26 SOIL, LEAF, WATER AND FRUIT ANALYSES

Leaf analyses

Leaf analyses are an indicator of the nutritional status of the trees. During the research into this method a relationship was established between the concentration of the nutrient elements in the leaves and production. This relationship was developed for almost every nutrient element. For some like chloride and sodium only the maximum tolerable concentration was determined. The production-leaf-concentration-curves are illustrated in Figure 12.

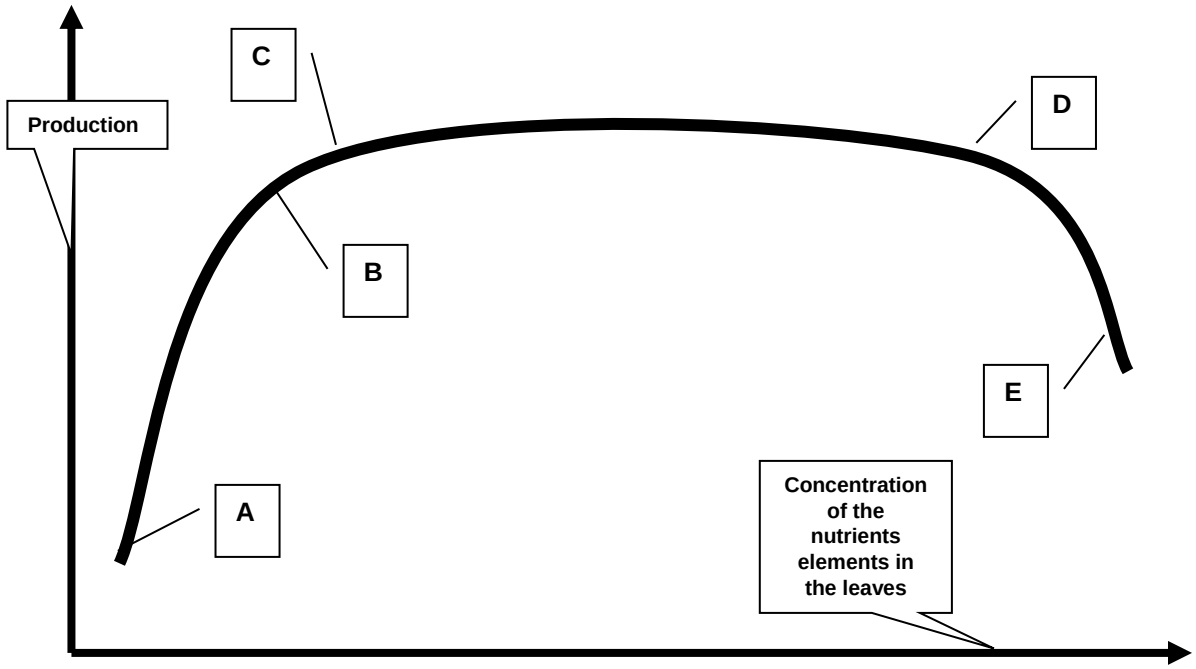

Figure 12. Generalised production curve as affected by the concentration of the nutrient elements in the leaves**.**

When the concentration of a nutrient increases from a very low status, the responds in production is dramatic as shown by portion AB. The part BC represents the best result in terms of production and nutrient status. CD represents the concentration range where a higher or lower concentration of the nutrient will have little effect on production. A decrease in production is experienced when the concentration of the nutrient is increased more than the maximum from D to E.

It is however impractical and hardly possible to keep the concentration of the nutrient within the narrow range of BC and in practise the concentration range between C and D is regarded as the optimal range. Any variation within this range will therefore be regarded as optimal and will not influence production.

These optimal ranges are not depended on external conditions like soil type, climate etc but these factors will differ between plant species and even selections within a specie (Table 64).

Table 64. Optimal concentration of the nutrient elements in the leaves (fruiting terminals) of a few citrus cultivars.

