Kenya Avocado Industry Support Project (KAISP)

Technical Note 6: Introduction to Plant Nutrition of Avocado

RA Fullerton[1], RM Gentile[2]

[1] The New Zealand Institute of Plant and Food Research Ltd, Auckland

[2] The New Zealand Institute of Plant and Food Research Ltd, Palmerston North

April 2024

CEC	Base sat.	Nitrogen			Phosphorus				Potassium	
		Soil	Soil	Leaf	Soil	Soil	Soil	Leaf	Soil	Leaf
		Total	Available		Olsen	Meh.	Total ???			
me/100g	%	%	kg/ha	%	mg/L	mg/L	mg/kg	%	me/100g	%
12-25	60-85	0.3-0.6	100-150	2.4-2.9	25-50	55-110	?	0.12-0.18	0.5-0.8	0.9-1.2
20	60			1.8	9	3		0.08	0.94	0.8
15		0.30					254		0.65	
15	34			1.9	4	<1		0.08	0.39	0.6
18		0.33					353		0.74	
16	50	0.22	25		8				1.15	
15	37			1.4	2	<1		0.07	0.24	0.5
16		0.31					214		0.67	
18	52			1.7	3	<1		0.08	0.89	0.7
17		0.30					322		0.72	
23	18	0.51	59		11				0.67	
23	18	0.5	93	2	8			0.09	0.36	0.7
21	19			1.8	9	6		0.1	0.54	1
11		0.50					508		0.44	
25	80	0.3	106		116				2.5	
24	79	0.27	88	2.2	67			0.1	3.79	0.9
22	63			2	6	37		0.08	1.95	1.1
19		0.33					325		0.81	
20	63	0.23	45		9				0.57	
15	44	0.24	92		5				0.52	
22	71	0.23	33	2	6.5			0.1	3.05	1

1 What elements do plants need for healthy growth?

The chemical elements needed by plants fall into two groups:

1. Elements required in large quantities are termed **macronutrients** or major elements.
2. Elements essential for healthy growth but needed in very small quantities are termed **microelements** or trace elements. Excesses of some microelements can be damaging to the plant.

Macronutrients / major elements

These are elements that are required in large quantities by plants.

You can remember them by:

'Charlie Hopkns Café (is) mighty good' = C H O P K N S Ca Fe Mg

Carbon (C)	The chemical backbone of all organic material. The only source of carbon for plants is carbon dioxide (CO_2) in the atmosphere (approximately 0.04%) and which is captured by the plant during photosynthesis**.**
Hydrogen (H)	A fundamental element in organic molecules and all organic reactions such as photosynthesis and respiration. Obtained primarily from water. Used in synthesis of sugars by photosynthesis and later conversion to starches, celluloses, lignins (wood) and for breakdown of sugars to release energy
Oxygen (O)	A vital element in plants. Major component of nucleic acids (DNA, RNA), cell membranes, essential for all metabolic processes in cells involving energy transfer. Readily translocated within the plant and deficiency shows first on lower leaves. Deficiency often shows as reddening of leaves and stems
Phosphorus (P)	A vital element in plants. Major component of nucleic acids (DNA, RNA), cell membranes, essential for all metabolic processes in cells involving energy transfer. Readily translocated within the plant and deficiency shows first on lower leaves. Deficiency often shows as reddening of leaves and stems.
Potassium (K)	Important in formation of proteins and carbohydrates and involved in regulation of plant processes including water regulation by opening and closing stomata. Important in leaves and growing points. Deficiency seen as dieback of growing points and often yellowing and death of margins of leaves (marginal necrosis).
Nitrogen (N)	A major constituent of compounds in the plant including cytoplasm, proteins, and chlorophyll. Nitrogen is the element required in greatest quantity by plants and is often the most limiting element in plant production. Deficiency is typically seen as slow growth and yellowing of plants. Nitrogen is translocated from old to young

