agKnowledge
"The Independent Fertiliser Experts"

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SUSTAIN

Ballance's product SustaiN has been the subject of many articles in previous Fertiliser Reviews (see No's 15, 22, 24, 28 and 32). I have been concerned that the scientific evidence does not support the claims being made for this product. Ballance AgriNutrients Ltd are of course aware of my views and late last year suggested that we should 'get together' to see if we could reach a common understanding on the science behind SustaiN. I readily agreed to this sensible and responsible approach, noting that many science disputes arise because the parties are not looking at the same set of data.

To recap, SustaiN is urea treated with the chemical AGROTAIN® (agrotain), which slows down the normal conversion of the urea N (not plant available) to ammonium N and hence to nitrate N, both of which are plant available (see Fertiliser Review 32).

The product was initially introduced onto the New Zealand market by Summit-Quinphos Ltd with claims like ".....on average 50% of the N from urea is lost after application." The implication was that SustaiN was 50% more effective than urea at increasing pasture production (i.e. 50% more dry matter/kg N applied).

Over time Summit-Quinphos became Altum, a subsidiary of Ballance AgriNutrients Ltd, and then Altum was absorbed into Ballance AgriNutrients Ltd.They are not as bullish in their claims about SustaiN as the previous owners. Their recent advertising claims include:

"SustaiN reduces ammonium volatilisation by 50%."
"SustaiN increases the amount of pasture you can grow per unit N applied."
"SustaiN just seemed to have a better response, better growth rates, so we stuck to it. It just grew more grass – for longer." (Comment from a farmer in a Ballance AgriNutrient advertisement)

Effects on Production

At the NZ Grassland Conference 2013, Dr McBride and myself published a summary of the field evidence comparing SustaiN versus urea (see also Fertiliser Review 32). At that time there were 16 field trials conducted in NZ. The average response of SustaiN relative to urea (compared on a absolute production basis –see later) was 4% with a confidence interval of 4%. The range in responses was from -25% to +28% with half the 'responses' being negative (8) and half positive (8).

Thanks to the information supplied to me by Ballance AgriNutrients, there is now a data-base of 105 field trials on pasture (from NZ and overseas) comparing SustaiN (or its equivalent, urea plus agrotain) with urea, at the same rate of N application. From this much larger data-set the average response to SustaiN relative to urea (compared again on an absolute production basis) was 2.3% with a confidence interval of 1.1%, a range of -11% to +24%, with 40 (38%) trials showing a 'negative' effect and 65 (62%) a 'positive' effect.

Understanding variability

To interpret this data we need to understand and appreciate that pasture production is not uniform over space. Not every square metre will give the same yield. To demonstrate the point, lets do a mental experiment. Take an otherwise 'uniform' flat paddock of pasture. Divide that paddock into a 10m x 10m grid covering the whole paddock. In each cell measure the pasture growth with a plate meter, taking 10 random clicks in each cell and carefully recording the average for each cell. From the many estimates of pasture production, calculate the average production of all the cells. By definition 50% of the cells will be lower than the average and 50% will be above.

What you are measuring is the variability – the "background noise" - in pasture production across the paddock.

When comparing the relative effectiveness of two products the same problem exists. We are trying to see if the products are different against this background noise. So what does this 'noise look like'?

An English scientist conducted 67 replicated field trials on a range of crops comparing the effect of a small amount of water, which would have no agronomic effect, with a control (no treatment). The average 'response' (I'm adding parentheses because we know that this amount of water would have no effect), to the water treatment, relative to the control was 0.6%, with a confidence interval of 2.3%. The range in 'apparent responses' was from -22% to +32%, with half the measured 'responses' negative and half positive. Because the amount of water applied in the treated plots was insignificant agronomically we can say that these results are simply reflecting the background noise.

Table 1 compares this background noise with pasture and crop responses to SustaiN, relative to urea for the two data sets referred to above.

