Nutrition

Fertilisation of avocado trees is a critical factor in achieving successful production, good tree health and sound fruit quality. To achieve correct fertilisation, it is important to understand the nutritional levels seen within the tree, through leaf analysis, and balances within the soil, through soil analysis. The core macro-nutrients which require focus include N, P, K and Ca. Each of these macro-nutrients play a significant role in plant and fruit development and can influence tree productivity and fruit quality if not applied in correct quantities.

- Know how many units (N, P, K, Ca) you are applying per year per hectare on your orchard.
- Units of nutrients applied must be done in relation to the estimated crop load (t/ha), along with the soil and leaf analysis results.
- Do not apply fertiliser above the rate recommended by your consultant without discussing it with them first.

LEAF AND SOIL SAMPLING

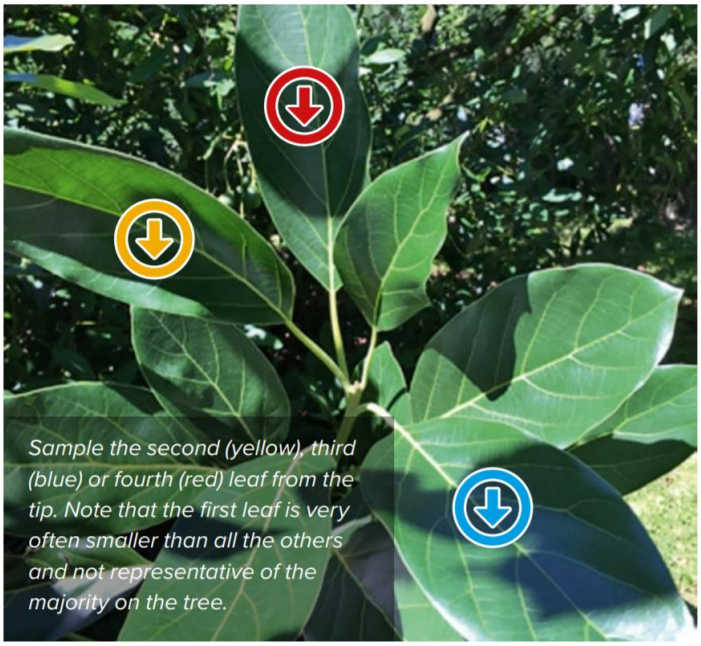
Take annual soil and leaf samples. Leaf and soil analyses are used to monitor the nutritional status of an orchard, to assist with formulating fertiliser programs and identify situations of deficiency or oversufficiency.

WHEN TO SAMPLE

Sample the leaves and soil every year to monitor trends. Take leaf samples in April/May – this is the time when elements are at their most stable. Soil samples can be taken at any time but are usually taken at the same time as the leaf samples.

HOW TO SAMPLE

Take samples from trees/blocks of the same age, on the same rootstock and growing in similar soil conditions.



Leaf sampling – select leaves at about shoulder height, from trees that are representative of those in the block. Pick the second, third, fourth or fifth leaf (blade + petiole) from summer flush branches that are not actively flushing, and not carrying any fruit. The leaves should be mature, fully expanded and representative of the average leaves on the tree. Sample from both the sunny and shaded sides of the trees. The final sample should consist of around 50 leaves. If the leaves are damp at the time of sampling, dry them before placing in a plastic bag for dispatch to the laboratory.

Soil sampling – Mulch and other organic material should be swept to one side before taking the sample. Do not sample directly into any soil where there are visible fertiliser residues left on the soil surface. Use a corer or extract a profile of soil to a depth of 15cm from halfway between the trunk and the dripline of the tree. Each core is known as a 'sub-sample' – mix the sub-samples together thoroughly before placing a blended 500 g sample in the sample bag. The more sub-samples that are taken, the more representative the final sample will be.