Element	Cultivar/selection	Deficient	Optimal	Excess
N%	Valencias Hot areas	<1,90	2,30-2,60	>2,80
	Other areas	<1,90	2,10-2,30	>2,50
	Young trees	<2,10	2,40-2,60	>2,80
	Deltas and Midknights	<2,10	2,40-2,60	>2,80
	Mid season type oranges	<1,90	2,10-2,30	>2,50
	Mid season type mandarins	<1,90	2,30-2,50	>2,75
	Clementines	<1,90	2,20-2,40	>2,60
	Minneola tangelo	<2,20	2,60-2,75	>3,00
	Satsumas Owari and others	<1,90	2,10-2,30	>2,50
	Miho Wase	<1,90	2,20-2,40	>2,50
	Navels	<1,90	2,40-2,60	>2,80
	Lemons	<1,90	2,30-2,60	>2,80
	Pommello	<1,90	2,30-2,60	>2,80
	Grapefruit	<1,70	1,80-2,20	>2,40
P%	Satsumas	<0,14	0.16-0,18	>0,22
	Grapefruit	<0,12	0,14-0,16	>0,18
	All others	<0,10	0,12-0,15	>0,17
K%	Valencias	<0,60	0,90-1,50	>1,80
	Deltas and Midknights	<0,60	0,90-1,50	>1,80
	Mid season type oranges	<0,60	0,90-1,50	>1,80
	Clementines	<0,60	0,90-1,60	>1,80
	Minneola tangelo	<0,60	0,90-1,25	>1,50
	Satsuma	<0,60	0,90-1,25	>1,50
	Navels	<0,50	0,70-1,10	>1,50
	Lemons	<0,60	0,80-1,20	>1,50
	Pommello	<0,60	0,80-1,00	>1,25
	Grapefruit	<0,60	0,80-1,00	>1,25
Ca%	All cultivars and selections	<2,50	3,50-6,00	>7,00
Mg%	All cultivars and selections	<0,25	0,35-0,50	>0,75
S%	All cultivars and selections	<0,15	0,20-0,30	>0,50
Cl%	All cultivars and selections			>0,65
Na mg/kg	All cultivars and selections			>4000
Cu mg/kg	All cultivars and selections	<3	5-20	>40
Fe mg/kg	All cultivars and selections	<40		
Mn mg/kg	All cultivars and selections	<25	40-150	>300
Zn mg/kg	All cultivars and selections	<15	25-100	>200
B mg/kg	All cultivars and selections	<40	75-200	>300
Mo mg/kg	All cultivars and selections	<0,05		

Leaf analysis is not a simple process. Different techniques can give different values for the same element on the same sample.

Nitrogen is present in two forms in leaves. The majority is present as amine nitrogen (NH_2^+) as in proteins and a small portion is present as nitrate nitrogen. The method originally used to establish the optimal values evaluates only the amine nitrogen because the nitrate represents less than 5% of the total nitrogen content of a leaf. It is not that important with citrus but with annual crops where the nitrates may represent as much as 25% of the total N, it is important to choose the correct method. The nitrogen status of

citrus leaves is determined in Isreal by the nitrate content (Bar-Akiva, 1974).
When the phosphorus status of most citrus orchards is compared year on year, a wave-like pattern is noticed. The general trend is downwards unless an application is done. For instance, successive leaf analyses data indicate levels of 0,15, 0,12, 0,13, 0,10 and 0,11% P with the next reading probably at 0,08% unless P is supplied.

Leaf analyses gave a good estimate of the phosphorus status of the trees. There is however no relationship between the concentration of P in the leaves and the concentration in the soil.

The results of a leaf analysis on the magnesium status can only be properly evaluated if the trees show no signs of a visual or hidden magnesium deficiency.

The concentration of Ca in the leaf has no relation with the physiological disorders related to a calcium deficiency. The leaf analyses give a summary of the calcium status over a 7 to 9 month period with no indication of a period of Ca stress. The physiological disorders are the result of a very short period of Ca deficiency.

The concentration of iron in the leaf has only any value in the deficient range of <35 mg/kg. Above this value the trees can experience a Fe deficiency or not, but the analyses cannot indicate that. The iron content reported is the total and not the concentration actively participating in the physiology. Leaves with a visual iron deficiency due to a high pH in the soil, contain high concentrations of total iron but too little is active in the physiology.

Rootstocks influence the composition of the leaves but the same optimal range is required, irrespective of the rootstock. The supplies and conditions required to reach the optimal range will however differ between rootstocks.

Leaf sampling at bearing trees

No analysis how sophisticated can change the quality of the sample. Therefore ensure that the right leaves are picked. Based on the results of this sample many cost will be incurred on fertilisers, while the yield and quality may also be at stake. Sample each year the same set of trees (index trees) and stick to the same procedure and time. Like any other sample, the leaf sample must represent the orchard in its totally. Also attend to the following specific requirements.

- Split the orchards in sampling units. A sampling unit is a group of trees of the same cultivar, rootstock, irrigation, age and planted on the same soil type.
- A sampling unit must preferably not exceed 5ha.
- Select two or four rows that are representative of the orchard and mark these rows. These rows are the index rows and all sampling (leaf, soil and fruit) can be done at these rows. Rows are preferred above diagonal paths due to ease of sampling and repetitiveness of the sampling procedure, year after year. By doing that one can concentrate on the changes brought about by the fertilisation program and not the variations in the orchard.
- Use every year the same index rows.
- Enter the orchard between two index rows and pick a leaf from the right and left hand (shady and sunny) sides between hip and head height.
- Pick between 50 and 75 leaves per sample.
- Pick leaves from fruit bearing terminals which had been grown from the same twig as the fruit during spring (Figure 13).
- The leaves must be 5 to 9 months old.
- Pick the samples during February and May each year the same time (second half of March) Leaf samples taken during June and even July are still useful but left little time to organise the orders and applications of fertilisers starting in July.
- Put the leaves in a clean plastic bag, squeeze out all the air and knot tight. If the leaves have free water on, firstly blot it dry with a paper towel.
- Mark the sample with a label sticked to the outside of the bag or tie it with a

string. Use a water resistant pen. Do not put the label with the leaves inside the bag. The label should contain at least your name and that of the orchard.

