18 NUTRITION AND FRUIT QUALITY

The effect of nutrition on fruit quality is well demonstrated when the nutritional status of any of the macro elements (N, P, K, Ca, Mg en S) is increased from a deficient to an optimal level (Figure 6). The change in the quality of the fruit within the optimal range of the elements is however small. When the nutrient concentrations move from optimal to excess the change in quality is again noticeable. Therefore it is very important to get the concentration of all nutrients within the optimal range. Then at least one production factor is under control and will not contribute to poor quality.

Figure 6 indicates the relationship between the nutritional status for N, P and K and certain fruit quality parameters. The changes within the optimal range are small and seldom controllable.

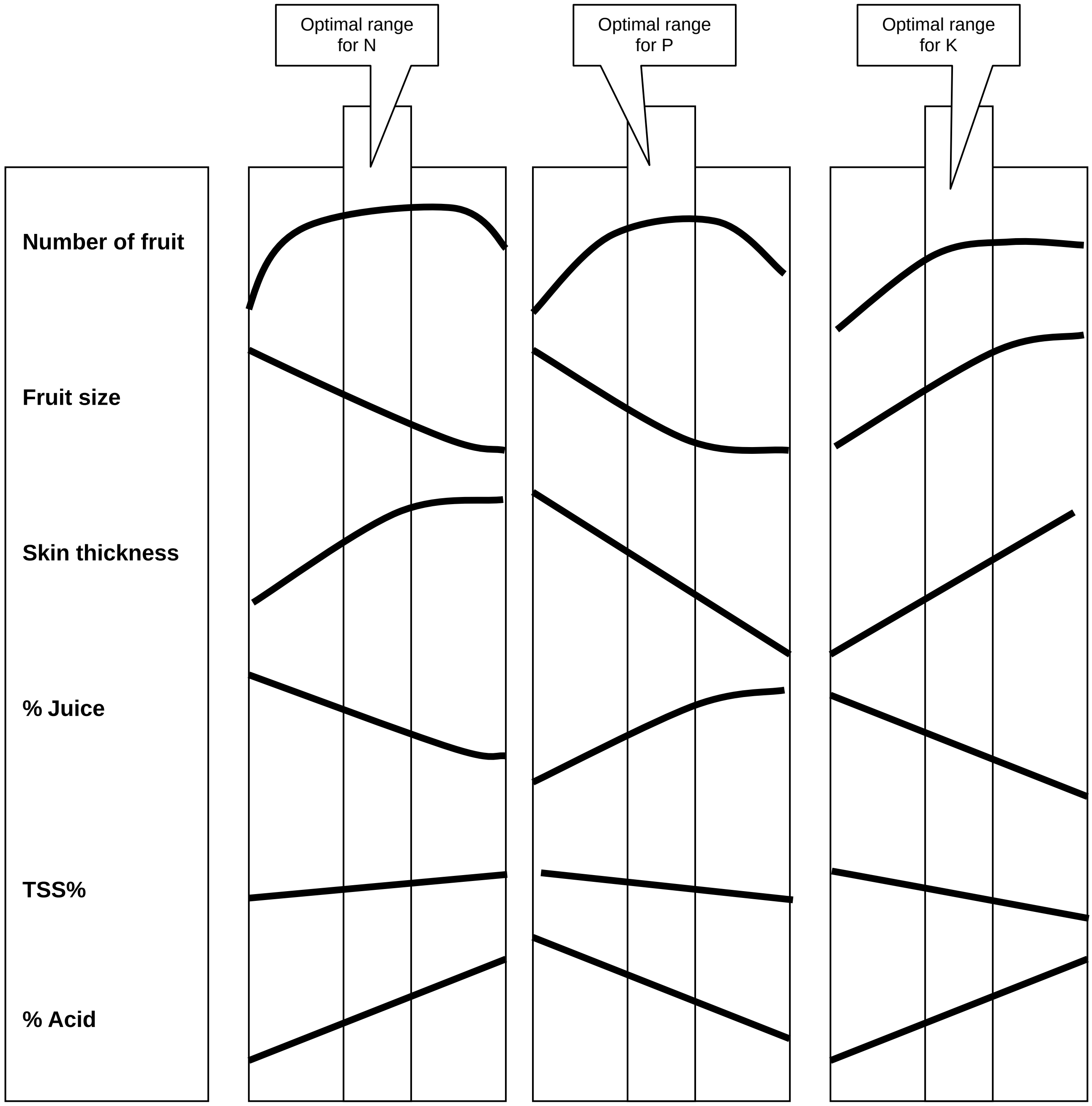

Figure 6. The relationship between the concentrations of the nutrient element and fruit quality.