Table 1: Target Soil and Leaf Nutrient Levels

Target Soil Nutrient Levels

pH	H_20	5.8 – 6.5
P	Olsen	11 – 29
K	mg/kg	200 – 400
Ca	mg/kg	1000 - 3000
Mg	mg/kg	100 - 400
Na	mg/kg	0 – 90
Zn (Melich 3)	mg/kg	10 - 50
B (Melich 3)	mg/kg	4 - 6
K	% of cation ratio	4 – 8
Ca	% of cation ratio	60 – 75
Mg	% of cation ratio	15 – 20
Na	% of cation ratio	0 - 2

Target Leaf Nutrient Levels

N	%	2.4 – 2.6
P	%	0.08 – 0.15
K	%	0.75 – 1.15
Ca	%	1.2 – 2.0
Mg	mg/kg	0.4 – 0.8
S	mg/kg	0.2 – 0.6
Zn	mg/kg	25 – 100
Mn	mg/kg	50 – 250
Fe	mg/kg	50 – 150
B	mg/kg	30 - 70
Cl	mg/kg	<0.25
Cu	mg/kg	10

EFFECTIVE AND EFFICIENT FERTILISATION

Efficient and effective management practices which support increased productivity and reduced input costs can be achieved if focus is given to the critical aspects of production.

To be efficient in fertilization, identify how much the tree needs of each element (N, P, K, Ca, Mg, Zn, B) in accordance with what the tree is producing (crop load/estimate) versus what the tree has available (identified through the soil/leaf analysis results). An estimate of the elements removed by the crop can be calculated by multiplying your orchard's crop load in tons per hectare by the kg removed per ton found in Table 3 (West et al, 2022). Accurately fertilise and apply only what is needed in order to reduce waste and minimize the risk of compromising post-harvest fruit quality. Application amounts of N, P and K should be within the ranges in Table 2.

To be effective in fertilization, ensure each of the specific elements is applied at the correct phenological event (Figure 15; Phenology, Page 3).

Table 2: Application rates for the crop load on your trees (N, P, K)

kg / ha	**5 T**	**10 T**	**15 T**	**20 T**	**25 T**	**30 T**
N	10 - 60	30 - 80	50 - 100	70 - 120	90 - 140	110 - 160
P	0-5	0-10	0-15	0-20	0-25	0-30
K	20-40	40 - 80	60 - 120	80 - 160	100 - 200	120-240

Table 3: Average Nutrient Removal NZ (West et al, 2022)

Nutrient	kg removed per 10 T/ha	kg removed per ton
N	27.1	2.71
P	4.1	0.41
K	44.5	4.45
Ca	1	0.1
Mg	2.7	0.27
S	3.5	0.35
Zn	0.060	0.006
Mn	0.018	0.0018
Fe	0.063	0.0063
B	0.226	0.0226
Cu	0.028	0.0028