- Keep the samples cool but do not freeze until it can be sent to the laboratory. Ship as soon as possible to the laboratory. Samples that have been treated properly (contain no free water and was kept cool) will last for up to one month.

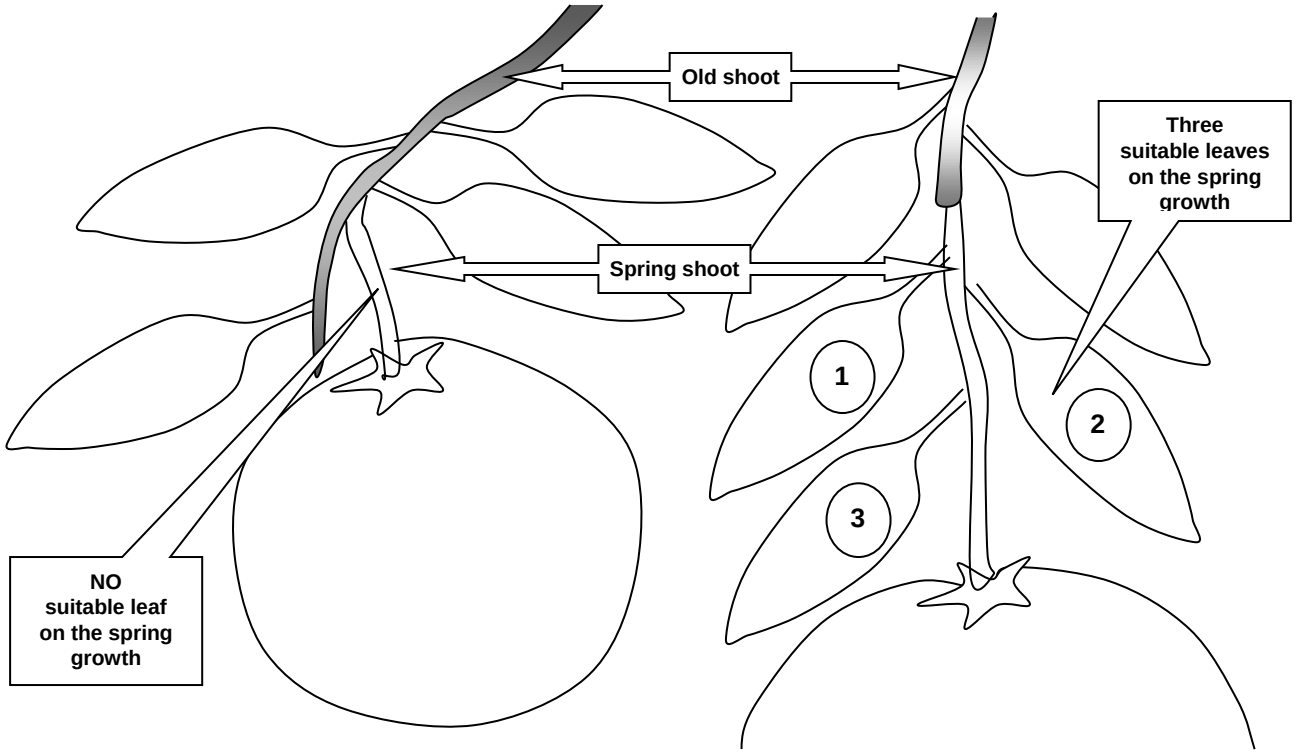

Figure 13. Illustration of the leaves from fruit bearing terminal, suitable for sampling.

Taking leaf samples from non-bearing trees
If the soil were sampled, prepared and fertilised properly before planting, it is not necessary to take leaf samples from non-bearing trees. However it is never too early to monitor the nutritional status.

Leaf samples can also be taken from nursery trees.

When sampling non-bearing trees, the same procedure regarding index trees, packaging and forwarding is applicable. Take 50 to 75 leaves per sample, one per plant, of leaf numbers 5 to 7 from the tip (Figure 14).

When sampling nursery stock pick leaf numbers 11 to 15. Pick 50 to 75 leaves per sample, one leaf per plant (Figure 14).

The optimal ranges of the nutrient elements for non-bearing and nursery stock are supplied in Table 65 (Coetzee, 1989).

Table 65. Optimal range of the concentration of the nutrient elements for leaf samples from nursery and non-bearing trees.