Climate plays an over riding role in the outcome of fruit quality. Even when the nutritional status of all nutrients is optimal, climate can impact negatively on fruit quality. An example is skin thickness which is increased by the warm winter temperatures notwithstanding the optimal status for N, P and K and all the other elements. The hotter the winters the thicker the skins. The opposite is also true and climate can over ride the poor nutritional status to improve fruit quality. In Malelane area low potassium levels are over riden by humidity and heat to give acceptable sized fruit.

A water stress during February/March will increase TSS. The stress can be due to hot climate or purposely induced. This can however not always be done successfully in the summer rainfall areas.

Fruit size

The prevailing conditions during the development of a fruit will determine the size and quality of that fruit. When a fruitlet formed on a rough lemon (RL) rootstock is grafted on a Carrizo citrange (CC) rootstock, the mature fruit will express the characteristics of that of fruit produced on the CC and not the RL.

The potential size of a fruit is determined by the number of cells in the ovary but the eventual size by regulating factors like light, temperature, nutrition, irrigation etc. It is therefore very important to keep conditions optimal during bud break, blossom and fruit set. That is one reason why it is risky to used nitrogen stress to reduce the number of fruit in the hope to increase fruit size. Nitrogen is essential for cell division to get the maximum number of cells in the ovary.

Therefore the only time and way the grower can influence the number of cells in the ovary is to keep conditions optimal during bud break, blossom and fruit set. Thereafter he/she can only grow what number of cells was formed. Starting with many cells, required to grow them to 50% of their capacity to get a large fruit. But starting with a few cells in the ovary, every one must be grown to 100% of its capacity to get an acceptable size fruit.

The success of a foliar spray with potassium nitrate depends on the K status of the trees. A K status between 1,00 and 1,25% (optimal) will more likely increase the number of cells in the ovary because the other processes already received enough K. However, when the K status is low (<0,70%) additional K will also be required for other processes than cell division for example for development of leaf buds and more flowers. A foliar spray will therefore also increase the number of fruit which will dilute the effect on fruit size.

In Israel, 18ppm 2,4-D is added to the 4% potassium nitrate to increase fruit size (Haifa Chemicals).

Another important aspect of nutrition and fruit size is the N:K ratios in the leaves. This was studied in depth by Du Plessis and others. To produce large Valencia fruit the N:K ration must be 1,6 to 2,2 provided the K-status is at least 0,80% (Du Plessis & Koen, 1988 and Du Plessis, 1992). It is usually much easier to change the N-status to reach the required ratio, than to increase the K-status. However, do not attempt to reach the optimal ratio if the K-status is too low. As soon as the K-status improves the N-level in the leaves can also be increased. Ensure that the N-status was determined correctly and that the "hidden nitrogen deficiency syndrome" (See chapter 2) did not mask the true N level. In areas where the climate assists in better fruit size the N:K ratios can be increased to 3,4 to 4,5. For instance in areas like Malelane-Komatipoort where the influence of low K on fruit size is over riden by the climate (probably humidity and heat) good sized fruit is produced at K levels as low as 0,60%. Du Plessis also determined that a K_{leaf}:Mg_{leaf} < 1,00 results in too small fruit. The optimal ratio is ± 2,85.

Selections of clementines like SRA are known to bear too small fruit. However, the nitrogen level cannot be reduced to give larger fruit. This can better be done by pruning, fruit thinning and hormonal sprays on trees that are in an optimal nutritional condition.

Creasing

Although calcium plays an important roll a deficient supply of other elements like S, Mo, Zn, B, Mn, P and K are also involved in this

physiological disorder.
Calcium is absorbed passively and at a rate of ±10% that of potassium which renders the calcium supply more prone to be too low. Another factor that suppresses the absorption of Ca is the biochemistry. When K is absorbed in the presence of nitrate (NO_3) the ratio is 1:1 but when Ca is absorbed the Ca: NO_3 is 1:0,8. This ratio will increase the pH on the root surface. Ca is immobile in the plant and unlike K cannot be stored in the plant for use when supplies are low. Therefore, it is very important to apply Ca at the correct physiological time when the absorption is critical. For the same reason, foliar sprays with Ca will not be effective. Foliar sprays with Ca only have value when they are applied at exactly the period when the supply of Ca is too low. Continuous supply to the leaves and fruit via the roots is still the most successful way.

