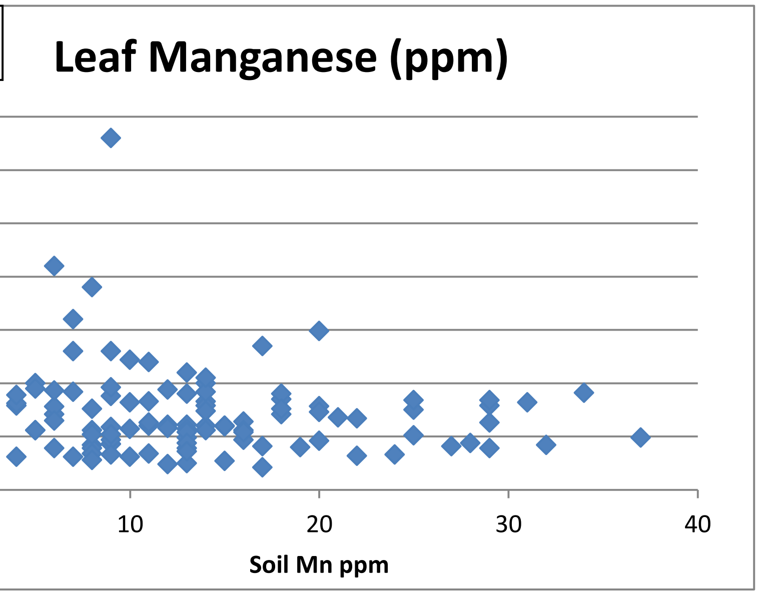
Study Manganese and Iron Uptake By Actinidia Cheninsis
On Kerikeri High Iron (Ferralitic) soil.

Manganese (Mn) uptake by Kerikeri kiwifruit orchards appears to be very erratic and it does not have any significant relationship to the soil test values for manganese (See figure 1).

Figure 1



Hills Laboratory Guide for advisors presents the normal spring leaf manganese range for kiwifruit as between 50 & 100ppm. Figure 1 certainly shows several cases that are below the normal range and two or three cases that may be into the toxicity range. Table 1 (Data 2002 to 2013) shows 11 out of 15 orchards have suffered from manganese deficiency and two of those orchards also suffered from toxicity in other years. If we were to just take the mean average data over the years we would not see a great problem unless of course you were not grower "J" however with the economic orcharding situation in recent years growers just cannot afford to have "Off years" and manganese deficiency is certainly a likely cause for an off year especially when considering highly probably effects on Fruit Dry Matter percentage.

Table 1	Kerikeri Kiwifruit Leaf Manganese levels by orchard														
Grower	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Mean	97	89	71	55	64	88	61	87	48	38	60	62	65	68	86
Min	39	39	31	21	27	31	39	37	39	34	56	60	41	54	28
Max	190	160	130	149	105	330	100	135	56	43	63	64	85	76	210
Range	151	121	99	128	78	299	61	98	17	9	7	4	44	22	182
	Deficient		Toxicity?												

When considering supplying nutrients with fertilisers many take a simplistic approach where if you have a certain soil test value then you can make a fertiliser recommendation purely based on that value. When it comes to Iron (Fe) & Mn, that approach does not work and applying solid Fe and Mn fertilisers is very costly and rarely effective because the applied fertilisers rapidly oxidise to the non-available form.

In the soil Fe & Mn both exist in several forms and there is a continuous cycle of change between the oxidised and reduced forms depending on soil moisture and oxygen content and according to rainfall and irrigation. Oxidised ferric iron (Fe^{3+}) is typically red like the soils of Pukekhoe due to the haematite content and is sparsely plant available. Conversely the ferrous iron (Fe^{2+}) is grey/blue/green like the wet soils of the Hauraki plains Readily plant available. Reduced manganous Mn (plant available) is in the (Mn^{2+} form and when it is oxidised to the manganic form it is the Mn^{4+} State. In some regions there are high levels of Mn in the soil and in the Cambridge area we see small up to 0.5cm black cubes of manganese oxide. With the oxidation state of manganese being so important soil drainage and seasonal rainfall are key issues. The pH of the soil is also a well know key issue effecting Fe & Mn oxidation, however we have found recently that

the effect is more the other way round, the wetting or drying of the soil with the two way changes between ferrous & ferric is actually controlling the soil pH.
Because Iron and manganese gain entry into the root through the same molecular porthole we also need to consider the effects of ionic competition.

The Bi-plot

To identify how all these complex factors interact we have used a powerful statistical tool call the Biplot, it takes ever data point for every factor and considers how they relate to each other.
The key factors that our Biplot included:
Rain Fall September & October combined (average of 7 years).
Leaf water content (average of 41 composite samples of 32 to 40 leaves) leaves sampled late October.
Leaf Iron content.
Leaf Manganese content.
Soil pH
Soil Iron Mehlich extraction (Mainly ferrous)
Soil Manganese Mehlich extraction (Mainly Manganous)

