All About Almonds

Fact Sheet 08 – Crop Nutrient Removal

Welcome to the eighth edition of "All About Almonds", Crop Nutrient Removal. Fact sheets are distributed to almond growers via email and fax, in addition to being made available for download from the almond growers' section of the ABA website: www.australianalmonds.com.au (follow links to the login section of the "industry" page).

The information provided in these fact sheets should be kept confidential.

Background

Historically, fertiliser programs for most horticultural crops have been monitored using leaf analysis at a particular period of the growing season. Whilst this technique has been useful in assessing nutrient status and nutrient levels, it does not either directly indicate the quantity of nutrients required to produce a crop or provide an accurate assessment of the nutrient ratios which the season's fertiliser program should be based around. The more recent introduction of "new" intensive water and fertiliser management systems such as the CT Optimisation Trial and Hydroponic systems has made it possible to adjust fertiliser inputs quite precisely, so understanding how much nutrient is removed when the crop is harvested could be very helpful in setting input quantities and ratios.

Measuring crop removal at harvest could be used three ways:

1. Evaluation of the current season's fertiliser program against a set of standards or past results, the same way leaf analysis is used.
2. Calculating the **minimum** quantity of nutrients required in a fertiliser program to at least replace the nutrients removed at harvest. This could involve the replacement of both macro elements (i.e. N, P, K, Ca, Mg) and micro elements (i.e. Cu, Zn, Mn, Fe and B).
3. Understanding the approximate ratio of nutrients that should be included in the fertigation program

Although an understanding of the composition of the harvested nuts and calculation of nutrient removal provides the manager an important basis for the preliminary design of a fertiliser program, it does have limitations. It does not help us understand; a) when best to apply the nutrients to

match the trees' requirements at the different phenological (development) stages of the growing season, b) how much, or which nutrients are being supplied to the tree from other sources, such as soil mineralisation, c) how much, or which additional nutrients are required to grow new foliage and roots, d) what the inefficiencies and limitations of on-farm fertiliser and water application may be, e) which nutrients are lost through volatilisation, leaching below the active root zone or soil fixation, or f) which nutrients are left behind at harvest and stored within the tree. In the future, information on crop nutrient removal will be extremely helpful as the basis of modern, best practice fertiliser programs and after a number of years will allow mangers to benchmark against previous seasons and, estimate the majority of nutrients required to produce a crop and in what ratio.

Until better research information is available, a rough rule of thumb can be used to estimate the additional nutrient required to meet the other growth demands (e.g. foliage and root growth) and losses. Present information would suggest applying further 20-30% to the crop nutrient removal figures.

Methodology

Growers who would like to begin to measure crop removal could use the nut sampling method used on the CT Trial. Samples are collected just prior to **harvest.** The same trees used for leaf analysis are visited and the same sampling criteria are used, that is:

Sampling

- **Small to medium sized trees** - if good light interception is present around the whole tree, the sample should include four fruit (one from each of the north, east, south and west sides of the tree) from twenty to twenty five trees at shoulder height.
- **Large trees or hedgerow plantings** - the sample should include four fruit (two from each side of the tree) from twenty to twenty five trees at shoulder height.
- **A representative area** - Regardless of the situation, the sample should take into account variety (commonly Nonpareil is the only variety sampled), rootstock, age, soil type, topography, etc and avoid diseased, damaged, irregular sized, water stressed fruit, end trees and end rows. Commonly a diagonal transect is taken from one corner of the patch to the opposite corner. In hedgerow plantings an up and back loop through the orchard may be used. The sampling track should be recorded so that the same trees can be sampled each year.

The fruit should be hand cracked by the grower into the three fruit components, husk, shell and kernel (no blanks or part thereof are to be included in the sample) and each sample placed in three separate, well labelled paper bags. The fruit could be analysed as whole fruit but more information such as hull boron levels, nutrient partitioning, etc can be obtained from the separate analysis.

Analysis

The bags should be delivered to the same laboratory used in previous year's fruit or leaf analysis. However, to satisfy quality control or curiosity, additional sub-samples may be sent to another laboratory for cross checking.

Commonly used laboratory:

Geoff Proudfoot
CSBP Soil & Plant Laboratory
2 Altona Street
Bibra Lake, WA, 6163
Phone: (08) 9434 4600

Growers will need to specify to the laboratory that the following tests are required for each sample:

- Wet weight (gm).
- Dry weight (gm).
- Moisture content (%) (Calculated from the above measurements and enabling a comparison against your processor's crack out results. Of course, this comparison needs to be made in reference to stockpiling duration, moisture loss, etc).
- Dry matter production (%) is consequently calculated.
- Full analysis of the sample to include Nitrogen (N%), Phosphorus (P%), Potassium (K%), Sulphur (S%), Calcium (Ca%), Magnesium (Mg%), Sodium (Na%), Chloride (Cl%), Zinc (Zn mg/kg), Manganese (Mn mg/kg), Iron (Fe mg/kg), Copper (Cu mg/kg), Boron (B mg/kg).