Table 1: Comparison of the background noise with pasture and crop responses to SustaiN relative to urea.

Study	Mean response (%)	Confidence interval	Range (%)	Distribution
2013 database (n=16)	4.0	4.0	-25 to +28	50% < 0% 50% > 0%
Recent database (n=105)	2.3	1.1	-11 to +24	38% < 0% 62% > 0%
Background noise (n=67)	-0.6	2.3	-22 to +32	50% < 0% 50% > 0%

As more data comes to hand the various statistics become more accurate. Hence the differences between the 2013 and the current results. Comparing the numbers from the most recent results with the background noise it is noted a) that the confidence interval of 1.1 does not include zero, and b) slightly more of the responses (62%) are greater than zero. Thus, we can conclude that on average, SustaiN (or adding agrotain to urea) has a small effect on pasture production, relative to urea, but it is only just observable over the background noise.

Absolute versus marginal responses

The estimated responses above have been calculated on an absolute basis. That is to say the calculated responses are the difference between the total production from SustaiN minus the total production from urea (expressed as a percentage of the production from urea). There is another way to express these treatment differences, referred to as the marginal response. This takes into account the yield of the control (no treatment) (For a discussion of these two methods see Fertiliser Review No 24). In this case the marginal effect of SustaiN relative to urea is about 5% not 2% (on an absolute basis). It does not matter which approach is adopted providing they are correctly applied when using these estimates (see example below).

Ammonium volatilisation

The chemical agrotain, when added to urea, is claimed to reduce the volatilization of ammonia gas. Once again Ballance AgriNutrients have kindly provided me with their results of research specifically designed to measure this loss. This data suggests that SustaiN reduces volatilization of ammonia from urea by about 50% and that typical volatilisation rates are about 10-20% of the N applied. Can these numbers be reconciled with the pasture production results?

Putting it together

Assume an application rate of urea of 25 kg N/ha. If the N loss via volatilisation is 10-20% of the N applied, then this would represent a total loss of 2.5 to 5.0 kg N/ha. Sustain reduces this loss by 50% (i.e. 1.2-2.5 kg N/ha/ha). Assuming that all this conserved N was taken up by pasture (an unlikely assumption) then this would represent an increase in pasture production of about 30 to 60 kg DM/ha (assuming 4% N in pasture DM). If only half of the conserved N was captured then the estimated increase in pasture production would be 15-30kg DM/ha.

Assume that the effect of urea (25 kg N/ha/application) lasts for 4 weeks and that the pasture growth rate (with 25 kg/ha urea) is about 60 kg DM/ha/day. (i.e. 1800 kg DM/month). Thus, if SustaiN was used in place of urea, the calculated benefit is an extra 30 to 60 kg DM/ha/month. This represents an increase in total monthly production of about 2-4%, consistent with the measured benefit of SustaiN, relative to urea, of about 2%.

[If the marginal response of urea N was 10-20 kg DM/kg N/ha, and the marginal benefit of SustaiN relative to urea is 5%, this would represent an increase in production (from 25 kg N/ha/month) of 12-25 kg DM/month]

There is one further point that must be discussed. The estimated effects of SustaiN, relative to urea, range from -11% to +23% and about 60% of the estimates are > 0 (i.e. they range from 0% to +23%). It is tempting to suggest that the reason for this range in estimated effects is due to the many factors which affect volatilisation of N from urea, and the effects of agrotain, which include: soil organic matter and moisture content, rate of N application and rainfall post application. This may be true but how then can the negative effects (38% of the trials gave negative 'responses') be explained? Since there is no reason to suspect that adding agrotain to urea actually makes urea less effective the only rational reason for the negative effects is the background noise. And if this is accepted, then it must be accepted that this is the same reason for the range in positive responses.

My advice?

The evidence suggest that we are dealing with a product whose effects are small and can only just be seen above the background noise. Expressing this differently the results from the 105 trials indicate a probability of achieving a small benefit from Sustain is 62%. Expressed differently if 105 farmers used Sustain, only 62% would get a small positive benefit.