Element	Minimum to maximum
N %	3,00 to 4,50
P %	0,25 to 0,35
K %	2,25 to 3,00
Ca %	1,50 to 3,00
Mg %	0,25 to 0,50
S %	0,25 to 0,50
Cu mg/kg	8 to 20
Fe mg/kg	>30 if the pH < 7,0
Mn mg/kg	30 to 200
Zn mg/kg	20 to 100
B mg/kg	25 to 100

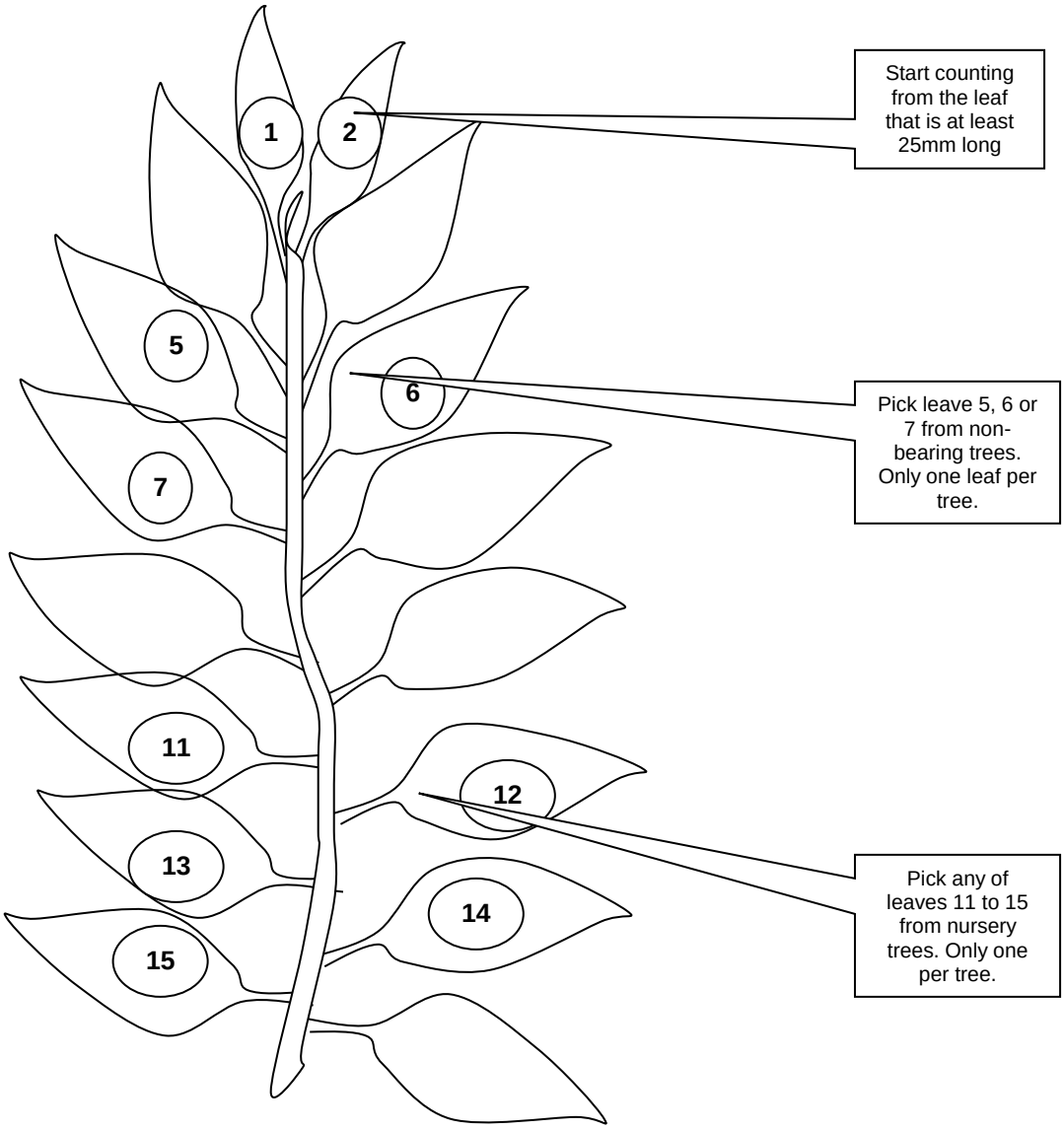

Figure 14. Illustration of the type of leaf to be sampled from non-bearing and nursery trees.

The electrical conductivity (EC) of an extract of leaves from nursery trees will also give an indication of the total amount of salt absorbed. This measurement is handy when dealing with fluctuating EC in the nutrient solution. One gram dried leaf material is extracted with 25ml demineralised water for one hour. The optimal EC of the extract is 150 to 200 mSm^{-1}.

Soil analysis

Soil analyses supply useful information to decide what measure to take to correct deficiencies, imbalances and excesses in the nutritional status of the trees. With a soil analysis it is attempted to remove from the soil in a few seconds corresponding masses of the nutrients that a plant will remove in 8 to 10 months. Each method applied, therefore went through a series of evaluating steps before it can be accepted as a suitable method for soil analyses.

These methods determine only the plant available portion of the nutrient in the soil, including a part of the reserves that will be utilised over the next few months. The portion measured therefore includes the water soluble and the readily available portion of the nutrients.