Once the data has been received from the laboratory, it is possible to calculate nutrient removal using the sample patch yield result (kg/ha of kernel). It can be entered into the crop nutrient removal section of the "Almond Water Use, Irrigation, Fertiliser and Foliar Spreadsheet" located in the login section of the Almond industry website: www. australianalmonds.com.au. The result will provide an indication of the partitioning of the nutrients within the fruit and the amount of nutrients removed at harvest.

For those who prefer to do their own calculations, the formula for each fruit compartment (i.e. husk, shell and kernel) which are then summed together to provide whole fruit, is simply:

- (Wet weight yield (kg/ha) x % element (wet weight basis)) = kg/ha element removed

Or

- (Wet weight yield (kg/ha) x mg/kg element (wet weight basis))/1,000,000 = kg/ha element removed

Results and Interpretation

There are no conclusive standards for the nutrient analysis of almonds in the literature, however the nutrient analysis data collected over the last few years from the ABA's commercial demonstration sites and from the CT Trial is provided in Table 1 as a guide.

Table 1. 2007/08 and 2008/09 Nonpareil nutrient analysis.

		N (%)	**P** (%)	**K** (%)	**Ca** (%)	**Mg** (%)	**Na** (%)	**Cl** (%)	**Zn** (mg/kg)	**Mn** (mg/kg)	**Fe^** (mg/kg)	**Cu** (mg/kg)	**B** (mg/kg)	**S** (%)
Keane	**Husk**	0.62	0.11	2.40	0.15	0.08	0.10	0.22	25.50	14.00	161.00	5.95	54.00	0.02
	Shell	0.54	0.03	0.82	0.16	0.03	0.07	0.09	4.00	5.40	55.50	4.70	23.00	0.02
	Kernel	3.85	0.50	0.82	0.25	0.30	0.01	0.05	41.50	27.50	71.00	13.50	20.00	0.15
Jubilee	**Husk**	0.81	0.09	2.75	0.14	0.08	0.01	0.07	20.00	14.50	62.00	4.75	54.00	0.04
	Shell	0.43	0.03	1.40	0.11	0.03	0.01	0.06	5.20	6.35	15.00	4.10	21.00	0.02
	Kernel	3.95	0.54	0.89	0.19	0.28	0.01	0.05	38.00	27.00	50.00	11.50	15.50	0.15
Pearce	**Husk**	1.30	0.14	3.15	0.15	0.07	0.02	0.20	27.00	51.00	232.00	5.10	45.50	0.04
	Shell	0.60	0.03	1.25	0.14	0.03	0.02	0.08	4.10	15.50	83.00	4.40	25.50	0.02
	Kernel	4.10	0.54	0.83	0.23	0.31	0.01	0.05	42.00	42.00	72.50	12.00	19.00	0.17
CT Trial[#]	**Husk**	0.3-0.5	0.02-0.05	1.4-2.6	0.06-0.08	0.02-0.03	0.01	0.03-0.07	30-82	3.2-7.5	29-42	0.8-2.2	28-56	0.01
	Shell	0.3-0.5	0.01-0.02	0.5-1.8	0.05-0.1	0.01-0.03	0.01	0.05-0.07	7.3-15	2.4-8.7	5.1-27	0.9-2.7	11-28	0.01-0.02
	Kernel	1.7-3.4	0.19-0.39	0.34-0.756	0.09-0.2	0.11-0.24	0.01	0.07	19-51	11-37	20-50	3.1-7.9	11-31	0.01-0.13

[#]Due to the increased number of samples and considerable variation in results, a range has been displayed rather than an average.

^Husk Fe levels are normally unusually high due to contamination from the orchard floor (soil) at harvest.

Using the data in Table 1 and the kernel yield results, crop nutrient removal, crop nutrient removal plus 20% and an approximate nutrient balance is provided in Table 2, Table 3 and, Table 4 respectively.

Table 2. 2007/08 and 2008/09 Nonpareil whole fruit nutrient removal (kg/ha).

	Kernel Yield (kg/ha)	Water (ML/ha)	N	P	K	Ca	Mg	Na	Cl	Zn	Mn	Fe^	Cu	B	S
Keane	2,625	9.37	145.82	20.10	179.93	17.64	12.69	7.01	15.83	0.27	0.17	1.25	0.08	0.41	5.42
Jubilee	4,510	16.09	266.32	33.74	340.00	23.81	20.64	1.64	10.16	0.38	0.28	0.87	0.11	0.65	10.52
Pearce	3,977	10.87	247.64	29.28	231.46	20.56	16.36	1.63	14.16	0.32	0.47	1.72	0.09	0.39	9.41
CT Trial#	3,785-4,138	11.10-17.70	95-291	10-27	136-357	8-21	7-17	1-3	5-18	0.5-1.0	0.1-0.3	0.3-1.1	0.02-0.07	0.3-1.3	2-7

#Due to the increased number of samples and considerable variation in results, a range has been displayed rather than an average.