One important qualification is required. There is a place for SustaiN on crops where large applications (say >100 kg urea/ha/application) are sometimes required.

Acknowledgment

I want to acknowledge the openness adopted by Ballance AgriNutrients to this issue. If only all fertiliser companies would approach their research in the same way.

CAVEATE EMPTOR

I was recently asked to provide expert evidence in a legal dispute. The Plaintiff became convinced by the Defendants that they had the necessary knowledge, skill, and experience to offer appropriate nutrient advice, and the necessary fertilisers and chemicals, that would result in superior yields and better quality, which would give the Plaintiff an edge over their competitors in the production of crops.

The Plaintiff accepted their advice and grew wheat, beans and potatoes. Despite the promises made by the Defendants, the crops were a failure. I was asked to consider the possible reasons for this.

A summary of the typical nutrient inputs recommended for wheat, potato and beans is given in Table 2.

Table 2:Typical inputs of nutrients (kg/ha/yr) recommended for wheat, potato and beans[1]

Crop		N	P	K	S
Wheat	***Typical fertiliser input***	*200*	*20-40*	*0-30*	*15-20*
Potato	***Typical fertiliser input***	*100 - 150*	*ng*[2]	*ng*[2]	*ng*[2]
Beans	***Typical fertiliser input***	*0*[3]	*20*	*70*	*20*

Notes
1) Summarized from Ballance Nutrient Handbook 2003, Managing Soil Fertility on Cropping Farms 2000, Fertiliser Recommendations for Horticultural Crops 2008, Vegetable Growers Handbook 2005.
2) ng = not given.
3) Beans are legumes and fix their own N hence no fertiliser N required.

The Defendants prepared fertiliser schedules for each of 9 different paddocks of wheat, 3 paddocks of beans and 4 paddocks of potatoes. For the wheat paddocks only liquid fertilisers were recommended (i.e. no solid fertiliser as a base) to be applied at specific times during the crop growth phases. For the beans and potatoes some solid fertiliser was applied as a base, together with liquid fertiliser applied during the crop's development.

The Tables (3a to 3c) below summarise the typical total nutrient inputs applied on each crop as recommended by the Defendants.

Table 3: Typical amounts of nutrients recommended by the Plaintiff and applied.

(a)	Wheat - actual nutrient inputs applied (kg/ha)							
	N	**P**	**K**	**S**	**Mg**	**Ca**	**Base**	**Trace elements**
Range (9 sites)	*0.3-1.2*	*0-1.8*	*0.16-0.38*	*1.2-3.2*	*0.83-2.24*	*0.12-0.30*	*nil*	Typically: Zn, Cu, B, Co, Mo, Mn

(b)	Form	Potato – actual nutrient inputs applied (kg/ha)				Trace elements
		N	**P**[1]	**K**	**S**	
Range (4 sites)	***Solid and liquid***	*7.7-49*	*1.8-40*	*195-198*	*130-290*	Typically: B, Mn, TE mix[2]

Notes 1) Total P applied as Viaphos, a slow release P fertiliser (45% available P).
2) content not specified.

(c)	Form	Beans – actual nutrient inputs applied (kg/ha)				Trace elements
		N	P[1]	K	S	
Range (3 sites)	*Solid and liquid*	*0.7 – 3.4*	*0 - 10*	*0 – 0.3*	*0 - 121*	Typically: Mo, B, Mn, TE mix[2]

Notes 1) total P applied as Viaphos a slow release P fertiliser (45% available P).
2) content not specified.

Comparison of the typical nutrient inputs required for good crops of wheat, potato and beans (Table 2) with the actual nutrient inputs (Table 3) show that the advice offered by the Defendants was inadequate.

Lessons to be learnt

1. Be wary of salesmen who have no formal qualifications in soil fertility and plant nutrition.
2. Be wary if the salesman says he has new ideas about crop nutrition and new types of fertiliser products.
3. If in doubt seek professional advice.

