Final Report

Project code: **Monaro - Targeting fertiliser applications - S1103**

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Targeting fertiliser applications to soil fertility

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Abstract

Monaro soils differ intrinsically in their nutrient properties and carrying capacities and therefore differ substantially in their fertilizer requirements. Globally increasing fertiliser prices coupled with declining nutrient resources, make it imperative that farmers adopt a more efficient and targeted approach to fertility management. This project addressed the issue of whole-farm nutrient planning by implementing an annual, bulk soil testing program over four years backed up with an annual interpretation & analysis session as well as the formation of paddock trials to link theory with the practice of correcting nutrient deficiencies and the impact on pasture legume composition. The paddock trials also focussed specifically on comparing S fertiliser products and their soil retention properties. Results highlighted the extent and distribution of nutrient deficiencies on the basalt, shale and granite soil types and gave producers the skills to better analyse and interpret soil tests and to use long-term soil monitoring to set nutrient targets on a paddock by paddock basis and link with annual fertiliser inputs and sustainable increases in stocking rates. The S Trial demonstrated the different properties of elemental sulphur versus sulphate sulphur and the implications for long term S levels. Economic outcomes of various fertiliser strategies, specific for the Monaro were also explored.

Basalt Site…"Springfield", Nimmitabel

Executive Summary

The overall aim of the project was to address the management of soil nutrient deficiencies and their impact on legume content of pastures in the Monaro district and to enable more informed fertiliser management decisions and targeting of fertiliser investments.

Project objectives included increasing the number of land managers adopting new technology decision making tools ie. the P Tool to integrate into their long term soil fertility planning and also to use paddock trials to demonstrate optimal Sulphur (S) and Phosphorus (P) management and the resulting impact on legume establishment and persistence in pasture systems. Other objectives included investigating alternative legumes which may be better adapted to the Monaro environment and looking at the performance of alternative sulphur (S) fertiliser products in respect to retention in the soil profile, plant availability and pasture response.
The Project aimed to encourage producers to use soil test information recorded over several years combined with the P-Tool methodology to be able to benchmark their soil nutrient status on a paddock scale and then set nutrient targets based on stocking rate goals. The project aimed to increase the confidence of producers in taking regular soil tests and interpreting soil test information which can then be used to make more evidence based, informed decisions and encourage adoption of variable fertiliser rate spreading strategies.

An annual, soil testing program implemented over the previous four (4) years has resulted in a data base of 1055 Monaro soil tests with 680 paddocks tested and engaging 55 farm businesses.

The cumulative results over the last four (4) years are as follows;

On the **basalt** soils, 20% are below optimum for P, 80% are below optimum for S and 20% of soils are P & S deficient. There is adequate to high K levels.
On the **granite** soils, 60% are below optimum for P, 80% below optimum for S and 25% are below optimum for K. 55% are P & S deficient and 25% are P, S and K deficient.
On the **shale** soils, 80% are below optimum for P, 80% below optimum for S and 50% are below optimum for K. 70% are P&S deficient and 35% are P, S & K deficient.

The MFS data base created by CSIRO is a manageable way of collating and storing MFS soil test data, as well as an efficient and rapid way of extracting soil test information and individual paddock history or farm reports. Currently MFS is in consultation with CSIRO to develop enhancements for the data base to further increase the value to producers.

Results for the paddock trials showed significant differences in the retention properties of the S products. The results clearly show that elemental sulphur has some very strong residual ability and resists leaching, compared to straight sulphate sulphur products. This in particular has advantages where farmers are applying fertilizer every 2 – 3 years and on soils which are very low in available sulphur and prone to leaching. In this trial, 31 kg of Elemental sulphur significantly outperformed 58 kg of sulphate sulphur in Single Super, in both pasture trials

Economic modelling of several different fertiliser strategies aimed to analyse the economic response to fertilizing with S and combinations of S and P. In almost all scenarios modelled even with the poorest sequences of seasons the use of fertiliser still yielded a profit over the 10 year period. The greatest cumulative cash flow gains were made on improved pasture systems

versus native pasture systems even though the breakeven point may be further along the time scale.

All this information will be freely available via the MFS website and can be used by the grazing industry on the Monaro to help make more informed decisions regarding fertiliser investments. Practice change has been initiated as evidenced by the producer feedback. Producers now have the tools, skills & information to refine their fertiliser strategies & budgets and actually target fertiliser outputs to specific nutrient targets and document long term goals.