	leaves and often lower leaves will be yellow while leaves closer to the growing point are green.
Sulphur (S)	Important in proteins, vitamins, formation of chloroplasts and in photosynthesis. Does not move in plants so deficiency often seen as yellowing of younger tissues and stunted growth.
Calcium (Ca)	Has a range of functions in metabolism. Major constituent of cell walls, important in cell division and elongation. Is not translocated readily within plants. Deficient plants often have weak root systems. Blossom end rot in tomatoes and other fruits is the result of calcium deficiency.
Iron (Fe)	Often classified as a minor element. Important in photosynthesis. Deficiency seen as interveinal chlorosis with network of green veins.
Magnesium (Mg)	The core element of the chlorophyll molecule. Also vital to many metabolic reactions in the plant. Readily translocated in the plant so symptoms show first on older leaves. Typical symptoms are a green inverted V extending up the midrib from the petiole with yellowing of the margins and tip of the leaf.

Micronutrients/minor elements (trace elements)

These elements are essential for healthy plant growth but are required only in very small amounts (trace amounts = trace elements)

Copper (Cu)	Important for photosynthesis.
Zinc (Zn)	Important in enzymes. Typical symptoms of deficiency are clusters of small, yellow leaves at the growing points ('little leaf')
Manganese (Mn)	Essential for photosynthesis and chlorophyll formation. Deficiency symptoms typically show as irregular yellow patches between veins on leaves.
Molybdenum (Mo)	Important in nitrogen metabolism and formation of proteins.
Boron (B)	Important for a wide range of metabolic functions in the plant. Affects cell division and structure of cell walls with consequent effects on plant growth, flowering and fruiting. There is a fine line between B deficiency and B toxicity in the plant. In soils with high pH, boron can become attached to other soil minerals in clay soils and become unavailable to plants. Low pH releases boron into the soil solution but it is then prone to leaching. Deficiency is often seen as cracks and corky areas on petioles and midribs of leaves, deformed fruit and corky tissues in fruit. A very important trace element for avocado.
Sodium (Na)	Important for a particular form of photosynthesis (C4 plants). Not normally deficient.

Aluminium (Al)	More often concerns from aluminium toxicity than deficiency, particularly at low pH. Excessive Al in the soil affects cell division and elongation of root tips leading to stunted root systems and poor uptake of nutrients and water.

2 Where do plant nutrients come from?

Plants obtain mineral nutrients naturally by uptake from the soil solution by roots. Sources of these nutrients in soil include:

- Decomposition of plant residues, animal remains, and soil microorganisms
- Weathering of rocks and soil minerals
- Fertiliser applications
- Fixation of atmospheric nitrogen by legumes
- Atmospheric deposition, such as nitrogen and sulphur from acid rain or nitrogen fixation by lightning discharges
- Deposition of nutrient-rich sediment from erosion and flooding.

Trace elements are also obtained naturally from the soil.

Many macro- and micronutrients can be absorbed through the leaves as specially formulated foliar fertilisers.

3 How are nutrients held in soil?

Soil is typically composed of mixture of inorganic and organic material. The inorganic component consists of a mixture of solid particles of differing sizes ranging from stones down to coarse gravel, fine gravel, coarse sand, fine sand, silt and clay. The inorganic material is mixed with organic matter derived from decomposing plants and animals, and inhabited by a vast population of living organisms of different sizes (e.g earthworms, insects, nematodes, bacteria, fungi, archaea).

The proportions of inorganic particles of various sizes determine what we commonly call ‘soil type’. For example sandy soils, silt soils, clay soils, heavy clays.

In a well-drained soil, the individual particles are surrounded by a thin film of water with air in the spaces between the particles. Plant nutrients are found in the water films and attached to the soil particles. Nutrients in the soil water are available for uptake by plant roots via their root hairs. Nutrients in soil water are at risk of being washed out of the soil during heavy rain – a process called leaching.

Clay particles and humus (decomposed organic matter) have the ability to attract and hold many nutrients onto their surfaces. For that reason soils with a high clay or humus content, under natural conditions, are typically more ‘fertile’ than sandy, gravelly or stony soils.

The elements in the soil solution are in the form of ions. Ions are molecules that carry a minute electric charge. The charge can be either positive (cations) or negative (anions).