CHANGES TO THE FAIR TRADING ACT

I have argued elsewhere that fertilisers, and this includes those products referred to variously as soil additives, tonics or amendments, are different from most consumer products. Once the product is applied to the soil there is no way for a farmer to know with certainty if the product is working as claimed. For example after the application of such products, pasture or animal production may well increase, but is this because the product is effective, or was it a better growing season, maybe the stock and pasture management policies where changed or the insect pressure or worm burden was less? Maybe the farmer simply got his A-into-G and farmed more conscientiously. The list of possible factors that can mask the farmer's assessment of a given product can be long indeed. It is for this reason that anecdotal evidence is no evidence at all. In addition, if a farmer believes the product did not work he/she cannot take it back!

The other problem that arises in the process of the sale and purchase of fertilisers and related products is that there is an imbalance of information. Farmers do not have, and cannot be expected to have, the knowledge or information to evaluate the claims made by proprietors about their products.

It is precisely for these reasons that changes have been made to the Fair Trading Act, which came into force in July 2014. These changes will, I believe, have a major positive impact on the marketing of fertilisers and soil amendments in New Zealand.

Under the amended Fair Trading Act, "it is now illegal to make a representation about a good or service without any reasonable basis. What this means is that businesses that make claims or imply something about their goods or services must have reasonable grounds for making those claim."

"Reasonable grounds can come from: information provided by a reputable suppliers or manufacturers, information the business making the claims hold, or any other reasonable source (for example, scientific or medical journals)."

"Importantly, a business must have reasonable grounds *at the time* (my emphasis) they are making the claim." It appears that gathering data to support a claim after it is made will not be sufficient.

"There is no precise test for what constitutes reasonable grounds. The nature of the goods and services and of the claim itself will influence what type of substantiation is required to support a claim."

[The quotes above are from the Commerce Commission Fact Sheet on unsubstantiated representations. See www.comcom.govt.nz/fair-trading-act-fact sheets/unsubstantiated-representations]

Burden of Proof

These changes shift the burden of proof from the Commerce Commission to the business making the claim. In the past the Commerce Commission had to prove beyond reasonable doubt that claims made for goods and services were false. Now it is up to businesses to prove the claims they make for their products.

This makes sense to me at least in the world of fertilisers. Too many products have been launched onto the New Zealand market-place in recent years without any or very little research to support their claims.The sometimes extravagant claims made in the past for new-age fertilisers like EcoN, LessN and SustaiN are examples (see Fertiliser Review 28). In some cases, when I have challenged proprietors about their products – do they work? – I am met with the argument that 'we do not have funds for research so we have to rely on feed-back from the market.' Why should the farmer be used as a 'guinea pig' and in any case, for the reasons given above, the farmer has no way of objectively determining whether a product is effective.

How might these changes be applied?

Table 4 below records a random collection of claims made about various fertiliser products. Let's assume that the Commerce Commission is asked whether these claims breached the Fair Trading Act? Can they be substantiated? The Commerce Commission in considering size and importance of the fertiliser industry to New Zealand agriculture decides that a high standard - the science standard - should be set in terms of defining 'reasonable grounds'. They therefore seek the professional advice from an independent scientist with expertise in this area. The scientist considers each claim in relation to known scientific evidence and summarises the situation (Table 4):

Table 4. A selection of claims made for various products, their source and brief comment about the science.