^Husk Fe levels are normally unusually high due to contamination from the orchard floor (soil) at harvest.

Table 3. 2007/08 and 2008/09 Nonpareil whole fruit nutrient removal plus 20%.

	Kernel Yield (kg/ha)	Water (ML/ha)	N	P	K	Ca	Mg	Na	Cl	Zn	Mn	Fe^	Cu	B	S
Keane	NA	9.37	174.98	24.12	215.92	21.17	15.23	8.41	19.00	0.32	0.20	1.50	0.10	0.49	6.50
Jubilee	NA	16.09	319.58	40.49	408.00	28.57	24.77	1.97	12.19	0.46	0.34	1.04	0.13	0.78	12.62
Pearce	NA	10.87	297.17	35.14	277.75	24.67	19.63	1.96	16.99	0.38	0.56	2.06	0.11	0.47	11.29
CT Trial#	NA	11.10-17.70	114-349	12-32	163-428	10-25	8-20	1.2-3.6	6-22	0.6-1.2	0.1-0.4	0.4-1.3	0.02-0.08	0.4-1.6	2-8

#Due to the increased number of samples and considerable variation in results, a range has been displayed rather than an average.

^Husk Fe levels are normally unusually high due to contamination from the orchard floor (soil) at harvest.

Table 4. Nonpareil 2007/08 and 2008/09 whole fruit nutrient balance.

	Kernel Yield (kg/ha)	Water (ML/ha)	N	P	K	Ca	Mg	Na	Cl	Zn	Mn	Fe^	Cu	B	S
Keane	NA	9.37	174.98	24.12	215.92	21.17	15.23	8.41	19.00	0.32	0.20	1.50	0.10	0.49	6.50
Jubilee	NA	16.09	319.58	40.49	408.00	28.57	24.77	1.97	12.19	0.46	0.34	1.04	0.13	0.78	12.62
Pearce	NA	10.87	297.17	35.14	277.75	24.67	19.63	1.96	16.99	0.38	0.56	2.06	0.11	0.47	11.29
CT Trial#	NA	11.10-17.70	114-349	12-32	163-428	10-25	8-20	1.2-3.6	6-22	0.6-1.2	0.1-0.4	0.4-1.3	0.02-0.08	0.4-1.6	2-8

	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	Actual Applied (IN)	**Calculated Removal + 20% (OUT)**	**Balance (+/-)**	**Actual Applied (IN)**	**Calculated Removal + 20% (OUT)**	**Balance (+/-)**	**Actual Applied (IN)**	**Calculated Removal + 20% (OUT)**	**Balance (+/-)**
Keane	240	175	+65	25	24	+1	400	216	+184
Jubilee	320	320	0	50	41	+9	600	408	+192
Pearce	320	297	+23	38	35	+3	500	278	+222
CT Trial#	240-320	114-349	+206 to -109	54	12-32	+22 to -42	400-600	163-428	+237 to +172

#Due to the increased number of samples and considerable variation in results, a range has been displayed rather than an average.

Analysis of the above tables very simply suggests:

- Keane - More nitrogen applied than removed, good balance of phosphorus, more potassium applied than removed
- Jubilee Almonds - Good balance of nitrogen, good balance of phosphorus, more potassium applied than removed
- Pearce - Good balance of nitrogen, good balance of phosphorus, more potassium applied than removed
- CT Trial - Variable.

The variable nutrient removal from the CT Trial compared to the other orchards is difficult to explain and will require further seasons data and investigation. Quite simply, it could be seasonal or sampling variability across the orchard. For example, the three commercial orchards sampling is a result of a bulk sampling procedure and consequently an average of the patch where as the CT Trial results are the range from individual trees with no bulk sampling and averaging.

Each grower's orchard may also have different results due to sampling rigour, a lighter yield, a lower analysis fruit caused by a lighter fertiliser program or different crackout percentages and weights. At this stage we are all feeling our way on how the data should be interpreted, but if all almond orchards included measurements of crop nutrient removal in their yearly monitoring program (for example from one or more representative patches of Nonpareil) it is expect that the usefulness of the data will become evident. The data may slightly vary from one patch to the next but this tool will provide a good basis on which to formulate a strategic fertiliser program from one year to the next. Further analysis of future crops, including traditional leaf analysis, and the use of other tools such as soil sampling and soil solution extractors will not only fine tune the total nutrient requirements of an almond orchard but also the timing of nutrient applications and in what ratios.

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