The incidence of creasing is determined very early in the life of the fruit. Additional Ca must therefore be applied during August to November to reduce creasing. With microjets and even drippers, gypsum can be applied. With drippers the gypsum must be applied in a small basin below each dripper. Calcium nitrate can be used as a source of N, which will also supply ample Ca during the critical period.

As already mentioned, other nutritional elements are also involved in creasing. When the N and/or K status is low, the skins of fruit will be thinner and smoother which make creasing more visible. The same applies when the P status is too high.

Foliar applied zinc and molybdenum can reduce the incidence of creasing. These sprays have to be applied during the cell division stage, which is from prior to blossom up to petal drop.

Foliar sprays with urea phosphate (UP), MKP and even MAP are claimed to reduce creasing but the results are inconsistent. Sprays should also be done during pre-blossom to petal drop.

Gilfillan (1979) studied the effect of UP on creasing and concluded that it is only successful when combined with gibberillic acid. In some trials the gibberillic acid on its own gave better results.

Alternating bearing
An alternating bearing pattern is seldom due to nutritional imbalances or deficiencies. However with certain mandarins a deficient magnesium status can trigger the alternating pattern.

Alternating bearing has an effect on the nutritional status of the trees. During an “on year” (high yield) the concentrations of N, P and K in the leaves are lower and visa versa during “off years” (Table 27).

Table 27. The effect of fruit load on the nutritional status of the trees with a marginal status.

Season	Yield	%N	%P	%K
2000	High	2,12	0,10	0,50
2001	Low	2,43	0.12	0,74
2002	High	1.79	0,09	0,40
2003	Low	2,04	0.11	0.74

Trees with an optimal or near optimal nutritional status resist such huge variations in the concentrations of these three elements better (Table 28).

Table 28. The effect of fruit load on the nutritional status of the trees with a high status.

Season	Yield	%N	%P	%K
2001	High	2,31	0.13	1,35
2002	Low	2,43	0.13	1,44
2003	High	2,32	0,12	1,37
2004	Low	2,39	0,14	1,42

On the other hand, the larger the variation in yield of Deltas the larger will be the variation in the nutritional status of the trees (Table 29).

Table 29. The effect of an alternating fruit load on the nutritional status of the trees.

Season	Yield	%N	%P	%K
2001	27 ton/ha	2,91	0.18	1,38
2002	49 ton/ha	2,10	0.13	0,79
2003	30 ton/ha	3,00	0,17	1,25
2004	52 ton/ha	2,05	0,11	0,66

The alternating fruit bearing pattern should be taken inconsideration when the fertilisation program is formulated. When an “on year” is expected the applications of N and sometimes K must be increased unless the grower will thin the number of fruit. When an “off year” is expected the N application can be reduced (depending on the leaf level) unless actions like girdling or gibberillic acid sprays will be done.

Remember when Deltas are harvested late, the next set will be reduced by ±5% for every week later than the “normal” time.

Internal fruit quality

Changes within the optimal concentration range of the nutrient elements will have little effect on the internal quality of the fruit. Significant changes will occur when a deficiency or excess are corrected.

It is therefore important to measure the nutritional status of the trees through leaf analyses and do the required adjustments in the fertilisation program in order to get the concentration of all 14 nutrient elements in the optimal range.

Climate, rootstock, cultivar, soil type and fruit load usually over ride the effects of the nutritional status during adverse conditions but compliment it when conditions are favourable.

The result of the effects of N, P and K is cumulative and together an excess of N and K plus a deficient status of P will have a bigger impact on fruit quality than the effect of single elements. The cumulative effects can be expressed in terms of N+K:P, N:P and K:P. Preliminary optimal ranges for navels are presented in Table 30.

Table 30. The relationship between the concentration of N, P and K in the leaves and the acid content of the fruit.

Ratio	Fruit with a low acid content	Fruit with a high acid content
N:P	<19	>21
K:P	<6,50	>7,25
N+K:P	<25	>29

Preliminary ranges for the N, P and K concentrations in the leaves of grapefruit, satsumas and navels known to produce good quality fruit are given in Table 31.