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Shale Site "Finchley", Craigie

Background - *Why the group wanted to take on this project*

Monaro Farming Systems is a farmer initiated and farmer driven incorporated association with a membership base of approx. 50 farm businesses who own and manage approx. 35% of the privately held land on the Monaro and account for approx. 45% of the production output. It contains some of the most innovative, driven and forward thinking producers on the Monaro who see opportunities for continuous improvement in productivity and economic, environmental and social sustainability.

The Monaro has contrasting soil types which differ substantially in their intrinsic fertility and fertiliser requirements. Low clover/legume content of pastures in general, but especially on the basalt soil types, has been recognised as one of the key constraints to pasture productivity.

MFS initiated a "Soil Club" in Oct 2010 to provide support for producers to start to critically analyse their soil fertility profiles and build a whole farm soil fertility management plan which facilitates better targeting of phosphorus (P) applications to underpin sustainable increases in stocking rates.
Initial results indicated that 46% of topsoils analysed were below optimum P fertility on the granite derived soils and 8% were below optimum P on the basalt soils. Over 50% of topsoils analysed were also below optimum P on the shale soils.
A significant % of the topsoils tested were below optimum in S (sulphur) (67% on the granite derived soils and 62% on the basalt derived soils).

Of the soils tested, there was only a small percentage which were adequate for both P and S.

The results indicated that S deficiencies are found more widely on the Monaro that was thought previously and that K deficiencies are emerging as an issue on granite and shale soil types. These issues, coupled with the lack of legume content in many Monaro pastures, pose significant constraints to pasture production and stocking rates.

Other local trials have demonstrated that S retention in the soil profile can be poor depending on the "type" of S applied thereby raising the critical issue of leaching of S out of the top and sub-soil profile, affecting plant availability, uptake and therefore pasture response.

Appropriate fertiliser use is critical to optimising pasture systems and productivity gains on the Monaro by matching pasture potential with appropriate stocking rates. However, fertilizers are a significant and increasing cost for all grazing properties adding pressure for producers to adopt a much more targeted approach to their soil fertility management as well as the need to critically analyse the costs and returns from fertilizer investment.

This project was initiated to follow on and address some of the issues identified above which have emerged via the soil club activities. The overall aim of the project is to address the management of soil nutrient deficiencies and their impact on legume content of pastures in the Monaro district and to enable more informed fertiliser management decisions and targeting of fertiliser investments. Methods used for soil testing Olsen P extraction for phosphorus, Colwell K for potassium and KCl 40 for sulphur.

Project Objectives

1. Develop the appropriate skills and knowledge among land managers in the integration of modern soil technology tools (i.e. through use of the 5 Easy Steps P-Tool calculator in fertiliser decisions) and enable continual application of this acquired skill.

2. Establish paddock trials on three soil types (granite, basalt and shale) to (i) investigate the impact of optimal S and P management on legume persistence and production, and (ii) examine the use of alternative fertiliser types to improve S retention in topsoils.

3. Through the demonstration trials, identify alternative legumes which may be better adapted and suitable for the Monaro soil types.

4. Over a five year period, use the demonstration trials to (i) reinforce the theory and practice of soil fertility management for members, and (ii) reach a wider audience of producers on the Monaro.

5. Over a five year period use the P-Tool methodology: (i) apply knowledge of how to correct S and P deficiencies in farm paddocks of the project participants (ii) better understand the impact of these deficiencies on legume production, and (iii) to apply the concepts of aligning stocking rates with soil fertility management.

6. Over a five year period, use the pooled Soil Club soil fertility data to; (1) lift confidence in soil test use and interpretation, (2) document soil fertility trends which can be linked to adoption of the P-Tool methodology,(3) characterise the nutrient needs of the contrasting Monaro soil types,(4) develop relationships between amount of fertiliser applied and response in soil test values to guide fertiliser application rates and monitor emerging soil fertility issues (e.g. K deficiency on granite and shale-derived soils).

Methodology

1. Consolidate the formation of the MFS "Soil Club" with a structured annual soil fertility program and a timely-reminder service for soil test collection, submission and interpretation. Conduct annual educational and interpretive workshops (initial session to cover P-Tool) and coordinate annual bulk soil collections and bulk submissions.