The clay and humus particles naturally carry a negative charge on their surfaces. Positively charged cations are attracted to the negatively charged clay and humus particles and are firmly held on their surfaces. There, they are protected from being washed out of the soil and are a reserve of plant nutrients in the soil. As the concentration of nutrients in the soil solution drops (as a result of plant uptake or leaching), ions are released from the clay and humus particles and move into the soil solution thus replenishing the supply available to the plants.

Thus cations can move from the soil solution to clay particles and vice versa. This is called cation exchange. For example if the fertiliser calcium nitrate is applied to the soil, the $Ca(NO_3)_2$ molecules are first converted to the ions Ca^{++} and NO_3^-. The positively charged calcium ions are attracted to the negatively charged clay particles and held on clay particles. The negatively charged nitrate ions are not attracted to the clay particles and remain in the soil solution. They are immediately available to plants but can be easily leached from the soil.

Some common cations are: K^+, Mg^{++} Na^+, H^+, Ca^{++}. Al^{+++}, NH_4^{++}. The higher the clay and humus content of soil, the more cations that can be held and exchanged between particles and soil solution. This is called the Cation Exchange Capacity (CEC) of the soil – the higher the CEC the more cations of different kinds that can be held. Clay soils with a high CEC are typically much more fertile and productive than sandy soils that typically have a low CEC.

Some anions are $(NO_2)^{--}$, $(NO_3)^-$, $(BO_3)^{---}$, $(SO_4)^{--}$, Cl^-, $(H_2PO_4)^-$, $(HPO_4)^{--}$, $(PO_3)^{---}$

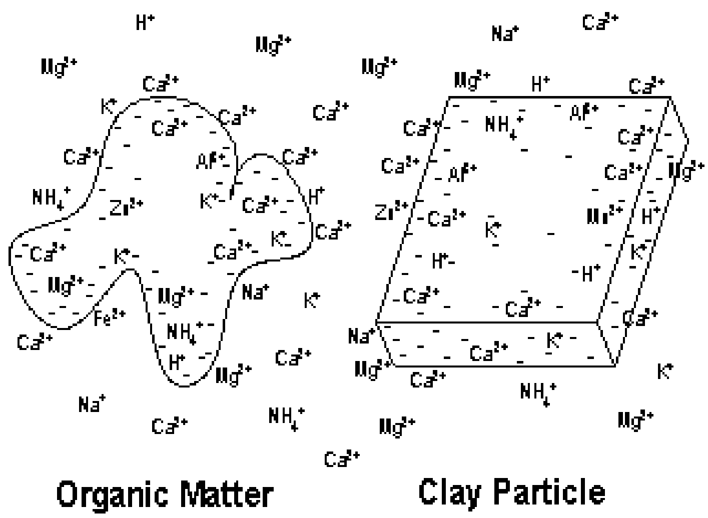

Figure 1. Cations and anions in organic matter and clay particles

4 How are nutrients lost from the soil?

Nutrients are lost from the soil in a number of ways.

1. **In plant material.** Nutrients are taken up by plants and removed from the farm in plant products e.g. fruit and vegetables harvest, firewood. This is a major cause of loss of fertility of soils. If the nutrients removed in crops arer not replaced, the fertility of the soil will drop. The soil is then regarded as being ‘degraded’.

2. **Leaching.** Nutrients dissolved in water that moves down through the soil or out of the field in subsurface drains.

3. **Surface runoff water.** Loss of dissolved nutrients in water moving across the soil surface.

4. **Erosion.** Loss of nutrients in soil that is removed from fields by wind or water movement.

5. **Gaseous losses to the atmosphere.** Different forms of nitrogen lost directly from the soil through volatilization and denitrification

5 The Nitrogen Cycle

Nitrogen is one of the most common elements and the one needed in greatest quantities by plants. It is also the one most often deficient in plant production. Although air is 78% nitrogen it is not available directly to plants.

Nitrogen, like most other elements, is readily cycled from the soil through plants, animals and microorganisms and returned to the soil in organic matter. As the organic matter is broken down by microbes, the nitrogen is released firstly as the ammonium ion (NH_4^{++}). That process is called **ammonification**. Most plants cannot absorb nitrogen in the ammonium form. But being a cation it attaches to clay and humus and in that state is protected from being leached out. Other specialised soil microbes can convert the ammonium firstly to nitrite (NO_2^-) then to nitrate (NO_3^-) which is the form most often taken up by plants. The process of converting ammonium to nitrite and finally nitrate is called **nitrification**.

