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Crop Nutrition: It's not just NPK

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Background

Too often when fertigation schedules are drawn up the main focus is on nitrogen, phosphorus and potassium. Naturally they are the main macro elements required in large quantities for tree growth and crop production however there are also other macro and micro elements that are required in varying quantities. When a basic nutritional analysis is performed, a number of elements are included in the report. These are: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sodium (Na), Chloride (Cl), Zinc (Zn), Manganese (Mn), Iron, (Fe), Copper (Cu), Boron (B) and Sulphur (S). Nitrate-N (NO3-N) is often included in a typical nutritional analysis. A previous All About Almonds fact sheet titled "Crop Nutrient Removal" outlined how to take fruit samples at harvest and compared the nutrient inputs and fruit removal from the ABA's three commercial demonstration sites. That fact sheet highlights the need for the tree to have access to at least the same amount of each nutrient as is removed from the orchard in the form of fruit together with some extra to allow for root and shoot growth, as well as losses incurred during application (leaching or nutrients being locked-up in the soil). An extra 20-30% above the fruit removal is often considered adequate. There are reservoirs of some nutrients in soil minerals which can keep the trees supplied for many years, whereas some are only available in limited amounts or are easily lost from the soil profile.

Fruit sampling and analysis

During the 2010/11 and 2011/12 seasons fruit samples were collected every fortnight from three Riverland orchards, from fruit set through to harvest. The samples were sent to the lab for nutrient analysis and the amount contained in the whole crop was then compared to the cumulative fertiliser inputs as the season progressed. More details of this fruit nutrition comparison can be found in an up-coming fact sheet.

The comparison of inputs (fertiliser) and outputs (fruit) at harvest for the two seasons is shown in Table 1 and 2. In almost all cases the amount of fertiliser applied was greater than the amount removed in crop exported from the orchard. The only exceptions to this were Grower 3 applying less potassium than was removed and Grower 2 applying less phosphorus than was removed during the 2010-11 season (Table 1). All fertiliser inputs were higher than the crop removal during 2011-12 for all growers (Table 2). Naturally almond trees need more nutrient inputs than just what is removed from the crop. Nutrients are used and recycled in leaves, stored in the wood of the trunk and branches etc, lost in the soil through leaching, locked up in the soil or potentially lost to the atmosphere, especially in the case of nitrogen through volatilisation. Nutrients are also exported from the orchard through the removal and burning of prunings.

Table 1: Fruit nutrient removal at harvest 2011 (all units in kg/Ha)

	Grower 1			Grower 2			Grower 3		
Yield	1,876			3,001			3,985		
	Removal	Input	+/-	Removal	Input	+/-	Removal	Input	+/-
N	111.21	266.22	+	145.03	220.25	+	209.12	246.59	+
P	14.67	49.75	+	18.65	12.46	-	23.77	34.51	+
K	149.89	398.67	+	207.93	255.35	+	217.87	201.68	-
Ca	9.62	0	-	13.31	0	-	16.65	0	-
Mg	8.44	0.09	-	10.59	0	-	14.01	0.03	-

Table 2: Fruit nutrient removal at harvest 2012 (all units in kg/Ha)

	Grower 1			Grower 2			Grower 3		
Yield	3,433			2,850			3,379		
	Removal	Input	+/-	Removal	Input	+/-	Removal	Input	+/-
N	169.89	319.18	+	144.76	269.64	+	193.58	261.81	+
P	25.16	49.75	+	8.52	21.34	+	6.31	14.38	+
K	209.69	576.00	+	177.07	273.16	+	195.04	229.82	+
Ca	20.46	0	-	11.74	25.83	+	12.24	0	-
Mg	15.33	0.11	-	5.57	0	-	5.31	0.05	-

Table 3: Fruit nutrient removal at harvest plus 20% to allow for root, shoot growth etc, 2011 (all units in kg/Ha)