These are important principles and the reason for more than one method for the same element that will give different values for the same soil. The variety of methods was developed in an endeavour to simulate the plant. That is also a reason why different methods are used for different crops and in different areas.

Seven different methods are in use in South Africa to test for available P, 2 for K and 3 for pH of the soil. Therefore it is also important to mention the method used on the analytical report. For example, the three methods for pH will give three different answers for the same soil. On average pH(KCl) + 0,50 = pH($CaCl_2$) + 0,50 = pH(water) or pH(KCl) + 1,00 = pH(water). The description in brackets indicates the chemical used to suspend the soil namely KCl (potassium chloride) or $CaCl_2$ (calcium chloride) or water at a specific ratio with the soil. A pH reading of a soil of 5,00 means nothing until the designation is attached. If it was a reading from a KCl suspension the pH of that soil is almost optimal. However if it was done in a water suspension, the soil is too acid.

The relation between these three methods mentioned above, is based on averages but is seldom applicable in practise. Factors like the salt content of the soil have an influence on the reading. Therefore it is not advisable to jump between methods.

Due to the non-existence of a relation between the P content of the soil and that of the water, and that we strive to maintain a pH(water) between 6,5 and 7,5 the Bray 1 method for P is preferred. This does not implicate that any of the other methods are inferior.

The base cations in the soil (K, Ca, Mg and Na) are extracted by 1N ammonium acetate (pH 7). These results are then be used to determine the following.

- Can K be supplied by means of soil applications or foliar sprays?
- Does the soil contain enough Ca to supply the trees and maintain the structure of the soil?
- Existence and magnitude of any imbalances.
- Can Mg be supplied by means of soil applications or foliar sprays?
- What is the magnitude of the salinity hazard?

For the reasons mentioned, the results are also expressed as ratios. A typical report is illustrated in Table 66.

Table 66. An example of a report on the base cations. Optimal ranges are given in brackets below.

K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	K%	Ca%	Mg%	Na%	Mg:K	Ca+Mg+Na :K
235	763	198	32	9,7	61	27	2,2	2,73	6,33
*	*	*	*	5-7,5	70-75	20-25	<3	<5	<18

***** The clay content of a soil determines the optimal concentration of K, Ca, Mg and Na and therefore cannot be listed. The higher the clay content the higher the optimal concentration.

These ratios are less important in soils containing less than 10% clay. The ratios are of importance because they have effects on the absorption of the cations and the structure of the soil. These ratios are not applicable to citrus cultivated with hydroponic systems. In nutrient solutions the concentration of K is about five times that of Ca and in the soil exactly the opposite.

The potassium-, calcium-, magnesium- and sodium saturation of the soils are expressed as the percentage that the cations contribute to the total.

The saturation of each of the cations can be calculated as follows.

- %K = K÷ 390x100/Ca÷200 + Mg ÷ 120 + K÷ 390 + Na ÷ 230
  = 235÷ 390x100/763 ÷ 200 + 198÷ 120 + 235÷ 390 + 32÷230
  = 0,6026x100/3,8150+1,6500+0,6026+0,1391
  = 60,26/6,2067
  = 9,71
- %Ca = Ca ÷ 200x100/Ca ÷ 200 + Mg ÷ 120 + K÷ 390 + Na ÷ 230
  = 763÷ 200x100/763 ÷ 200 + 198÷ 120 + 235÷ 390 + 32÷230
  = 3,8150x100/3,8150+1,6500+0,6026+0,1391
  = 381,50/6,2067
  = 61,47
- %Mg = Mg ÷ 120x100/Ca ÷ 200 + Mg ÷ 120 + K÷ 390 + Na ÷ 230
  = 198÷ 120x100/763 ÷ 200 + 198÷ 120 + 235÷ 390 + 32÷230
  = 1,6500x100/3,8150+1,6500+0,6026+0,1391
  = 165/6,2067
  = 26,58
- %Na = Na ÷ 230x100/Ca ÷200 + Mg ÷ 120 + K÷ 390 + Na ÷230
  = 32÷ 230x100/763 ÷ 200 + 198÷ 120 + 235÷ 390 + 32÷230
  = 0,1391x100/3,8150+1,6500+0,6026+0,1391
  = 13,91/6,2067
  = 2,24

To put these values in perspective, potassium (K) will be used in an example. The K% in the example above is 9,71% indicating that the soil contains enough available K. In Table 67 another dimension of K is emphasized when the concentration K in the soil is related to the volume of soil per tree (spacing) and the mass K removed by the crop. To calculate the volume of soil the following assumptions were made; Volume = inter-row-spacing less 2,5m for roads, times the between-tree-spacing times the assumed rooting depth of 40cm. To convert from kg to litres, the density of the soil is taken as 1,25. Now it can be calculated that 150kg fruit will remove only 33mg K per kg soil at spacing of 7x4m is (Table 67). The 235mg K/kg soil in the example above will be enough for about 7 crops of 150kg fruit per tree.

Table 67. The mg K removed by yields of 50, 100, 150 and 200kg fruit per tree, at various tree spacing from the soil.