The overall process of converting nitrogen from an unavailable form in organic matter to inorganic nitrogen available to plants is called **mineralisation**.

But remember nitrite and nitrate are ‘anions’ that carry a negative charge. They are not held on the negatively charged clay particles. So when nitrogen is in the form that is readily taken up by plants (nitrate form) it is also in a form able to be readily leached from the soil. This is one reason why nitrogen is so often limiting in soils. Some soil microorganisms can also utilise nitrate and convert it to nitrogen gas which is then released to the atmosphere. This process is called **denitrification**.

Atmospheric nitrogen can be converted to a form available to plants by a group of specialised bacteria (*Rhizobium species*) that live in symbiotic association with the roots of legumes. They form nodules on the roots and are able to ‘fix’ nitrogen from the atmosphere and make it available to the plant. This capability makes legumes one of the most valuable plants in farming systems for naturally increasing nitrogen content of soils.

Atmospheric nitrogen can be converted directly to nitrites by events such as lightning strike. Some fre-living soil bacteria can also directly convert atmospheric nitrogen to nitrites and nitrates. In terms of plant nutrition the nitrogen contributed of both these systems is small.

Synthetic fertilisers e.g. sulphate of ammonia, ammonium nitrate, calcium nitrate and urea are the most common means of providing additional nitrogen for crop growth. However they cannot be used for organic production and alternative sources must be found.

Under organic management systems one effective option for supplying nitrogen is the use of legumes as a ground cover in orchards and which fix atmospheric nitrogen in a form readily available to plants.

6 Nutrient removal and replacement in avocado orchards

Analysis of avocado fruit shows that each 1000 kg of fruit removed from an orchard removes Nitrogen 3 kg; Phosphorus 0.5 kg; Potassium 5 kg.

Thus large quantities of nutrients are exported annually from high producing orchards. To maintain soil fertility and productivity these losses as well as losses from leaching must be replaced annually

Under conventional production systems these losses can be readily replaced by the use of synthetic fertilisers at rates calculated to return the quantities removed in the crop plus an estimate for leaching losses. This will sustain the long-term fertility and productivity of the orchard.

Under organic production systems, options for nutrient replacement are limited to plant organic matter and animal manures. The ‘average’ composition of composted animal manure in the Central Highlands is:

Nitrogen %	0.75
Phosphorus %	0.20
Potassium %	0.89

Thus; the amount of cattle manure required to replace exported nutrients in 1000 kg fruit is:

Nitrogen 400 kg/year; Phosphorus 250 kg/year; Potassium 560 kg/year.

A 250 kg cow producing 1550 kg manure per year will theoretically be able to supply nutrients to the following number of medium-sized trees yielding 100 kg/year:

Nitrogen to 39 trees; Phosphorus to 62 trees; Potassium to 28 trees.

(This does not include potential losses from leaching and erosion)

The maintenance of fertility of soils used for long term organic production is an ongoing challenge particularly as any imported organic material used for composting should itself conform to organic production standards. In addition if the soils on which the organic material for mulching is deficient in particular elements the plant material will also be deficient in those elements. Thus if the soil on which organic material for composting is sourced is deficient in particular elements the compost will also be low in those elements.

7 Soil and Leaf analysis for Nutrition Management

Chemical analyses of soil and leaves are the most common methods of determining the nutrient status of soil and deficiencies that are likely to affect crop production. The nutrient status of soils is relatively stable and can normally only be changed significantly by nutrient additions over a considerable period of time. Therefore soil analyses are normally carried out to provide a broad picture of the nutrient status of soils in an area and to identify elements that are in good supply and those that will have to be supplemented. Soil analyses do not need to be carried out often.

