Field Investigations of Potential Yield Limitations in Fodder Beet Crop Nutrition 2016-17

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Introduction

Due to ongoing instances of large and hitherto unexplained variations in crop performance, we have conducted a series of preliminary investigations in order to identify critical factors that are influencing this variability in fodder beet yields. It is generally observed that high fertility sites such as effluent paddocks are producing much better yields than other sites with various cropping histories. In some instances, site specific soil testing is employed to accurately apply fertiliser at the rate required to meet crop requirement for the expected yield level. This approach has also given sub-optimal yield responses, and nutrient use efficiency has been unsatisfactory. The following is a summary of specific observations made in different crops of beet throughout the 2016-17 season including photos, leaf analysis and soil tests. The crops investigated are all commercial winter green feed productions for direct feeding in-situ across a range of soils, climate and management inputs.

Materials & Methods

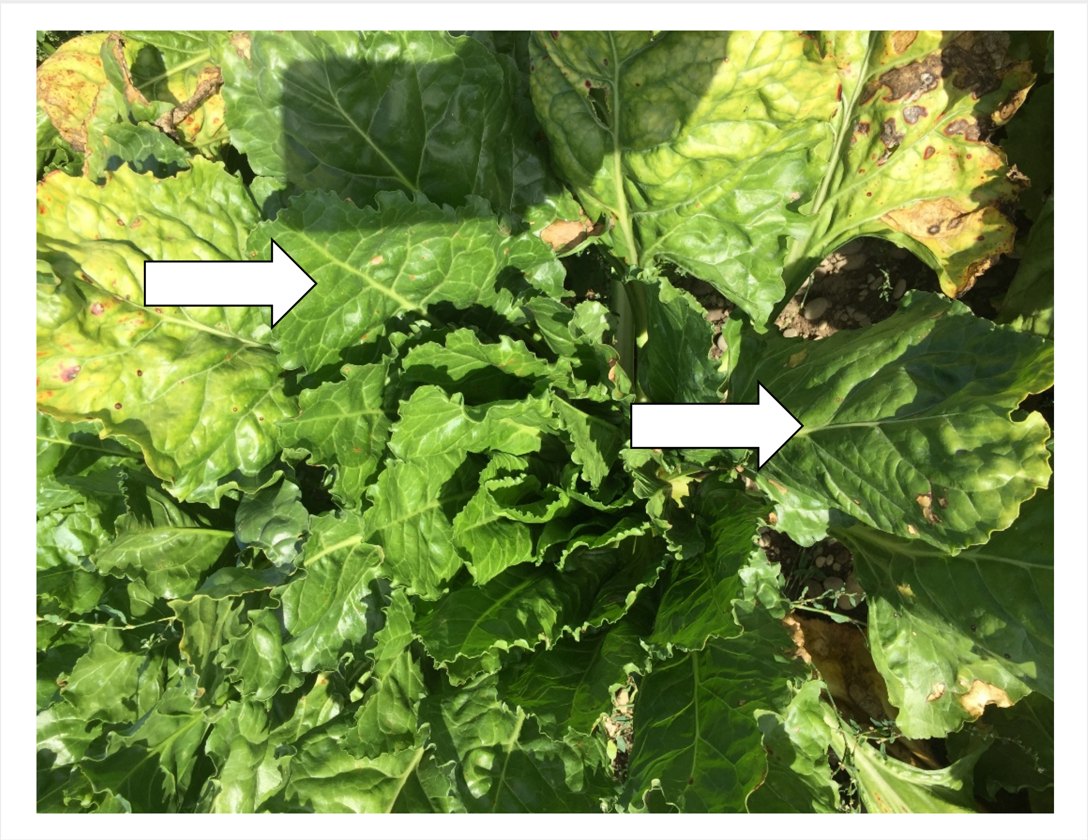
Following small scale topdressing trials in preceding seasons which had shown responses to additional N & K, it was clear that poor crop nutrition was limiting yield.

Other field trials had also previously shown small yield responses to additional applications of magnesium, boron & copper. The fodder beet crops investigated in the 2016-17 season were selected to identify other possible reasons for the large differences yield, both within and between different crops.

The first crop tested in Mid Canterbury was selected to identify any nutritional causes of sporadic chlorosis and premature leaf senescence. The general appearance of the crop canopy was poor, and disease levels were high. *(photo right)*

Two parallel samples from a representative transect across the crop (previous slide) were submitted for laboratory analysis with two leaves being sampled simultaneously from the same plant and submitted separately.

