphorus application increases cocoa yield in the presence of nitrogen - Nigeria

without P application

67 kg P/ha applied

Abia  Apoje  Ajasor  Ibule  mean

Abia  Apoje  Ajasor  Ibule  mean

N rate applied [kg N/ha]

N rate applied [kg N/ha]
Impact of increasing phosphorus rates on bean yield of cocoa - Brazil

P was applied as TSP, the initial soil P content is 1-3 mg P/kg soil

source: Morais 1998b
Impact of phosphorus application on yield and incidence of 'witches broom' in cocoa - Brazil

- **Initial P content on both soils**: <4 mg P/kg soil (low)

**Graphs**

- **Dry bean yield [kg/ha]**
  - Terra rossa (calcareous)
  - Latossolo amarelo

- **Witches broom infestation [%]**
  - Terra rossa (calcareous)
  - Latossolo amarelo

**Source**: Morais 1998b
Foliar Nitrogen and Sugar Production, according to the Saturation Level of Foliar K
Impact of increasing nitrogen rates on cocoa yield - Colombia

- low K level (50 kg K2O/ha)
- high K level (200 kg K2O/ha)

source: Uribe, 2000
Impact of increasing potassium rates on cocoa yield, Colombia

source: Uribe, 2000
Foliar Nitrogen and Sugar Production, according to the Saturation Level of Foliar K
Evolution of Potassium Saturation in Soil

Excessive applications of potassium as KCl to achieve doses up to 1000 kg/ha/year, generated over time nutritional imbalances, mainly against Calcium. Old Nutrition did not consider the application of soluble calcium immediately available to the plant; It generated over time nutritional imbalances that favor the presence of metabolic disorders such as maturity bronzing. Currently Nitrabor including, allows the proper balance of bases on the soil and the leaf.
Excessive potassium recommendations to the soil, show the negative effect of these on the weight of banana bunch.

Potasio del suelo y peso del racimo.

Año 1970

Año 2005

x:0.621687
y:22.5872
One of the main effects of excess potassium in the soil is foliar Ca deficiency. At equilibrium soil bases, more potassium has absorbability than Ca and Mg.
## Evolution of the Soil Nutrition in banana

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>700</td>
<td>500</td>
<td>475</td>
<td>400</td>
<td>400-375</td>
</tr>
<tr>
<td>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
<td>150</td>
<td>120</td>
<td>80</td>
<td>50</td>
<td>30-20</td>
</tr>
<tr>
<td>K&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>1000</td>
<td>700</td>
<td>450</td>
<td>400</td>
<td>400-500</td>
</tr>
<tr>
<td>MgO</td>
<td>0</td>
<td>40</td>
<td>75</td>
<td>100</td>
<td>100-120</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>12</td>
<td>8</td>
<td>5</td>
<td>5-3</td>
</tr>
<tr>
<td>CaO</td>
<td>0</td>
<td>0</td>
<td>125</td>
<td>150</td>
<td>150-200</td>
</tr>
<tr>
<td>S</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>120</td>
<td>120-80</td>
</tr>
<tr>
<td>Zn</td>
<td>0</td>
<td>20</td>
<td>14</td>
<td>8</td>
<td>4-0</td>
</tr>
</tbody>
</table>
Bunch Weight

![Graph showing bunch weight over time with linear trendline](image-url)
Effect of magnesium application on cocoa yield - India

- **beans/pod**
  - control
  - + Mg
  - + Ca
  - + Mg + B
  - n.s.

- **100 bean fresh weight [g]**
  - control
  - + Mg
  - + Ca
  - + Mg + B
  - s.*
  - CD (5%) = 0.14

- **FM bean yield [kg/tree]**
  - control
  - + Mg
  - + Ca
  - + Mg + B
  - b
  - a
  - c

* significant to control treatment

Source: Uthaiah, 1980
Effect of calcium application on cocoa yield and quality - India

- **Beans/pod**
  - Control: n.s.
  - +Ca: n.s.
  - +Ca +Mg +B: n.s.

- **100 bean fresh weight [g]**
  - Control: s.
  - +Ca: s.*
  - +Ca +Mg +B: s.

- **FM bean yield [kg/tree]**
  - Control: s.
  - +Ca: s.
  - +Ca +Mg +B: s.

* significant to control treatment

Source: Uthaiah, 1980
Calcium application improves yield and bean weight - India

Calcium: 10 g CaCl$_2$/tree in 2 L water + 60 g CaCl$_2$/tree

source: Uthaiah. 1980
Effect of soil boron application on cocoa yield
- Nigeria

B application to the soil is efficient.
6.2 g B/tree applied around the stem base, other nutrients applied at same level.

source: Ojeniyi. 1981b
Impact of zinc application on cocoa yield - Brazil

source: Morais, 1998a
World production is over 4 Mill. Tons Cocoa beans. West Africa represents 70 % of the total.