Table 31. Ratios of N, P and K in the leaves that usually result in good quality fruit.

	N:P	N+K:P
Grapefruit	13 tot 18	18 tot 22
Satsumas	11 tot 15	16 tot 20
Navels	16 tot 24	24 tot 28

The value of these ratios is to help in determining the possibility that the nutritional status contributes to the poor quality of the fruit. If the quality of grapefruit is poor and the N:P ratio is 20 then the nutritional status contributes to the problem. The opposite is not true that if the ratio is 20 the quality of the fruit will be poor. Too many other factors contribute to quality

The nutritional status of the plants and climate also has a cumulative effect on fruit quality. A cool climate and a deficient P status will give thicker skins than the two factors alone. However, this can also result in a positive effect where the one offsets the negative effect of the other. In a cool climate the effect of too high nitrogen levels will be neutralised by low temperatures prior to harvesting. The effect of a low K status is "neutralised" by higher heat units and humidity in the Malelane area.

Nevertheless a number of practises will help to improve fruit quality. Some foliar applications are used to manipulate the trees. These chemicals accidentally also contain nutrient elements but the reason for the applications is not to apply nutrients but to manipulate.

For instance, foliar sprays with 1% MAP 6 weeks after petal drop will reduce the acid content of the fruit by manipulating the physiological process involved in acid formation. This treatment replaces the application of calcium arsenate The decrease in the concentration of acids can perhaps also being achieved with extra P through the drippers. Fruit thinning and hence increase in size was achieved by applying a 4% MAP (Lavon & Bar-Akiva 1976).

Foliar application of 1,25% MKP 6, 4 and 2 weeks prior to harvest can apparently increase the sugar content of fruit with as much as 1% (from 9,0 to 10,0%). Perhaps this can also being achieved with extra P through drippers.

A controlled water stress lasting 6 weeks during January to March will increase the dissolved solids (sugars and acids) in the fruit. Early cultivars need to be stressed in January/February and late cultivars in February/March. With controlled water stress the water tension at the roots should not exceed -60 to -70 kPa. If the trees are too much stressed, the stomata will close and photosynthesis will stop and the whole purpose of the exercise is negated. The stress must also not be too weak. An indicator of the level of stress is the curling of the leaves. If the leaves curl by 11:00 the stress must be lifted by irrigation. If by 11:00 no curling is experience, no irrigation is required for that day.

With Marisol the acid content of the fruit depends on the fruit load. If the load is high, the acids will be low.

Skin thickness and texture
Again, the nutritional status of the trees will only influence the thickness and texture of the skin if the concentrations are too high or too low. A too low P and too high N and K status will result in thick and coarse skins. As mentioned earlier, these effects are cumulative. Trees with a nitrogen deficiency will set less fruit and when the K status is high, the few fruit will be large with thick and coarse skins.

Poor quality fruit is not related to the nitrogen status during fruit set, but during autumn. The nitrogen levels of orchards are measured during late summer and autumn and the optimal level is what it should be at that time to ensure good quality fruit. The nitrogen content has a lesser effect on fruit colour of late than early cultivars. Remember to pick the leaf sample from behind a fruit.

A number of special treatments can be applied to get smoother skins. However the results are quite variable. Some of these treatments are listed below.

- A foliar spray with 5%MKP to Star Ruby grapefruit increased the juice content and skin thickness. The acid content dropped and the P and K content of the leaves increased (Lavon et al 1995).

- Urea phosphate (UP) is a physical mixture of urea (50%) and MAP and is applied to improve the skin qualities. UP contains 27% N and 12,7% P and is applied as 1 to 1,5% solutions. Foliar sprays with various P compounds 6 weeks after full bloom gave smoother skins with Nouvelle, Thoro Temple, Shamouti and Valencia Late. Applications rates were 1% MKP, 3% MKP, 5% MKP and 2% UP with little difference between P compounds (Mudau et al. 2005).

- Shamouti is prone to coarse skins but with special treatment this can be improved (Refer to the program in Chapter 22). The number of fruit set on Shamouti, certain satsumas and even young Star Ruby grapefruit must be high to improve skin qualities. Waterstress, urea sprays and other methods must be used to set enough fruit.

- When lemons are cultivated for their oil content in the peel, gibberillic acid sprays will enlarge the oil cells and hence the oil production.