The "Green" sample was taken from the youngest mature leaf (YML) with no visible chlorosis (as indicated by the left arrow). The "Yellow" sample was from the YML showing early stage chlorosis (right arrow).



Example of typical plant as sampled

The Green Sample

The “Green” sample (shown right) was submitted for tissue analysis and the results were then compared to the results from the “Yellow” sample (next slide).

Sample Name: FB Green **Lab Number:** 1747314.1
Sample Type: LEAF Fodderbeet (Mid growth) (P328)

Analysis		Level Found	Medium Range	Low	Medium	High
Nitrogen*	%	4.5	3.5 - 5.0			
Phosphorus	%	0.31	0.30 - 0.60			
Potassium	%	2.9	3.0 - 5.5			
Sulphur	%	0.29	0.30 - 0.80			
Calcium	%	0.69	0.70 - 2.00			
Magnesium	%	0.41	0.30 - 0.80			
Sodium	%	0.990	0.500 - 3.00			
Iron	mg/kg	134	50 - 150			
Manganese	mg/kg	85	35 - 100			
Zinc	mg/kg	31	20 - 50			
Copper	mg/kg	6	5 - 15			
Boron	mg/kg	46	35 - 80			
Molybdenum	mg/kg	0.84	0.20 - 2.0			
Chloride*	%	2.6	0.50 - 2.0			

The Yellow Sample

Sample Name: FB Yellow

Sample Type: LEAF Fodderbeet (Mid growth) (P328)

Lab Number: 1747314.2

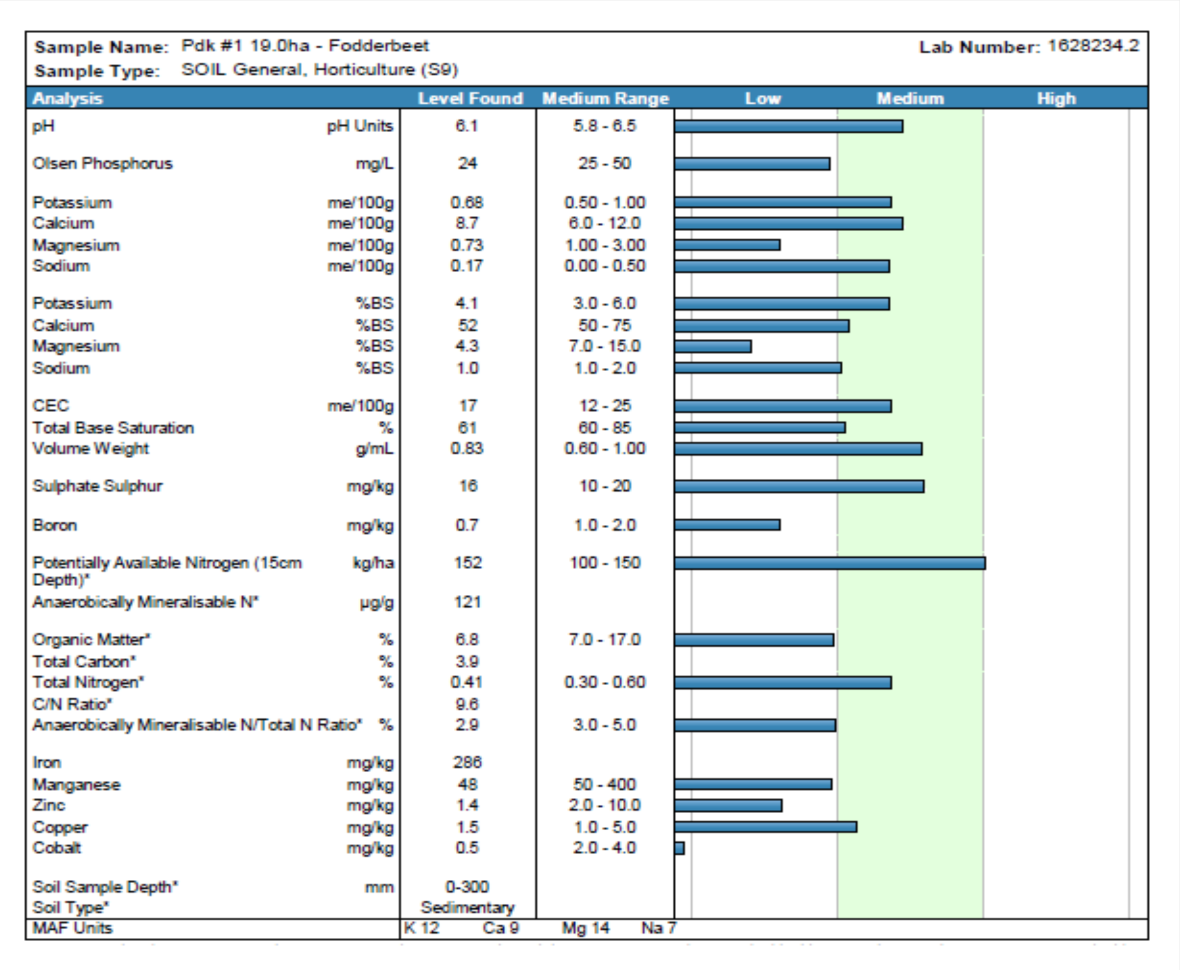
Analysis		Level Found	Medium Range
Nitrogen*	%	3.3	3.5 - 5.0
Phosphorus	%	0.15	0.30 - 0.60
Potassium	%	2.0	3.0 - 5.5
Sulphur	%	0.29	0.30 - 0.80
Calcium	%	1.41	0.70 - 2.00
Magnesium	%	0.84	0.30 - 0.80
Sodium	%	1.150	0.500 - 3.00
Iron	mg/kg	155	50 - 150
Manganese	mg/kg	150	35 - 100
Zinc	mg/kg	25	20 - 50
Copper	mg/kg	3	5 - 15
Boron	mg/kg	55	35 - 80
Molybdenum	mg/kg	1.02	0.20 - 2.0
Chloride*	%	3.0	0.50 - 2.0