Product	Claim	Source	Science
Nitrosol (Liquid fertiliser)	"Higher yields from hardy, robust, healthier plants ..."	www.nitrosol.co.nz/ nitrosol	A recent review of the international literature concludes that this product and products like it have no effect on crop yields
Agrisea (liquid fertiliser)	"Increases DM yield"	Company brochure	A recent review of the international literature concludes that this product and products like it have no effect on crop yields
Maxicrop (liquid probiotic)	By implication "increases lamb performance"	Company brochure	A recent review of the international literature concludes that this product and products like it have no effect on animal production
Roksolid (powdered basalt rock)	"Naturally balanced blend of all the essential mineral..."	www.agrissentials. com/index	It is most unlikely that any of the minerals and especially the nutrients in fine basalt rock will be plant available over the short-term (5-10 yrs)
Dicalcic phosphate (solid fertiliser)	"less phosphate input"	www.hatumadp.co.nz/ benefits/index	While it is true that this product contains about 50% of the P in super this does not mean that P requirements can be reduced without losing production.
Fine particle fertiliser	"..leads to improved fertiliser efficiency"	www. mainlandminerals.com	Trials show that Fine particle fertilisers are not more efficient than other forms of fertiliser.

Conclusions

It appears from this type of analysis that companies selling fertilisers and soil amendments will need to be increasingly careful about the claims they make. Assuming the scientific standard is adopted claims will need to be STP (scientifically tested and proven). Farmers and New Zealand agriculture will be better off as a result.

MAXICROP IS BACK

I recently received the Bell-Booth "Summer Catalogue". To my great surprise it prominently advised that Maxicrop, their liquid seaweed product, is back. I was surprised because in 1987 a High Court Judge, after hearing evidence from all over the world, concluded that Maxicrop, in all it forms, could not and does not work - could not work based on what it contained, and did not work based on the field trial evidence.

Bell-Booth now claim that "Maxicrop contains plant growth stimulants called betaines" and that "Betaines are known to increase cell division in the leaf and to increase mass and weight of roots."

Is there some new science going on here I wondered? I contacted the company and they supplied me with a list of 37 relatively recent scientific papers.

Nearly all these papers where about the effects of betaines on plants at the cellular, plant physiological level. At this level of understanding the claims made above are probably true. But my interest in these matters is at the whole plant level – do betaines, and products, which purportedly contain betaines, affect plant growth at the broad-acre level?

So lets wind back the clock a little.

Initially (back in the early 1980s) the company claimed that Maxicrop worked because it contained nutrients (remember the ad? "Three pints will feed an acre"). This was abandoned when it was shown that the amounts of nutrients in Maxicrop, when applied as recommended, were trivially small and could not affect plant growth. Next came the theory that it contained organic matter and that this stimulated soil biological activity and hence plant growth. This also withered under the scrutiny of science. It may contain organic matter but the amount is trivial relative to the amount already in the soil – pasture - animal cycle.

At the time of the Court Case (1985-86) Bell-Booth's claimed that Maxicrop worked because it contained the plant growth regulator cytokinnin. Initially they claimed that the concentration was 252ppm.

This was modified downward as the case proceeded until eventually their star witness on this matter, Dr Paula Jameson, withdrew her evidence.

You can see the pattern? As each claim is shot down a new one emerges. Now the active ingredient in Maxicrop is betaines. The logic that we are now invited to accept is that Maxicrop contains betaines; betaines affect plants at a physiological level; therefore Maxicrop works at the broad-acre level. The logic is best expressed by: calves drink milk, I drink milk, therefore I am a calf!

To prove their current claims several evidential hurdles need to be jumped: a) what is the concentration of betaines in Maxicrop? b) what is the amount of betaines applied when Maxicrop is used as recommended, c) is this amount sufficient to elicit a response in plant growth in the field, and d) from the farmers perspective, is it economic? There are no answers to these questions is the recent research sent to me and until these questions are answered there is no rational basis to recommend the product.

