# 22 SOIL APPLICATIONS

Soil applications are the most natural way to supply nutrients to the trees. These applications are done to supply the required nutrients, to create conditions for optimal root growth and root activity, to manipulate the trees and to suppress imbalances and other negative reactions.

As already have been mentioned in the chapters on nutritional elements, growing plants require 17 elements for optimal production. These elements are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), sulphur (S), chloride (Cl), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B) and molybdenum (Mo). Three of these (C, H en O) are not considered in any conventional fertilisation program. They are utilised as gasses ($CO_2$, $O_2$) and water ($H_2O$) by the plants.

Fortunately it is seldom required to apply all 14 nutrient elements in one program except in hydroponics or other drip systems where the hydroponic principles are applicable. Soils and irrigation water also contribute to the total requirement of the trees although not always in the required concentrations and ratios. Unfortunately, some elements are also over supplied.

The citrus tree has to provide in his requirements in this climate of over and short supply. Sometimes the requirement is unnatural and the requirements need to be adapted to suit the market. The best example for this is the natural tendency for most trees to bear a lot of small fruit. To suit the market the tree must now set less but larger fruit.

Fertilisation is therefore meant to supply those elements that are in short supply, to reach a certain predetermined goal. The purpose of the fertilisation program is therefore to improve or maintain the status of all the nutritional elements in the optimal range in the most economical way. Excessive supplies are limited which will help to preserve the soil for future production.

This leads to a requirement of methods to determine the nutritional status of an orchard and methods to satisfy the needs. These include analyses of leaves, soil, water and fruit as well as other information on crop and quality.

When the type and mass of nutrients required are determined, the most effective fertiliser and method to apply the fertiliser must be used. We endeavour to reach the situation where the biggest advantage is reached with the smallest input.

Factors that determine the success of a soil application are the following.

- The mass of the nutrient,
- The chemical compound of the nutritional element
- The pH, salt content, concentration of clay in the soil.
- Application time or times.
- The method of application.

The better a nutrient is absorbed and utilised by the plant the less needs to be applied to reach the optimal concentration in the leaf. The method of application is therefore important and determines to a large extent the success of a fertilisation program.

**The concentration of the nutrient in the fertiliser**

When the concentration of the nutrient in the fertiliser is low, large masses/volumes must be applied in order to get the required mass of the nutrient into the plant. This will increase the transport, handling, application and storage cost. On the other hand if the fertilisers are concentrated, small masses/volumes need to be applied, which make spreading difficult.

Otherwise, the concentration of the nutrient in the fertiliser is of little importance.

**The chemical formulation of the nutrient element**

The conditions prevailing on the farm and in the orchard will determine which chemical compound will be the best. In general the most acceptable chemical formula is the one that is

- Directly available to the plant,
- Can easily be transformed to an available form
- Contains no elements that will harm the soil or tree and
- One that will also supply a second element that is required.

For an acid soil the right nitrogen formulation will be the one with the lowest acidifying potential, but for an alkaline soil the one with the highest acidification potential. When P needs to be applied in a narrow strip (banding) then a water soluble phosphate that contains no N and K is the best. In this case single or double supers will be selected. MAP, MKP or rock phosphate will not do.

A wide variety of fertilisers are available. These include the so called straights (contains only one of N or P or K), compound fertilisers (a chemical composition with a set ratio between N, P and/or K) and mixtures (more than one of N, P and K). Straights contain only one of N, P or K but may also contain Ca, Mg and S.

Fertiliser mixes contain 2 or more of N, P and/or K in a variable ratio. These are merely physical mixtures of the straights. The elements Ca, Mg and S can also be included. Fertiliser mixtures are identified by the ratio between N, P and K as well as the total concentration of these three elements in the fertiliser.

For instance a 4:1:1 (30) contains 4 parts N, 1 part P and 1 part K and the three together constitute 30% of the contents of the bag. The other 70% consists of O, H, S, Mg, Ca and inactive filler material like clay.

This means that the 4:1:1(30) mix contains;

$\frac{4}{4+1+1}$ x 30 = 20% nitrogen;

$\frac{1}{4+1+1}$ x 30 = 5% phosphorus and

$\frac{1}{4+1+1}$ x 30 = 5% potassium.

The ratios of N, P and K can be changed, within limits, at will and a wide range of mixtures are possible.
Compound fertilisers or chemical mixtures have a definite and fixed ratio between the elements. The total concentration of the nutrients is only limited by the purity of the compound. Potassium nitrate is a chemical mixture containing 39% K and 13% N. If it is pure potassium nitrate the total N+K = 52%

The simpler the formulation of a fertiliser, the easier the application rate can be adjusted to satisfy the requirement of an orchard. In fact by storing three fertilisers, a source of N, one for P and one for K, the requirement for all orchards in terms of N, P and K can be met very effectively. Once mixtures are incorporated into the program many more types of fertilisers are required to meet the demand. One or even two mixtures will very seldom satisfy the demand of all orchards. Using mixtures one has to over supply P or K more often than not, to apply the required N.