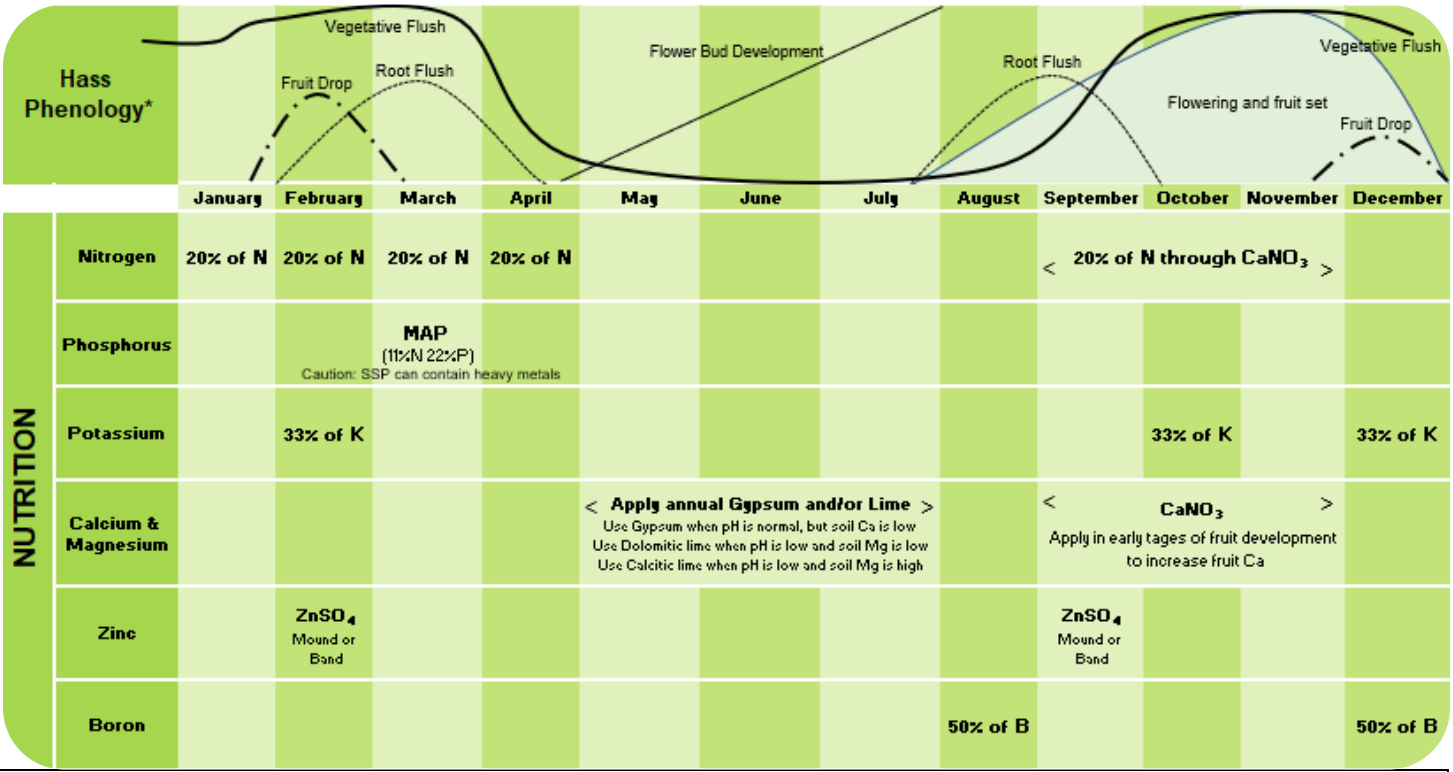
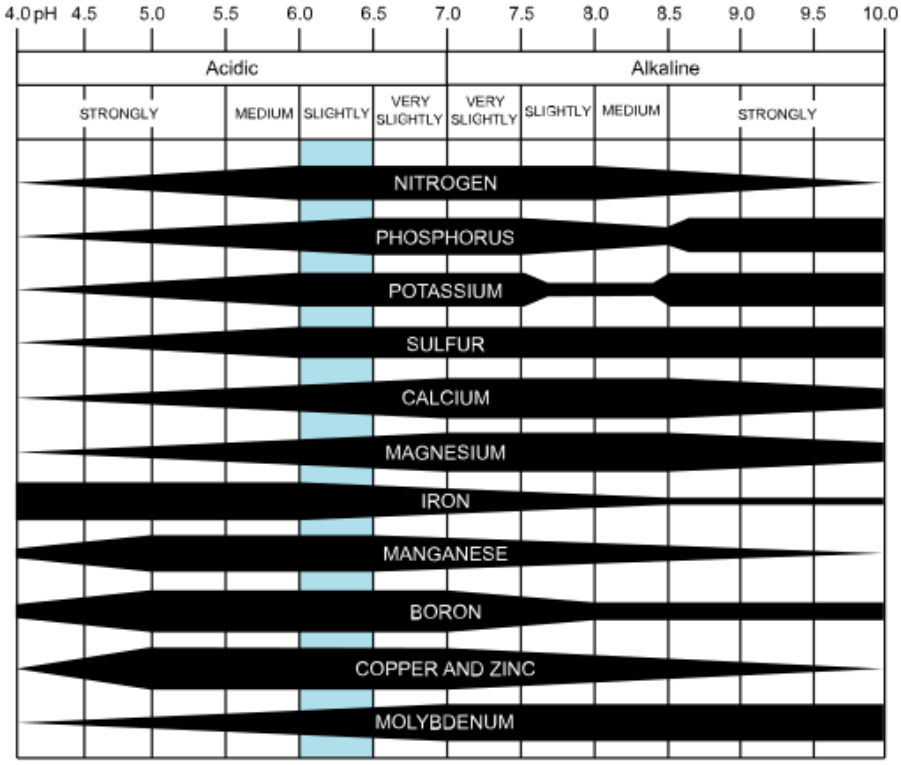


Figure 15: Hass phenology and fertiliser timing

**Months are an indication only. Phenological events may shift in timing due to climatic effects.*

SOIL PH

Soil pH has an impact on the availability of nutrients.