	Grower 1			Grower 2			Grower 3		
Yield	1,876			3,001			3,985		
	Removal	Input	+/-	Removal	Input	+/-	Removal	Input	+/-
N	133.45	266.22	+	174.03	220.25	+	250.94	246.59	-
P	17.61	49.75	+	22.38	12.46	-	28.52	34.51	+
K	179.86	398.67	+	249.52	255.35	+	261.45	201.68	-
Ca	11.54	0	-	15.97	0	-	19.98	0	-
Mg	10.12	0.09	-	12.71	0	-	16.81	0.03	-

Table 4: Fruit nutrient removal at harvest plus 20% to allow for root, shoot growth etc, 2012 (all units in kg/Ha)

	Grower 1			Grower 2			Grower 3		
Yield	3,433			2,850			3,379		
	Removal	Input	+/-	Removal	Input	+/-	Removal	Input	+/-
N	203.87	319.18	+	173.71	269.64	+	232.30	261.81	+
P	30.19	49.75	+	10.22	21.34	+	7.57	14.38	+
K	251.63	576.00	+	212.49	273.16	+	234.05	229.82	-
Ca	24.56	0	-	14.08	25.83	+	14.69	0	-
Mg	18.40	0.11	-	6.69	0	-	6.38	0.05	-

How much extra nutrient is needed to allow for use by the rest of the tree and to take account of losses within the production system? As already mentioned an extra 20-30% above the level of fruit removal is considered to be adequate. Tables 3 and 4 show the crop removal figures in kg/Ha after they have been increased by 20% for all growers and both seasons. A quick comparison now highlights that Grower 3 is close to maintaining a balanced supply/demand of nutrients and Grower 1 is applying more nutrients than is removed (N.B. Grower 1 is part of a high input trial, hence the high rates of nitrogen and potassium). Grower 2 sits somewhere in the mid range, inputs are higher than the crop removal but not excessively.

What happens if my inputs are vastly higher than the crop removal?

The short answer is that the nutrients will accumulate in the soil for future use or if they are in a highly mobile form e.g. nitrate-N, they can be leached from the root zone. The complex answer involves your cash flow budget and a look at the health status of your orchard. Applying vastly higher nutritional inputs than the tree needs may not result in extra yield (i.e. the results of the three fertiliser rates at the CT Trial) but will certainly be an added expense which in turn affects the bottom line of your business. In a normal season an average yielding tree will be carrying enough crop to keep itself in balance i.e. not too vegetative but 'just right'. However if the yields are low, as the almond industry has experienced over the last two seasons, the crop levels may not be high enough to keep the tree in balance. There is a strong possibility that the tree can become too vegetative. Normally extra growth is considered a good thing, growth equals buds equals crop, right? Wrong! If the tree becomes too vegetative the balance is lost and fruitfulness will decline due to increased shading within the canopy, poor flower bud development and eventually shoot death in the lower part of the tree. Light and moderated tree stress is needed for bud differentiation which is naturally achieved by maintaining a healthy cropping/vegetative ratio i.e. a tree that's in balance. It's a principle that is widely adhered to in the summer fruit industry; tree vigour needs to be controlled to maintain adequate yields. If your projected yields are light and the spring growing conditions are favourable for vegetative growth (e.g. the mild, wet springs of the previous two seasons) it may pay to reduce the rates of fertiliser applied to match tree demand. There will be an economic benefit in the short term and hopefully tree performance benefits for the following season.

What about the calcium and magnesium?

You will notice in the nutrient balance tables (Tables 1 to 4) I have included the crop removal figures for calcium and magnesium. Most of the focus so far has been on the application and removal of nitrogen, phosphorus and potassium but calcium and magnesium are also considered to be important macro elements. In each of the tables the level of nutrient removal of calcium and magnesium is almost as high as phosphorus. Most orchards include phosphorus applications in their fertigation plan (e.g as MAP) but historically very few have included dedicated applications of calcium and magnesium. The small amount of magnesium applied by Grower 1 and 3 is due to the inclusion of Ferti-mix at 2-6kg/Ha as part of their respective fertigation programs. This still falls well short of the crop removal target. Grower 2 has applied calcium nitrate at a rate of 22kg/Ha in 2011-12 which has met the required removal target.