The root system of citrus is sensitive for high concentrations of salts. To satisfy the requirements of all the elements will need fairly heavy applications. Therefore the applications should be split into a few applications otherwise temporary salinity could damage the roots, leaves and even shoots. For instance 1850g 3:1:5 (38) or 500g urea is needed to satisfy the N-requirement. The mix cannot be applied in one single application and the only advantage of fertiliser mixes is defeated.

**pH and salt content of the soil**

The pH and concentration of salts in the soil will determine the most appropriate chemical compound. When the concentration salt is high, fertilisers with a low salt index will be preferred. Chlorides usually have higher salt indexes than the nitrates and nitrate do not apply unwanted elements. Cost will also be a decisive factor.

The pH need to be considered when the nitrogen sources are selected. Ammonium nitrogen ($NH_4^+$) will acidify but is also subjected to volatilisation in alkaline soils. When ammonium is applied to alkaline soils ammonia gas ($NH_3$) is formed. This gas will escape into the atmosphere and the magnitude of losses is determined by the prevailing conditions when applied.

Volatilisation is highest when the ammonium is applied to the surface (Table 44, du Preez and Burger, according to Van Biljon, 2004).

**Table 44.** Losses of ammonium nitrogen (as % of the mass applied) from various sources under different conditions.

| Product | Spread on the surface (units) | Mixed with the topsoil (units) | Banding below the surface (units) |
|---|---|---|---|
| Urea | 34 | 27 | 16 |
| LAN* | 14 | 7 | 3 |
| DAP** | 30 | 23 | 13 |

* Limestone ammonium nitrate **Di-ammonium phosphate

**Time of application**

The time of application of a fertiliser is determined by the phenology of the tree, the physiology of the element and the transformations of the element in the soil.

- According to the phenology of the tree/crop, certain nutrient elements will be required at higher concentrations at certain stages. The applications must provide for these special requirements.
- The physiology determines whether an element can be accumulated in the tree to be relocated at another time. Potassium, nitrogen, phosphorus and magnesium are mobile in the tree and can be accumulated for future use. Calcium and to some extent S are immobile and need to be supplied when required.
- Certain fertilisers contain the nutrient element is a form that needs to be transformed before it will be available. The transformation will require certain conditions and time. The N in urea and organic material need to be transformed before the plants can utilise it. Moisture, temperature and pH will determine the rate of conversion.

**Application of fertilisers**

The clay content and to some extent the pH and cation balance will determine whether fertilisation must be done in one or more applications. The less clay a soil contains, the smaller the maximum mass of water soluble fertilisers that can be applied without increasing the total salt content too much. Table 45 provides guidelines to the splitting of N, P and K fertilisers applied by hand, mechanically or fertigation with microjets. The splitting is based on the clay content of the soil.

**Table 45.** Split applications of the fertilisers (as % of the total requirement) on sandy to clayey soils.

| % Clay | Element | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|
| <5 | N | 40 (0)* | 30 (40) | 20 (30) | 10 (20) | 0 (10) | |
| | P | | 100 (0)* | 0 (100)* | | | |
| | K | | | | 33 | 33 | 33 |
| | Gypsum | | 100 (0)* | 0 (100)* | | | |
| | MgO | | | | 100 | | |
| | Lime | | | | | 100** | |
| 5 tot 10 | N | 40 (0)* | 40 (40) | 0 (40) | 20 (0) | 0 (20) | |
| | P | | 100 (0)* | 0 (100)* | | | |
| | K | | | | 33 | 33 | 33 |
| | Gypsum | | 100 (0)* | 0 (100)* | | | |
| | MgO | | | | 100 | | |
| | Lime | | | | | 100** | |
| 11 tot 20 | N | 50 (0)* | 25 (50) | 25 (25) | 0 (25) | | |
| | P | | 100 (0)* | 0 (100)* | | | |
| | K | | | | 50 | 50 | |
| | Gypsum | | 100 (0)* | 0 (100)* | | | |
| | MgO | | | | 100 | | |
| | Lime | | | | | 100** | |
| 21 tot 30 | N | 50 (0)* | 50 (50) | 0 (50) | | | |
| | P | | 100 (0)* | 0 (100)* | | | |
| | K | | | | 100 | | |
| | Gypsum | | 100 (0)* | 0 (100)* | | | |
| | MgO | | | | 100 | | |
| | Lime | | | | | 100** | |
| >30 | N | 100 (0)* | 0 (100) | | | | |
| | P | | 100 (0)* | 0 (100)* | | | |
| | K | | | | 100 | | |
| | Gypsum | | 100 (0)* | 0 (100)* | | | |
| | MgO | | | | 100 | | |
| | Lime | | | | | 100* | |