Calcium can be used to adjust the pH of the soil if low (Ideal range 5.8 – 6.5)

- Calcitic lime : Ca only and adjusts pH
- Dolomitic lime : Ca + Mg and adjusts pH
- Gypsum : Ca only and does not influence pH

NUTRIENT INTERACTIONS

Elements in the soil interact with one another (Appendix 2: Mulders Chart of soil nutrient interactions).

NITROGEN

Nitrogen is an important macro-nutrient required for vegetative growth and maintaining tree health; however, it must be noted that this can be at the detriment to fruit quality.

- Nitrogen is the key element for vegetative growth.
- Referred to as the 'manipulator element'.
- Increases vegetative growth at the expense of reproductive growth (temporarily).
- Good leaf cover favors energy production for fruit development.
- Split applications of fertiliser biased post fruitset.
- Too much N applied at the wrong time can induce fruit drop.
- Deficiency seen as pale green or yellow leaves.

Do not apply greater than 160 units of N/ha/year. This is in order to not exceed the crop removal factor in line with the crop load and considering available N from soil organic matter, etc.

Nitrogen has an influence on the movements of other nutrients, such as calcium; if a high amount of nitrogen is applied in the incorrect time of the tree's phenology, it can create a strong vegetative flush which acts as a strong 'sink' and will pull the available calcium into the leaf, at the detriment of the fruit. This creates a dilution effect of calcium within the fruit during development and will lead to a higher potential for weak cell wall and cell membrane structure. The result is a higher probability for cell collapse within the skin and flesh when exposed to the cold chain and will limit shelf life of the fruit. Symptoms will exhibit as chilling injury on the skin as cells collapse and blacken due to stress under cooling. Internally, the flesh may develop grey pulp which is due to polyphenol oxidase leaking from cell membranes and oxidizing. This becomes more prevalent as fruit age increases post-harvest.

PHOSPHOROUS

If levels of P are sufficient, do not apply.

- Important for development of roots, flowers and fruit due to the involvement in cell division.
- If deficient seen as red/purple leaves, small trees and misshaped fruit
- Avocados are naturally low P scavengers.
- Usually a single application is sufficient. Many orchards will never require a P application.
- Timing of application is during root flush to help uptake into tree.
- Very slow-moving element in soil profile and in tree.
- P sources have risk of heavy metal contamination (rock phosphate).
- High P levels can create post-harvest quality issues.

POTASSIUM

- Important for fruit development / size.
- Application after fruit set.
- Apply in 3 split applications biased towards early fruit set.
- Important not to use KCl as avocados are very sensitive to Cl and salinity.
- Best products to use are Potassium Sulphate (K_2SO_4) or Potassium Nitrate (KNO_3).

CALCIUM

Available calcium is required to ensure cell wall development and integrity, so application of calcium nitrate should be applied at early fruit set and through early fruit development to ensure uptake into fruit whist it is a strong 'sink'. Application of calcium nitrate once the fruit is in its plateau stage of development would not see the same effect.

- Calcium is very important for the cell wall strength, fruit size and post-harvest quality.
- Application should be done just prior to or at very early fruit set.
- Shown to help with suppression of Phytophthora root rot.
- Calcium nitrate is key to ensuring Ca is readily taken up/available to the tree during flowering and early fruit set.

MAGNESIUM

- Important component in chlorophyll molecule, therefore photosynthesis.
- Role in enzymes to stimulate normal growth.
- Deficiency seen as interveinal chlorosis.
- Not commonly an issue but soils high in calcium could create issues.
- Single application of MgSO4 usually sufficient to get back into balance.

BORON

- Important for flower development and fruit set.
- Very narrow optimal range. Becomes toxic or deficient very easily.
- Deficiency symptoms include small holes in leaves (Figure 16).
- Common products are organibor, solubor and boronate.
- Can include in foliar sprays during flower as ‘short term fix’.

Figure 16: Boron deficiency 'shotholes'

ZINC

- Important for shoot and leaf development.
- Deficiency symptoms include stumpy growth and curled leaves.
- Very difficult to achieve uptake into trees.
- Heavy interaction with P and Ca (need at least a 2-month gap in applications).
- Apply Zinc Sulphate in mounds / banded around drip zone.
- Can include a chelated Zn in foliar sprays to attempt short term uptake.