Leaf analyses provide immediate information on the nutrient status of the plant and show which elements are good supply and those that are deficient at any particular time.. This is a much more valuable tool for managing crop nutrition. Because the cycling of nutrients from the soil to the plant is quite rapid, nutrient deficiencies in the plant can be detected and corrected quite quickly. Regular leaf analysis will allow the effect of corrective actions to be monitored over time until the concentrations of different elements in the plant can be brought into the 'normal' or optimum range for that plant species.

8 Soil and Avocado Leaf Analysis in Central highlands

As part of the Kenya Avocado Industry Support Programme, a programme of soil and leaf analysis was carried out on a number of avocado orchards covering a range of soil types and altitudes in Muranga'a county.

A sample of test results is shown in Table 1.

Preliminary interpretation of Kenya soil analysis data

pH	pH variable between areas. A trend for lower pH (more acidic soils) at higher altitudes. Some soils are quite acidic and production may benefit from liming to raise pH.
Organic matter/carbon	As expected quite low. A trend for higher OM/C with higher elevation in the Kandara valley is evident from the sites sampled.
C/ N ratio	Low OM and generally low N means C/N ratios look reasonable but not a very strong position. A trend for higher C/N with elevation in the Kandara valley follows the trend of higher OM/C.
Cation Exchange Capacity (CEC)	Relatively high CEC is indicative of clay content of those soils. Able to retain cations and maintain high fertility with appropriate fertiliser use.
Base cation saturation (BS)	Quite different between sites and on this limited data set correlates closely with soil calcium. There are quite strong positive relationships between pH, base saturation, Ca, Mg and K. Soils with lower pH have lower base saturation and hence lower availability of the cations. It is difficult to distinguish any trend across zones due to the limited number of sites sampled.
Nitrogen	Generally low soil concentrations as could be expected after generations of cropping and very little being returned. A similar trend for higher total N with high elevation in the Kandara valley. Concentrations of N in leaves are low.
Phosphorus	Very low in all sites, as in common in E. African soils. Low soil P is reflected as low P in leaves. A high degree of unavailability of P in those soils is made worse by high Fe, relatively high Al, and low pH all of which would contribute to 'locking it up' and not able to be accessed by plants. P availability could be slightly improved by increasing pH.
Potassium	Generally well supplied in soil but leaf levels slightly low in some samples. May be some effect of quite high soil magnesium levels.
Sulphur	Some slightly low leaf levels. Symptoms typical of S deficiency can be seen on leaves of banana in the mid-altitude of the Kandara valley.

Calcium	Low/very low in some of the sites, adequate in others but probably not a direct nutritional issue as leaf levels were high throughout. However soils would benefit generally from liming to ameliorate pH, assist in cation balance and to reduce potential for Mn toxicity. As noted, soil Ca was related to soil pH and base saturation.
Magnesium	Quite high across most samples which is also reflected in high leaf levels. High Mg concentration could potentially affect K uptake.
Sodium	Low – no problem
Iron	Generally high in soil and also reflected in high leaf levels. No direct nutritional problems likely but may be an issue reducing P availability at low pH.
Manganese	Very high approaching extreme levels in soil and plants. Some leaf levels are likely to be in the toxicity range for avocado. May need to look out for Mn toxicity in orchards.
Zinc and Copper	Both well supplied and should be no problems with these elements. This is fortunate for organic producers as these two elements are frequently deficient in many soils and deficiencies would be very difficult to correct organically.
Boron	Very low in all soils tested. Surprisingly, concentrations in leaves, while low, are not excessively low except in one case were B was virtually non-existent in soil Typical deficiency symptoms in avocado are holes in leaves as the result of abnormal leaf blade formation. However that symptom is difficult to discriminate from leaf damage caused by scarab beetles. In general there are no obvious signs of widespread boron deficiency in the central highland orchards. Plants are apparently able to uptake adequate boron for normal growth.
Cobalt	Irrelevant in terms of avocado nutrition.
Aluminium	Moderate levels in soils tested. Could be having a role in phosphorus tie-up in soils with low pH soils
Chloride	Low. No problems anticipated.