(50)* Cold areas

** Any time after the last N-application up to April.

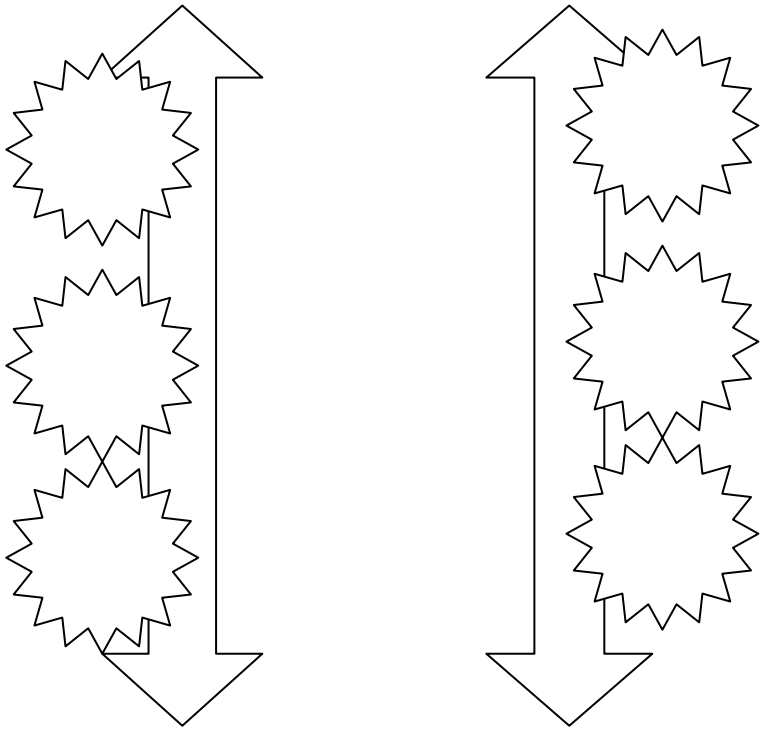

**Figure 11.** The most effective placing of fertilisers by hand or mechanical spreader when microjets are used.

When fertilisers are applied by hand or mechanically, the most effective placing is 50cm outside to 50cm inside the drip line of the trees (Figure 11). The next best is from the stem to 50cm beyond the drip line. It is however important that this area must be kept clean from weeds and also be irrigated.

The roots between the rows are not very active. Only 7% of the available P in the areas between the rows (orchard roads) is utilised by the trees (Citrus Industry Vol 3 p139).

**Special treatments**

Shamouti is prone to bear small crops of fruit with coarse and thick skins. To limit this, a special treatment was developed for Shamouti (Warrington, Karino Koöp, personal communication). The program is as follows.

Just after harvest (May);

- Irrigate with just 10 to 15 mm water.
- Apply 50% of the N requirement
- Apply a foliar spray of 1000g low biuret urea plus 150ml zinc nitrate (5,5% Zn) per 100 litre water.

May to end June;

- No irrigation until July.

July;

- Irrigate to wet the total root zone. This usually requires at least 1,5 times the normal application.
- Apply the second 50% of the N
- Apply a foliar spray of 1000g low biuret urea plus 150ml zinc nitrate (5,5% Zn) per 100 litre water.
- Irrigate at the normal rate for this time of the season.

August onwards;

- Irrigate at the normal rate for this time of the season.
- Apply the other nutrients as recommended.
- Apply 2x2000g MKP per 100 litre water at 100% petal drop.

Satsuma is also treated differently to overcome the problem with puffy fruit. Fertilisation after harvest is possible due to

the early harvesting. The program below improve fruit set and lower the incidence of puffy fruit.

After harvest;

- Irrigate the trees properly and ensure that the total root zone is wet.
- Apply 50% of the nitrogen requirement and a light irrigation to wash it into the root zone.
- Apply a foliar spray of 1000g low biuret urea per 100 litre water plus Zn and B if recommended.
- No further irrigation unless the trees show signs of water stress.

July onwards;

- Irrigate the trees properly and ensure that the total root zone is wet. This could require 1,5 times the normal application.
- Apply the second 50% of the N
- Apply a foliar spray of 1000g low biuret urea per 100 litre water plus Zn and B if recommended.
- Irrigate at the normal rate for this time of the season.

Apply the other nutrients as recommended.