Spacing m x m	Mass soil kg	50kg fruit per tree	100kg fruit per tree	150kg fruit per tree	200kg fruit per tree
7x6	13 500	8	15	22	30
7x5	11 250	9	18	27	36
7x4	9 000	11	22	33	44
6x6	10 500	10	19	29	38
6x4	8 750	11	23	33	46

If the potassium status of the trees in this example is not optimal, it will be useless to apply more K to the soil. The soil already contains enough K but the trees cannot utilise it. Other methods to improve the K status must be considered. Foliar sprays or fertigation with low concentrations continuously are two options. Another consideration is that potassium fertilisation has nothing to do with the current situation. A poor root system or poor irrigation could be the cause of the low potassium status. When deciding on an action to correct a problem as much as possible relevant information must be considered.

In the Sundays River Valley a relation of about 70% was found between the calcium saturation in the soil (Ca as % of the total of the four cations) and the Ca% in the leaves. When the calcium saturation was less than 70%, the concentration of Ca in the leaves was less than 3,50%.

Soil sampling and fertilisation advice

The soil samples are taken from the same index rows as the leaf samples. Kindly note the following specific requirements.

Soil sampling at microjets.

- Use a spade or soil auger to collect a sub-sample and sample the top 30cm. Remove the leaves and other debris but no soil.
- Take the sub-sample where the fertilisers and water are applied, usually below the drip line of the tree.
- Take 15 to 20 sub-samples from the trees in the index rows. Put the sub-samples in a plastic bucket, mix properly and retain ±500g for sending to the laboratory.
- Mark the samples with your name and that of the orchard plus all relevant information on a label and stick or tie it to the outside of the container.

Soil sampling at drippers (Figure 15).

- Remove the top 5cm of soil plus debris. .
- Take the sub-sample from 5 to 30cm deep.
- Take the sample between the dripper and the perimeter of the wetted zone. If the wetted zones of two adjacent drippers overlap, take the sub-sample between the two drippers.
- Collect 15 to 20 sub-samples at the index trees. Put the sub-samples in a plastic bucket, mix properly and retain ±500g for sending to the laboratory.
- Mark the samples with your name and that of the orchard plus all relevant information on a label and stick or tie it to the outside of the container.

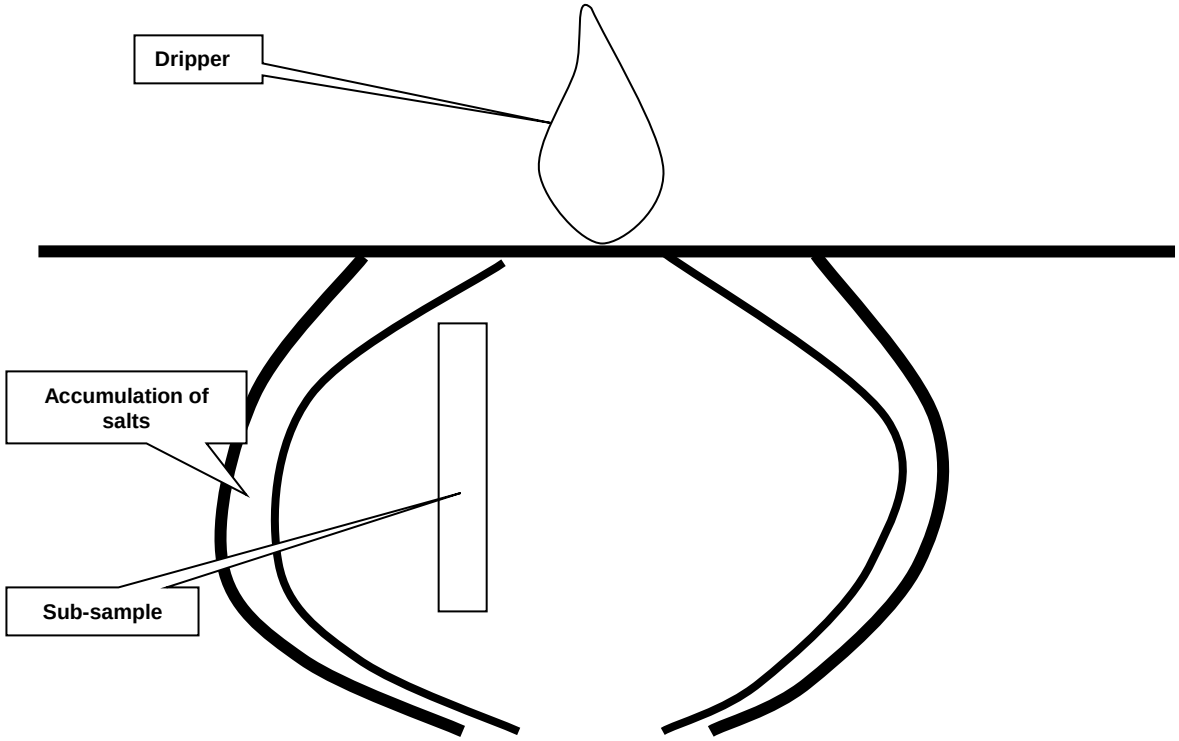

Figure 15. The sampling position in relation to the dripper, surface and perimeter of the wetted zone.