The Results

The Yellow sample has a chloride level of 3%, and the Green is slightly lower at 2.6 %. Between the 2 leaves sampled from the same plant there is an increase in chloride from Green to Yellow of 0.4%.

It can also be clearly seen that there is a much lower level of N P K & Cu in the yellow sample when compared to the green sample. This reduction in other leaf nutrient levels is greater than that expected from normal healthy leaves of the same physiological age difference and may well indicate that there is an antagonism due to the elevated chloride level which is preventing normal assimilation of other nutrients in this crop.

This site had also been soil tested prior to drilling in September 2016 (opposite). However chloride was not included in this soil test as it must be specifically requested. Total chloride applied pre and post planting was approx. 375 kg/ha.



Sample Name: Pdk #1 19.0ha - Fodderbeet — **Lab Number:** 1628234.2
Sample Type: SOIL General, Horticulture (S9)

Analysis		Level Found	Medium Range
pH	pH Units	6.1	5.8 - 6.5
Olsen Phosphorus	mg/L	24	25 - 50
Potassium	me/100g	0.68	0.50 - 1.00
Calcium	me/100g	8.7	6.0 - 12.0
Magnesium	me/100g	0.73	1.00 - 3.00
Sodium	me/100g	0.17	0.00 - 0.50
Potassium	%BS	4.1	3.0 - 6.0
Calcium	%BS	52	50 - 75
Magnesium	%BS	4.3	7.0 - 15.0
Sodium	%BS	1.0	1.0 - 2.0
CEC	me/100g	17	12 - 25
Total Base Saturation	%	61	60 - 85
Volume Weight	g/mL	0.83	0.60 - 1.00
Sulphate Sulphur	mg/kg	16	10 - 20
Boron	mg/kg	0.7	1.0 - 2.0
Potentially Available Nitrogen (15cm Depth)*	kg/ha	152	100 - 150
Anaerobically Mineralisable N*	µg/g	121	
Organic Matter*	%	6.8	7.0 - 17.0
Total Carbon*	%	3.9	
Total Nitrogen*	%	0.41	0.30 - 0.60
C/N Ratio*		9.6	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Iron	mg/kg	286	
Manganese	mg/kg	48	50 - 400
Zinc	mg/kg	1.4	2.0 - 10.0
Copper	mg/kg	1.5	1.0 - 5.0
Cobalt	mg/kg	0.5	2.0 - 4.0
Soil Sample Depth*	mm	0-300	
Soil Type*		Sedimentary	
MAF Units		K 12 Ca 9	Mg 14 Na 7

Above: Pre-Planting Soil Test Results. Note that K and Na levels are reported as medium, prior to fertiliser application.

The estimated yield of this crop was 25 t DM/ha.

The second crop of Fodder Beet in this investigation was very vigorous and healthy.
The best part of this crop included an area which produced the 14kg bulb (shown right).
The canopy was 900mm tall, very green and almost entirely disease free with minimal senescent leaf.