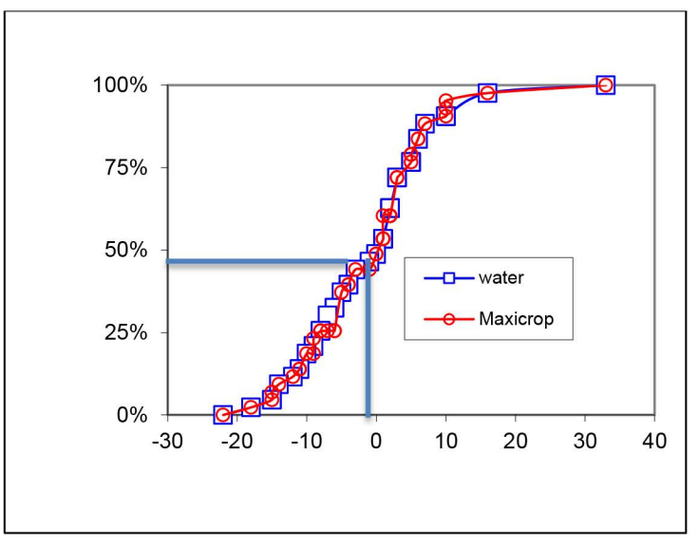
There is a further, possibly fatal, problem. Internationally 302 field trials have been conducted with Maxicrop. A summary of the results is given in Table 5. The measured effects of Maxicrop on crop production look very similar to the background noise (see article on SustaiN in this issue).

Table 5. The effects of Maxicrop on crop production relative to the background noise.

Study	Mean response (%)	Confidence interval	Range (%)	Distribution
Maxicrop (n = 302)	1.7	1.4	-40 to +60	50% >0%
Background noise (n= 67)	-0.6	2.3	-22 to +32	50% >0%

Indeed we can go a step further. Recall the experiment referred to earlier (see article on SustaiN in this issue) where an English scientist compared liquid fertilisers with the same amount of water they contained. For the product Maxicrop the results are shown in Figure 1. Maxicrop is no better than water!!!

Figure 1: The distribution of crop responses to Maxicrop and the same amount of water applied when Maxicrop is applied as recommended.



To conclude: Judge Ellis's conclusion that Maxicrop cannot and does not work, I believe, remains intact. So does the late Professor Walker's advice: " If you purchase this product keep the drum – it is the most valuable part! "

SOIL TEST HISTOGRAMS – What do they mean?

You have all seen soil test reports like the one below from Hill Laboratories. The actual results are classified as low, medium or high and these are shown as horizontal graphs - histograms. Some times the terminology for the categories is: below optimal, optimal or above optimal. Other laboratories often use a similar graphical presentation.

The visual impact of these histograms is powerful and often they are the only piece of information that farmers can readily digest from their reports. It is important therefore that the meaning and interpretation of these histograms is understood. I will limit the discussion below to their application in reporting test results for pastoral soils.

Hill Laboratories sets the scene in their document "Interpretation criteria for histogram reports." This is their assessment:

"As much as we would like to have a clearly defined approach, a certain amount of pragmatism and common sense is involved when setting the interpretive levels."

I think that is setting the bar too high. I think these histograms are misleading and should be ignored. Here is why.

Most soil testing labs will say that they are not in the business of interpreting soil tests – they leave that to the consultant. That is fine and sensible because a) the labs do not normally have the necessary background knowledge in soil fertility and pasture nutrition to interpret soil tests and make recommendations and, more importantly, b) they do not know the context in which the soil test results are to be used. For example, the composition and vigor of the pastures and the goals of the farmers should be taken into account when interpreting soil tests and offering fertiliser advice. But by describing the results as low, medium or high (or below optimal, optimal, above optimal) is an interpretive assessment of the results.

Second, these categories, low-medium-high, are not necessarily related to any agronomic or economic criteria. They do not reflect the agronomic optimal levels required to achieve near maximum pasture or crop production, and similarly, they do not reflect the economic optimal ranges required to optimize profitability. As I understand it, these categories are based on historical information accumulated over time in the lab, and, as Hill Laboratories describe it, " ….this data does not have any accompanying information regarding plant yield and or vigour….."