- Cote Ivoire + Ghana = 2,5 Mill. Tons
- Indonesia + Nigeria + Cameroun + Brazil + Ecuador = 1,3 Mill. Tons
- ROW = 0,5 Mill. Tons

Source: LMC report 2014, data from 2013/2014
Uptake of nutrient removed to produce 1 t/ha of cocoa with shell included

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>MgO</th>
<th>CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38.7</td>
<td>13.9</td>
<td>67.8</td>
<td>11</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Nutrient (Kg) Uptake to produce 4 million tons of cocoa (1,233TM)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>MgO</th>
<th>CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrients</td>
<td>160.000</td>
<td>58.600</td>
<td>271.200</td>
<td>44.000</td>
<td>35.600</td>
</tr>
<tr>
<td>KTM Tons of fertilizers with classic raw materials (urea, nitrate, dap, mop, kieserite, calcium nitrate)</td>
<td>348</td>
<td>120</td>
<td>452</td>
<td>176</td>
<td>137</td>
</tr>
</tbody>
</table>
**Nutrient (Kg) Uptake by a whole mature plant (1100 trees/ha)**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>MgO</th>
<th>CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>453</td>
<td>114</td>
<td>788</td>
<td>221</td>
<td>540</td>
</tr>
</tbody>
</table>

**Nutrient Uptake (Tons) by a whole mature plant for 2 million of hectares (11,246 )**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>MgO</th>
<th>CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nutrients</strong></td>
<td>906.000</td>
<td>228.000</td>
<td>1.576.000</td>
<td>44.200</td>
<td>1.080.000</td>
</tr>
<tr>
<td><strong>KTM Tons of fertilizers with classic raw materials (urea, nitrate, dap, mop, kieserite, calcium nitrate)</strong></td>
<td>1970</td>
<td>495</td>
<td>2827</td>
<td>1700</td>
<td>4254</td>
</tr>
</tbody>
</table>
Which is a fertilizer and an acidity regulator?

<table>
<thead>
<tr>
<th>Material</th>
<th>Fórmula Química</th>
<th>Solubilidad (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonato de calcio</td>
<td>CaCO3</td>
<td>0,014</td>
</tr>
<tr>
<td>Carbonato de magnesio</td>
<td>MgCO3</td>
<td>0,106</td>
</tr>
<tr>
<td>Hidróxido de calcio</td>
<td>Ca(OH)2</td>
<td>1,85</td>
</tr>
<tr>
<td>Hidróxido de magnesio</td>
<td>Mg(OH)2</td>
<td>0,09</td>
</tr>
<tr>
<td>Oxido de magnesio</td>
<td>MgO</td>
<td>0,086</td>
</tr>
<tr>
<td>Magnesil</td>
<td>%Si (SiO2)</td>
<td>0,34</td>
</tr>
<tr>
<td>Daphos</td>
<td>%Si (SiO2)</td>
<td>1,19</td>
</tr>
<tr>
<td>Magneserita</td>
<td>%Si (SiO2)</td>
<td>0,11</td>
</tr>
<tr>
<td>Yeso</td>
<td>CaSO4</td>
<td>1,84</td>
</tr>
<tr>
<td>Kmag</td>
<td>MgSO4xKSO4</td>
<td>280</td>
</tr>
<tr>
<td>Nitromag</td>
<td>NH4NO3xMgOCaNO3</td>
<td>330</td>
</tr>
<tr>
<td>Kieserite</td>
<td>MgSO4</td>
<td>340</td>
</tr>
<tr>
<td>Cloruro de Potasio</td>
<td>KCl</td>
<td>350</td>
</tr>
<tr>
<td>Fosfato diamónico</td>
<td>DAP</td>
<td>580</td>
</tr>
<tr>
<td>Urea</td>
<td>CO(NH2)2</td>
<td>1000</td>
</tr>
<tr>
<td>Nitrabor</td>
<td>CaNO3</td>
<td>1300</td>
</tr>
<tr>
<td>Nitrato de Amonio</td>
<td>NH4NO3</td>
<td>1900</td>
</tr>
</tbody>
</table>
Considerations

- Relationship of nutrients in cocoa production: 1:0,3:1,7:0,5:1,2+EM
- Cocoa plantations fertilized with the proportion of nutrients?
- We are "exploiting" the soil correctly?
- We are degrading our soils and environment?
- Applying fertilizers are free of heavy metals?
- Apply organic fertilizers and salinity and acidity correctors free of heavy metals?
- Fertilizers that governments "donate" to producers are correct?
- Its balance of nutrients are good?
Considerations

• what kind of soil they want to leave their farms for the future of their families?
Knowledge grows
Thank you