Analyses of growth mediums

One extraction method in the evaluation of growth mediums is the 1:1,5 (v/v, medium to water) for which the ranges of optimal values are given in Table 68 (Coetzee, 1989). The optimal concentrations of the nutrient elements also depend on the water holding capacity (WHC) and the moisture content of the sample.

Table 68. Optimal concentration range of the nutrient elements in a 1:1,5 water extract, at three different water holding capacities (WHC).

Element	WHV 10-20% In mmol/l	WHV 21-40% In mmol/l	WHV 41-60% In mmol/l	WHV 10-20% In mg/l	WHV 21-40% In mg/l	WHV 41-60% In mg/l
$HPO_4^=$	0,10-0,30	0,25-0,45	0,40-0,60	10-29	24-44	39-58
NO_3^-+NH_4^+	0,90-2,00	1,75-3,90	3,50-5,75	32-70	61-137	122-200
$SO_4^=$	0,21-0,50	0,40-0,85	0,65-1,25	20-48	38-82	62-120
Cl^-	<0,50	<1,00	<1,50	<18	<35	<53
K^+	0,35-0,75	0,65-1,40	1,25-2,00	14-29	25-55	49-78
Ca^{++}	0,35-0,75	0,65-1,40	1,20-1,75	14-30	26-56	48-70
Mg^{++}	0,15-0,35	0,30-0,60	0,55-0,80	4-8	7-14	13-19
Na^+	<0,50	<0,75	<1,00	<11	<17	<23
	In micromol/l	In micromol/l	In micromol/l	In mg/l	In mg/l	In mg/l
Cu^{++}	0,10-0,20	0,16-0,47	0,40-0,65	0,006-0,013	0,010-0,030	0,025-0,041
Fe^{++}	6-12	10-25	20-36	0,35-0,67	0,56-1,40	1,12-2,01
Mn^{++}	2,50-5,00	4-10	9-15	0,14-0,27	0,22-0,55	0,49-0,82
Zn^{++}	0,50-1,10	0,90-2,00	1,75-3,00	0,033-0,072	0,06-0,131	0,115-0,200

BO_3^{---}	23-46	37-56	46-69	0,25-0,50	0,40-0,60	0,50-0,75
EC mS/m	30-60	50-85	75-100	30-60	50-85	75-100

Water analyses

Natural water does not consist of water alone but also salts and is also a source of nutrients. Natural waters always contain some calcium, magnesium and sulphur and it is usually the magnesium content that interferes with the fertilisation program.

Unfortunately water contains also sodium (Na), chloride (Cl) and bicarbonate (HCO_3) and when present in high concentrations, could cause problems with osmotic pressure (sodium, Cl and all salts) or availability (HCO_3) of micro nutrient elements. The HCO_3 is responsible for the pH of the water but there is not a strong relation between these two measurements.

When drip irrigation and fertigation is used, nitric and phosphoric acid can be used to remove the HCO_3 and lower the pH at the same time.

The total soluble salt content of the water is also measured in terms of the electrical conductivity (EC). The higher the concentration of dissolved salts, the higher the EC. The international standard (SI) unit for EC is milli-Siemen per metre (mSm^{-1}). A water source with an EC of $150mSm^{-1}$ has a osmotic potential (OP) of 50kPa which is equal to the maximum tension a tree can handle without using energy to absorbed water. When the EC exceeds 150 mSm^{-1} sugars is used to increase the OP in the roots in order to obtain water. The use of sugars to obtain the required water in stead of producing leaves and fruit has a negative impact on production.

Polluted water also contains nitrates (NO_3), sulphates (SO_4) and even phosphates (PO_4). The presence of nitrates is quite common and can render water unsuitable for irrigation of citrus. This is a growing problem caused by liberal use of fertilisers but also from human and animal sewerage. .

The increasing concentration of nitrates in irrigation water holds a real treat to citrus production. When irrigation water contains too much nitrates the water can not be used during the second half of the production cycle. The amount of nitrogen applied by means of the irrigation water will be comparable to an application of nitrogen at the wrong time. Table 69 illustrates the mass of N applied by various irrigation regimes at various concentrations of nitrate. During the first part of the production cycle the nitrates in the water should form part of the nitrogen requirement.

Table 69. The relationship between the concentration of nitrogen in the water (mg/litre) and the mass nitrogen applied (kg per ha) with at 200 to 1000mm irrigation.

mg N per litre water	Irrigation at 200mm	Irrigation at 400mm	Irrigation at 600mm	Irrigation at 800mm	Irrigation at 1000mm
10	20	40	60	80	100
15	30	60	90	120	150
20	40	80	120	160	200
25	50	100	150	200	250
30	60	120	180	240	300

Therefore, an irrigation of 800mm per annum with water containing more than 20mg N per litre, will not be suitable for citrus, because too much nitrogen (>160÷2 = 80kg) will be applied during the second half of the production cycle.