Table 2. Biplot Summary Data

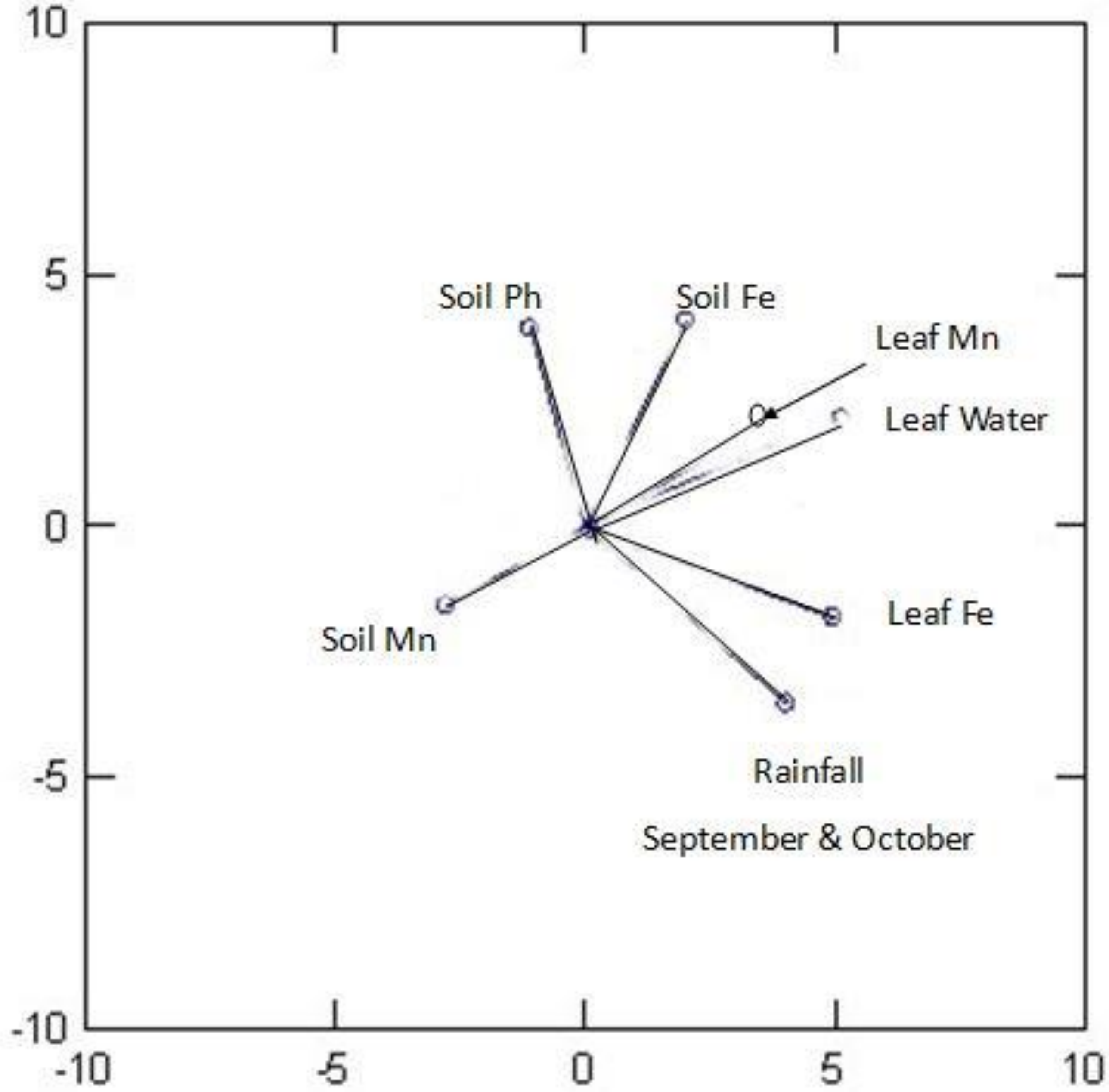
	Leaf Water	Leaf Iron	Leaf Manganese	Soil pH	Soil Iron	Soil Manganese	Rain March	Rain April	Rain Sept	Rain Oct
Unit	Percent	ppm	ppm	Log 10	ppm	ppm	cm	cm	cm	cm
Mean	72,48	75,31	71,40	6,17	115,84	13,95	111	136	121	67
Sdev	3,30	23,65	41,93	0,21	32,21	7,36	83	57	25	20
Cases	41	117	117	127	127	127	7	7	7	7

To produce a plot where all the components can interact on an equal footing; each data point was transformed to Standard deviation scaled data with the following equation.

$$\frac{Raw\ data\ Point\ Value - Mean\ average\ for\ that\ Element}{Standard\ Deviation\ for\ that\ element}$$

1. Once the entire data set has been transformed all the data has similar values yet each data point retains its relativity to the others of that same element.
2. Although the initial view of the Bi-plot may look complex, in reality it is very simple.
3. The length of each line represents the strength of influence that that factor has.
4. If two lines extend in the same direction closely then they closely relate to each other and they benefit each other or there is an unmeasured factor that equally affects these two factors.
5. If two lines travel in opposite directions then there is an antagonistic relationship.
6. If two lines are at right angles, then there is either no relationship between those factors or if there is one it is very weak compared to the other factors.

Figure 2 Kerikeri Kiwifruit Manganese Uptake Bi-Plot



Interpretation:

1) Leaf Manganese and soil manganese are very poorly correlated.
2) Leaf Iron and soil iron are weakly correlated.
3) Increasing soil pH results in a reduction of iron uptake (no surprise)
4) Leaf Iron & Rainfall closely correlated (no Surprise)
5) Leaf water and Rainfall are poorly correlated. The unmeasured reason for this has to be root mass.
6) Leaf Manganese and Leaf water are very closely correlated, therefore the key to increasing manganese uptake is to increase root mass.
7) Leaf Manganese and soil pH do not appear to be correlated.
8) Leaf Iron and Leaf Manganese do not appear to be antagonistic.