Table 1 Sample of results of soil and leaf analysis in Muranga'a County, Kenya

Soil and Leaf Analysis Kenya 2014

Colour code:
- Very high (blue)
- High (yellow)
- Medium (green)
- Low (red)
- Very low (pink)

County	Orchard	Owner	Variety	Date	Sampled	Lab	pH	OM	Carbon	C/N Ratio	CEC	Base sat.	Nitrogen			Phosphorus				Potassium	
													Soil	Soil	Leaf	Soil	Soil	Soil	Leaf	Soil	Leaf
													Total	Available		Olsen	Meh.	Total???			
								%	%		me/100g	%	%	kg/ha	%	mg/L	mg/L	mg/kg	%	me/100g	%
						Medium range	6.0-6.6	7-17	4-10		12-25	60-85	0.3-0.6	100-150	2.4-2.9	25-50	55-110	?	0.12-0.18	0.5-0.8	0.9-1.2
	F01-078- S3/L3			Dec-14	JC	Hills	5.9				20	60			1.8	9	3		0.08	0.94	0.8
	078/S3			Dec-14	JC	Soil Cares	5.0	5.7	3.3	11.1	15		0.30					254		0.65	
	F01-078- S4/L4			Dec-14	JC	Hills	5.1				15	34			1.9	4	<1		0.08	0.39	0.6
	078/S4			Dec-14	JC	Soil Cares	4.9	6.3	3.64	11.1	18		0.33					353		0.74	
	F01-431 S			Mar-14	AB	Hills	5.4	4.2	2.4	10.8	16	50	0.22	25		8				1.15	
	F01-431-S1/L1			Dec-14	JC	Hills	5.2				15	37			1.4	2	<1		0.07	0.24	0.5
	431/S1			Dec-14	JC	Soil Cares	4.9	5.9	3.4	11.2	16		0.31					214		0.67	
	F01-431-S2/L2			Dec-14	JC	Hills	5.6				18	52			1.7	3	<1		0.08	0.89	0.7
	431/S2			Dec-14	JC	Soil Cares	4.9	5.8	3.4	11.2	17		0.30					322		0.72	
	F01-651 A S			Mar-14	AB	Hills	5.3	10.9	6.3	12.5	23	18	0.51	59		11				0.67	
	F01-651 B S/L			Aug-14	AB	Hills	5.0	9.7	5.6	11.3	23	18	0.5	93	2	8			0.09	0.36	0.7
	F01-651-S5/L5			Dec-14	JC	Hills	5.1				21	19			1.8	9	6		0.1	0.54	1
	651/55			Dec-14	JC	Soil Cares	4.2	8.6	5.0	10.0	11		0.50					508		0.44	
	F02-001 A			Mar-14	AB	Hills	6.3	5.1	3.0	10.1	25	80	0.3	106		116				2.5	
	F02-001 B S/L			Aug-14	AB	Hills	6.4	4.7	2.7	10	24	79	0.27	88	2.2	67			0.1	3.79	0.9
	F02-001-S6/L6			Dec-14	JC	Hills	6.0				22	63			2	6	37		0.08	1.95	1.1
	001/56			Dec-14	JC	Soil Cares	5.2	7.0	4.1	12.3	19		0.33					325		0.81	
	F02-007			Mar-14	AB	Hills	5.6	5	2.9	12.8	20	63	0.23	45		9				0.57	
	F02-189 S			Mar-14	AB	Hills	5.1	4.6	2.7	11.1	15	44	0.24	92		5				0.52	
	F02-368 S/L			Aug-14	AB	Hills	6.5	4.1	2.4	10.3	22	71	0.23	33	2	6.5			0.1	3.05	1
	F03-011 S			Mar-14	AB	Hills	6.3	4.1	2.4	12.8	18	78	0.19	39		10				1.86	
	F04-019A S			Mar-14	AB	Hills	6.2	5.4	3.1	10.9	23	23	0.29	110		6.2				1.37	
	F07-16 S			Mar-14	AB	Hills	6.3	5.8	3.4	11.3	24	82	0.3	92		12				1.31	
	F07-034			Mar-14	AB	Hills	5.3	4.5	2.6	9.8	19	53	0.26	117		15				1.1	
	F07-059			Mar-14	AB	Hills	6	5.8	3.4	9.3	24	75	0.36	112		6				3.23	