Fortunately a biological process is available that will reduce the nitrates to N_2, a gas which is not available to the trees

Water containing more than 100mg Cl and 50mg Na per litre should not be used for foliar sprays, especially when potassium nitrate is

sprayed.

The pH and buffer capacity of water is important when used for foliar sprays. The absorption of nutrients is in general best at a pH between 5,00 and 6,00. If zinc nitrate is added to water with a pH above 6,50 the zinc will be precipitated and the efficiency of the spray reduced. The volume of acid required to lower the pH of the water is determined by the buffer capacity which in turn is dependent on the bicarbonate content of the water. Sometimes the volume of acid required is so much that the increase in the total salt contents of the water will scorch the leaves. In such cases, sulphuric acid will be a better acidifier than any of the weaker acids.

The leaching requirement (LR) is the extra water required to keep the concentration of salts in the root zone constant. The LR is expressed as a percentage of the application. A LR of 10% therefore means that 110% of "normal" precipitation is enquired to keep the salt content constant. The LR is therefore based on the salt content (EC) of the water (Table 70).

Table 70. The relationship between the EC of the water and the leaching requirement (LR) for 100 and 90% production.

EC of the water in mSm^{-1}	LR for 100% production	LR for 90% production
50	7	5
75	10	7
100	14	10
125	18	12
150	22	15
175	26	18

These values are calculated from the following formula;
LR for 100% production = EC of the water ÷ 850-EC of the water.
LR for 90% production = EC of the water ÷ 1165-EC of the water (according to Rhoades, 1978).

Taking water samples

The basic requirements for sampling any commodity are also applicable to water sampling. However, kindly note the following specific requirements for water samples.

- When water from a bore hole needs to be sampled, let the pump run to get rid of all the water that was standing in the pipes for some period. Only sample water that comes directly from the bore hole.
- Do not sample water next to the wall or side of a dam. Take the sample from the middle or at least 2 m from the side and 30-50cm below the surface.
- Rinse the cleaned sample container at least three times with the water that needs to be sampled. Ensure that the lid is also properly cleaned.
- When the water sample is also destined for microbial analyses, rinse the container three times with hot water (60-70°C) and then again three times with the water to be sampled.
- Use the 500ml soft drink polycarbonate bottles (Coke of Fanta) with a screw cap that is freely available.
- Mark the samples with a label sticked to or tie it to the bottle. Do not write on the bottle. Use a waterproof marker and write your name and the reference number of the water source on the label. Also write the analyses required (irrigation or human consumption) on the label.
- Send the sample to the laboratory as soon as possible. Samples that need to be analysed for their microbial content, especially *E. coli*, must reach the laboratory within 24 hours.

Fruit analyses

Fruit analyses to determine the nutritional status of the trees have been investigated more than once. This technique is not practcal due to the large volumes to be handled (50 fruit against 50 leaves per sample). Fruit is generally also less sensitive to changes in nutritional status than leaves.

Fruit analyses are however useful to determine their quality and shelf life. Analyses of fruit can also be used to determine the masses of nutrients removed from the orchard (See Table 2).

Although the composition of fruit from various cultivars differs, the variation between analyses from the same cultivar and year-on-year is of the same order. Table 71 contains the chemical composition of fruit from 10 different cultivars sampled over a period of three years. This serves only as a guideline to calculate removal figures and the efficiency of fertiliser applications.

Table 71. Average range of the nutrient element content of 10 different citrus cultivars obtained over a three year period.

Element	Concentration in dried material	Concentration in fresh material
N	1,00 – 1,75%	150 – 265mg/kg
P	0,10 – 0,15%	15 – 25mg/kg
K	1,70 – 3,00%	255 – 450mg/kg
Ca	0,50 – 0,75%	75 - 115mg/kg
Mg	0,10 – 0,20%	15 – 30mg/kg
S	0,15 – 0,25%	25 – 40mg/kg
Cu	5 -10 mg/kg	0,75 – 1,50mg/kg
Fe	10 - 20 mg/kg	1,50 – 3,00mg/kg
Mn	10 - 20 mg/kg	1,50 – 3,00mg/kg
Zn	7 – 15 mg/kg	1,05 – 2,25mg/kg
B	10 - 15 mg/kg	1,50 – 2,25mg/kg

Research to relate the mineral composition of fruit and fruit quality has started only recently. For example, the nitrogen content in the peel of good quality grapefruit is less than 1,50% in December, 1,30% in January/February and 1,10% in March (ITSG, report at a study group meeting) For good quality Valencias the peel should contain less than 0,90% nitrogen at maturity. Higher concentrations will result in thicker skins.

Silicon is also present in the skins of citrus fruit but its roll is still uncertain. Silicon provides a physical barrier against fungal, insect damage and sunburn in crops other than citrus.