Why should calcium and magnesium be taken into account when budgeting your annual fertiliser needs and why is it important for tree growth? Calcium is required for growth and function of root tips and is also a component in the cell walls of leaves. Calcium is also thought to be good for soil structure; maintaining soil stability and encouraging earthworm activity which in turn can maintain natural aeration of the soil. Calcium is immobile in plants and deficiency symptoms can occur in rapidly growing shoots. Calcium also makes up a large part of the exchangeable cations in soil. Soils with a calcareous carbonate layer (i.e. rubble layer) may be thought to be high in calcium but in the plant rootzone (generally the topsoil) of sandy soils that have a low cation exchange capacity, the levels of calcium might be low. The cation exchange capacity is important as it is a measure of soil structure and the ability to store nutrient cations (e.g. calcium, magnesium, potassium, as well as sodium). Sandy soils tend to have a lower CEC and clay soils a higher CEC but this can be altered significantly by humified organic matter. Soil calcium levels may also be low due to high applications of nitrogen.

Magnesium is also a vital element in plant health primarily as a component of chlorophyll, but with many other roles.

Chlorophyll is the pigment in plants that is responsible for capturing light energy in the process of photosynthesis. Up to 20% of the magnesium required by plants is used for chlorophyll production. Magnesium uptake is influenced by the levels of nitrogen and potassium; high potassium levels can reduce the uptake of magnesium while increased nitrogen levels will increase plant demand for magnesium.

Unless soils are strongly acid, there is some doubt how much calcium and magnesium will be needed, but it has been observed in both the CT Trial data and routine sampling of soil under drippers in commercial orchards it may not take many years of heavy nitrogen feeding for soil acidification to occur on our lighter sandy soils. It is thought once the natural buffering capacity is weakened soil pH can decline rapidly, especially with heavy use of ammonium forms of fertiliser.

Some final thoughts

It is worthwhile to consider reviewing your fertiliser program and matching it to your projected yield for the coming season. Taking fruit samples at harvest to calculate a fruit removal budget would be a valuable first step. *Details on how to do a fruit removal budget can be found in the Crop Nutrient Removal fact sheet or by contacting me at the Almond Board office.* The main objective is to regulate your fertiliser inputs according to yield and vigour to keep the tree in balance. By doing this you optimise your chances of growing an economically and sustainable crop.

Don't forget the calcium and magnesium! Both of these are still considered macro elements and should be incorporated into your fertiliser program if native soil reserves are insufficient. They might be used in smaller quantities than nitrogen and potassium but both play important roles in basic plant functions as well as maintaining the cation exchange capacity and pH levels. Another suggestion is to take a composite soil sample from a representative patch to have it nutritionally analysed. A typical test will give the results of macro and micro nutrients, organic matter, cation exchange capacity and exchangeable cations, pH, and salinity and may include recommendations on what the desired levels should be. The results might also give an indication of any changes needed to your current fertiliser program.

However, some words of caution:

- The standards against which soil tests are measured are not accurately calibrated for almonds and some assumptions must be made by experienced consultants when they are used.
- There are no good examples of trial work to show which approaches to calcium or magnesium feeding are best suited to our current production system.
- Fertigation has been widely used in glass houses for many years. Calcium nitrate is a good source of soluble calcium and has been widely used in fertigation, but it has two disadvantages. It is deliquescent (i.e. it takes up moisture from the air and therefore must be handled carefully) and it cannot easily be used mixed with soluble phosphorus fertilisers unless care is taken to avoid an insoluble precipitate of calcium and phosphate.
- The story with magnesium is less clear. Epsom salts (magnesium sulphate) is sufficiently soluble, but incompatible with calcium in mixes.
- Chloride forms of both calcium and magnesium are quite soluble and have been used, but application of chloride to sensitive species like almonds is not desirable.

Clearly there is room for some detailed investigation of the best approach to take.

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