Healthy vigorous canopy

Large mature bulbs with very few senescent leaves

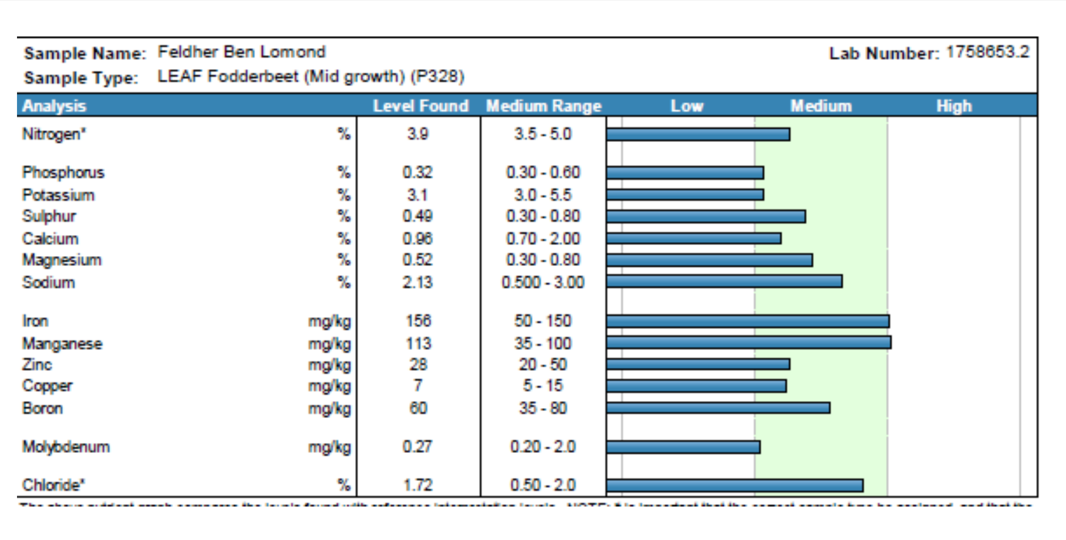
When sampled at maturity, this soil test is showing that the crop has taken up large amounts of soil nutrients and of particular note is the optimal pH, with soil chloride at less than 10 ppm. This crop did not have chloride applied.

Sample Name: Soil Test - Feldherr 300 **Lab Number:** 1758653.1
Sample Type: SOIL General, Horticulture (S9)

Analysis		Level Found	Medium Range	Low	Medium	High
pH	pH Units	6.7	5.8 - 6.5			
Olsen Phosphorus	mg/L	15	25 - 50			
Potassium	me/100g	0.25	0.50 - 1.00			
Calcium	me/100g	9.4	6.0 - 12.0			
Magnesium	me/100g	1.27	1.00 - 3.00			
Sodium	me/100g	0.30	0.00 - 0.50			
Potassium	%BS	1.9	3.0 - 6.0			
Calcium	%BS	71	50 - 75			
Magnesium	%BS	9.6	7.0 - 15.0			
Sodium	%BS	2.3	1.0 - 2.0			
CEC	me/100g	13	12 - 25			
Total Base Saturation	%	85	60 - 85			
Volume Weight	g/mL	1.03	0.60 - 1.00			
Sulphate Sulphur	mg/kg	12	10 - 20			
Boron	mg/kg	1.4	1.0 - 2.0			
Chloride	mg/kg	< 10				
Potentially Available Nitrogen (15cm Depth)*	kg/ha	78	100 - 150			
Anaerobically Mineralisable N*	µg/g	50				
Organic Matter*	%	4.2	7.0 - 17.0			
Total Carbon*	%	2.4				
Total Nitrogen*	%	0.22	0.30 - 0.60			
C/N Ratio*		11.0				
Anaerobically Mineralisable N/Total N Ratio*	%	2.3	3.0 - 5.0			
Iron	mg/kg	551				
Manganese	mg/kg	170	50 - 400			
Zinc	mg/kg	1.7	2.0 - 10.0			
Copper	mg/kg	1.3	1.0 - 5.0			
Cobalt	mg/kg	1.4	2.0 - 4.0			
Soil Sample Depth*	mm	0-300				
Soil Type*		Sedimentary				
MAF Units		K 5	Ca 12	Mg 29	Na 14	

At maturity, this part of the crop was simultaneously sampled for leaf tissue analysis (shown right) as well as the soil nutrients shown on the previous slide.