Orchard	Sulphur		Calcium		Magnesium		Sodium		Iron		Manganese		Zinc		Copper		Boron		Cobalt		Aluminium		Chloride	
	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf	Soil	Leaf		Leaf
			me/100g	%	me/100g	%	me/100g	%	mg/L	mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/L	mg/kg	mg/kg	mg/kg	mg/L	mg/kg		%
Medium range		0.2-0.3	7.0-18.0	1.2-2.0	1.0-3.0	0.30-0.55	0.0-0.50	0.00-0.25		40-100	50-400	80-300	2-10	25-50	1.0-5.0	5-15	4.0-6.0	30-50	2-4					0.0-0.25
											M 8-35		M 5-15		M 2.0-5.0		M 2.5-4.5				M 900-1300			
F01-078- S3/L3	-	0.21	7.6	2.43	3.21	0.68	<0.05	-	M 67	136	M344	1490	M 6.8	36	M 2.5	7	M 0.65	20	M 1.3		M 1050			<0.05
078/S3			6.2		2.74																			
F01-078- S4/L4		0.17	3	2.24	1.79	0.67	<0.05		M 65	215	M274	1830	M 2.84	26	M 1.8	8	M 0.55	22	M 1.6		M 1231			<0.05
078/S4			4.4		1.34																			
F01-431 S			4.5		2.39		<0.05		276		1538		15.1		8.4		1.3		9.4					
F01-431-S1/L1	-	0.21	3.2	2.46	2.35	0.73	<0.05	-	M 74	136	M 427	2300	M 4.2	48	M 0.9	5	M 0.52	25	M 1.1		M 1209			<0.05
431/S1			4.4		2.24																			
F01-431-S2/L2	-	0.2	5.1	2.21	3.37	0.72	<0.05	-	M 68	167	M394	2100	M 8.93	45	M 1.6	7	M 0.37	23	M 1.0		M 1081			<0.05
431/S2			3.9		1.48																			
F01-651 A S			6.1		1.58		<0.05		244		100		5.4		1.7		1.1		0.3					
F01-651 B S/L		0.17	3.1	2.42	0.7	0.48	<0.05		292	157	77	610	3.9	29	1.5	7	0.8	25	0.3					0.08
F01-651-S5/L5		0.16	2.6	2.34	0.73	0.44	<0.05		M 92	203	M 14	750	M 1.62	24	M 0.5	7	M 0.26	27	M <0.1		M 1646			<0.05
651/55			2.7		1.00																			
F02-001 A			12.6		4.84		<0.05		231		1887		61.2		4		1.8		2.3					
F02-001 B S/L		0.18	10.8	1.94	4.59	0.68	0.003		207	148	1836	1520	47.7	34	3.5	9	1.7	27	2.1					0.14
F02-001-S6/L6		0.16	8.3	2.13	3.44	0.76	<0.05		M 71	210	M 390	1840	M 20.8	41	M 1.8	7	M 0.90	18	M 0.8		M 901			
001/56			11.5		3.42																			
F02-007			7.4		4.32		<0.05		195		1928		16.4		2.4		1.5		4.6					
F02-189 S			4		1.92		<0.05		263		541		4.7		4.3		1.2		2.2					
F02-368 S/L		0.18	9.5	2.14	3.26	0.76	<0.05		167	76	1953	1490	36.3	30	2.8	6	2	17	3.4					<0.05
F03-011 S			8.5		3.52		0.1		161		1530		8.5		1.7		1.2		6.2					
F04-019A S			11.6		4.01		<0.05		311		1275		30.6		25.6		1.5		3					
F07-16 S			13.5		5.2		<0.05		194		1380		29.4		3		1.7		6.5					
F07-034			5.8		2.96		<0.05		346		1556		9.9		9.8		1.5		11.8					
F07-059			9.8		4.57		<0.05		179		2280		83.3		4.7		2		5.3					

For further information please contact:

RA Fullerton
Plant & Food Research Auckland
Private Bag 92169
Auckland Mail Centre
Auckland 1142
NEW ZEALAND

Tel: +64 9 925 7000
Email: bob.fullerton@plantandfood.co.nz