The alternative categories – below optimal, optimal and above optimal - are also fraught with interpretive difficulties. Does 'optimal' refer to optimal pasture growth such as the level required to achieve say 97% maximum yields or to the economic optimal – the level required to optimize profits. These can often be different.

If the later, then it must be realized that the economic optimal level for a given soil test will vary from farm-to-farm and requires a lot of farm-specific information that the lab is unlikely to have available.

If optimal means the level required for near maximum pasture production then the labs need to get profession advice from experts in this area of science, to correct and update their optimal criteria. For example with reference to the example below the optimal pH for pasture is 5.8-6.0 not as given (5.6-6.4). Similarly the optimal ranges for sulphate S and organic S are incorrect based on the latest research (they should be 10-12 rather than 10-20 and 12-20 respectively. And by the way there is no such thing as an optimal level for CEC, ASC, soil volume weight and base saturation ratios (% BS).

I have raised concerns before about the quality of the results coming out of our soil testing laboratories (Fertiliser Review No 23 and 25). I think it is high time our labs reviewed their policies and reporting practices. I think it is time the labs went back to what they do best – analysing soils – and leave any interpretation work to the farm consultants.

ANALYSIS RESULTS

Hill Laboratories

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Hill Laboratories

Client:
Address:

Laboratory No.:
Registered:
Reported:
Order No.:
Submitted By:
Client Ref:

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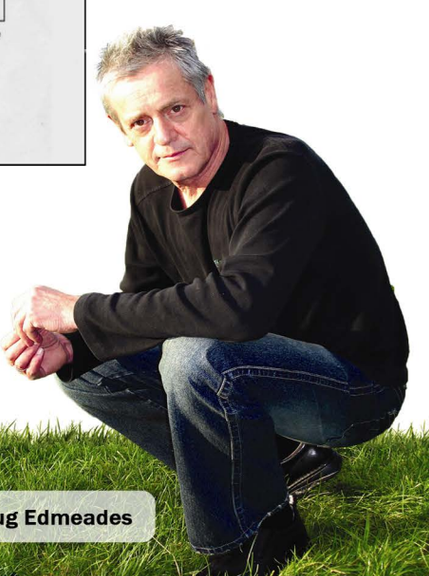
Client Phone

Sample Name: Hay Barn (Peat)
Sample Type: SOIL Maize (S6)

Analysis		Level Found	Optimum Range	Below Optimum / Optimum / Above Optimum
pH		6.3	5.6 - 6.4	
Resin P	(mg/kg)	61	40 - 75	
ASC/Phosphate Retention	(%)	37	30 - 60	
Potassium	(me/100g)	0.27	0.50 - 0.80	
Calcium	(me/100g)	81.2	5.0 - 12.0	
Magnesium	(me/100g)	2.79	0.80 - 3.00	
Sodium	(me/100g)	0.21	0.00 - 0.50	
Potassium	(%BS)	0.3	2.0 - 5.0	
Calcium	(%BS)	84	50 - 75	
Magnesium	(%BS)	2.9	5.0 - 15.0	
Sodium	(%BS)	0.2	1.0 - 2.0	
CEC	(me/100g)	97	12 - 25	
Base Saturation	(%)	88	50 - 85	
Volume Weight	(g/mL)	0.41	0.60 - 1.00	
Olsen P	(mg/L)	15		
Sulphate-S	(mg/kg)	4	10 - 20	
Organic Sulphur	(mg/kg)	27	12 - 20	
Available N (15cm Depth)	(kg/ha)	167	100 - 150	
Iron	(mg/kg)	1050		
Manganese	(mg/kg)	23	50 - 400	
Zinc	(mg/kg)	14.5	2.0 - 10.0	
Copper	(mg/kg)	5.7	1.0 - 5.0	
Cobalt	(mg/kg)	0.4	2.0 - 4.0	
MAF Units		K 2	Ca 42	Mg 28	Na 4
Anaerobically Mineralisable N		269 ug/g		

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: it is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information.



Dr. Doug Edmeades