It is of note that this leaf test is lower in chloride by 1.28% when compared to the first crop sampled. It is also significant that the N, P, K & copper are all approaching optimum levels, and although the chloride in the soil is very low, there has been a significant accumulation of chloride in the leaf tissue over the life of this crop.


Sample Name: Feldher Ben Lomond **Lab Number:** 1758653.2
Sample Type: LEAF Fodderbeet (Mid growth) (P328)

Analysis		Level Found	Medium Range
Nitrogen*	%	3.9	3.5 - 5.0
Phosphorus	%	0.32	0.30 - 0.60
Potassium	%	3.1	3.0 - 5.5
Sulphur	%	0.49	0.30 - 0.80
Calcium	%	0.96	0.70 - 2.00
Magnesium	%	0.52	0.30 - 0.80
Sodium	%	2.13	0.500 - 3.00
Iron	mg/kg	156	50 - 150
Manganese	mg/kg	113	35 - 100
Zinc	mg/kg	28	20 - 50
Copper	mg/kg	7	5 - 15
Boron	mg/kg	60	35 - 80
Molybdenum	mg/kg	0.27	0.20 - 2.0
Chloride*	%	1.72	0.50 - 2.0

Discussion

This investigation gives a very strong indication that chloride toxicity could be leading to yield suppression in Fodder Beet.

Hills data below (Newsletter #31 Sept 2015), indicates high chloride may be prevalent throughout NZ Fodder Beet crops.

	N%	P%	S%	K%	Ca%	Mg%	Na%	Cl%
Tops	3.4	0.29	0.39	3.6	1.08	0.75	1.81	2.5
Bulbs	1.4	0.15	0.08	2.0	0.16	0.14	0.35	0.5

n = ~ 500 for N; ~ 100 for other elements

	Mn** mg/kg	Zn mg/kg	Cu mg/kg	Fe** mg/kg	B mg/kg	Mo mg/kg	Co** mg/kg	Se mg/kg
Tops	240	54	7	320	44	0.51	0.23	0.08
Bulbs	57	28	6	400	13	0.11	0.22	0.02

** trace elements highly variable where soil & fungicide contamination present

Discussion

The following calculation gives an approximate estimate of how much of the total chloride applied would need to be taken up by the crop to produce the average tissue levels shown in the Hills data.

Assuming a total crop yield of 25,000 kg DM/ha of which 15% is comprised of tops:-

- 3750 kg DM in the tops and 21,250 kg DM/ha in the bulbs.
- Average chloride content of the tops at 2.5% = 93.75 kg of chloride/ha (from Hills data.)
- Average chloride content of the bulbs at 0.5% chloride = 106.25 kg chloride/ha (from Hills data.)

This would give a total of 200 kg chloride/ha in the fully grown crop, which in this case would be half of the total amount applied if the crop requires 400 kg/ha K as MOP in the season of production and there is no significant drainage through the soil in that season.

It is of some note that the chloride content of seawater is about 1.94% although inland seas, such as the Mediterranean may be slightly higher than this, sometimes as high as 2.1%.

Given that the beet family is considered to have evolved in a maritime environment, where it has become adapted to saline conditions, it is not surprising that the beet crop has a propensity to shed leaf when chloride levels are elevated.

Discussion

Problems such as poor leaf quality, reduced canopy mass and reduced bulb yield associated with high chloride may possibly arise where crop productions are located in areas where it is necessary to apply capital amounts of Potassium Chloride to meet crop demand for potassium.

Chloride in soils behaves differently to other nutrients. Because it is not strongly held on the soil colloids, it is found mostly in the soil solution unless, or until, it moves below the root zone with drainage. The net rate of decline in soil chloride is therefore controlled by soil type, drainage & irrigation, crop removal and the rate of application plus atmospheric deposition.

In the growing crop, excess chloride accumulates in the distal regions of the leaf, where it can quickly reach toxic levels. Hence we frequently observe significant deterioration in leaf quality in the late summer and autumn beginning with chlorosis and marginal necrosis. In extreme cases, this will often lead to premature senescence and shedding of leaves.

Given that chloride toxicity is not well recognised and must be specifically requested in routine leaf testing, growth responses to additional applied nutrients in remedial topdressings are likely to be less efficient in terms of yield response. This scenario could well lead to an increased risk of losses of surplus nutrient due to chloride antagonism.

Because the visible symptoms of chloride toxicity closely resemble deficiencies of N, P, K & Cu, and because visible responses to the application of these nutrients are possible, better information is required to ensure prudent fertiliser management in fodder beet crops.