2. Establishment of paddock trials ie. one trial on each of three Monaro soil types: granite, basalt and shale using soil test data to select sites that can illustrate soil fertility theory and practice most effectively (Dec 2011). Sub plots to be sown with sub clovers and a variety of alternative legumes (using recommendations from Monaro Grasslands Trial).

3. For each soil type, trial areas will demonstrate correction of known soil nutrient deficiencies by targeted fertiliser applications over a five year period.

4. Adjacent to main trial areas, the efficacy of alternative S fertilisers will be examined primarily by periodic measurement of the S concentrations in the soil profile (ie. 10cm, 20cm, 30cm, 40cm) to monitor movement of S over time and the retention properties of the different forms of S.

5. After the initial pasture establishment period trial areas will be rotationally (crash) grazed. The number of stock grazing days will be measured to collate animal production data and link to underpinning increases in stocking rate capacities.

6. Ongoing maintenance of paddock trials and collection and recording of soil, pasture and animal measurements. The soil test data will be regularly used in the P-Tool calculator to predict fertiliser requirements for each treatment area.

7. Develop the centralised database of MFS Soil Club soil test results to enable analysis of soil fertility trends, characterise the nutrient needs of Monaro soil types, to develop relationships between amount of fertiliser applied and response in soil test values to guide fertiliser application rates, and to monitor emerging soil fertility issues.

Results

- **Did the group achieve original outcomes?**

Many of the original outcomes were achieved and although some expectations were not fully realised, in other areas, the progress made actually exceeded original targets. Throughout the three year life of the project, numerous learnings were achieved in the following areas;

- Facilitated individual learning in both awareness and specific skills in soil fertility management (use of decision support software tools, correct procedures for collection of soil samples, understanding adequate ranges of P, K and S, as well as what it takes to build up soils from deficient to adequate.);
- The capacity as a farmer driven organisation to plan, implement and conduct demonstration trials;
- The power / strength of group data analysis over several years to show district trends and patterns versus an individual data set & the influence of this combined data set as a learning tool and to motivate changes in practice and on-ground decision making;
- The ability and powerful influence of farmer groups to be a vehicle for on-ground practice change and adoption to happen.

- **Report against each objective**

1. One of the first activities after the MFS soil club was formed was a Field Day for 32 participants, conducted in October 2010 by Richard Simpson to demonstrate the “five easy steps” of the P-Tool. This field day focussed specifically on the use of the tool and used a participant’s actual soil test results and farm system information as a case-study or example demonstration. All participants received the P-Tool booklet and CD to take home. This workshop was the first step in introducing the tool and integrating the use of this technology into whole farm soil fertility planning.
   [see **Attachment A** : Soil Club presentation - 2013)]

2. Paddock trials were established on the three main soil types. [Site selection was based on paddock deficiencies highlighted by the first annual bulk submission of soil tests in October 2010]. Site limitations on the Basalt trial area prevented the collection of biomass data for both the S trial and the main site area. This was due to the significant amount of poa tussock and rocks covering the sites making it impossible to collect quadrant cuts (see photos).

Basalt site ("Springfield", Nimmitabel, Jim & Vicki Haylock) – Paddock - **Terrick**

(1) Main Site (1 ha) – identified initial S deficiency via soil club testing
(2) S Trial - 4 tmts, replicated 3 times, 12 plots (5 X 2m)
(3) Legume trial plot fenced - (3 legumes, 3 reps)

Granite site ("Whinestone", Peak View, Bill and Sue Stephens) – Paddock – **Swinglebar**

(1) Main Site (1 ha) – identified initial S, P & K deficiencies via soil club testing
Oct 2011 applied 48 kg/ha P + 62 kg/ha S (sulphate sulphur) + 50 kg/ha K
(2) S Trial – 7 tmts, replicated 3 times, 21 plots (5 X 2m)
(3) Legume trial plot fenced – (3 legumes, 3 reps)

Shale site ("Finchley", Craigie, Dean and Anne Campbell) – Paddock – **Rye One**

(1) Main Site (1 ha) – identified initial S & P deficiency
Oct 2011 applied 525 kg/ha Single Super
(2) S Trial - 4 tmts, replicated 3 times, 12 plots (5 X 2m)
(3) Legume trial plot fenced – (3 legumes, 3 reps)

(i) Although a small legumes trial area was established at each of the 3 sites and 3 legumes (gland clover, sub clover & a burr medic) were sown at each of the three sites and establishment counts done, the impact of investigating optimal S & P management on legume persistence was not achieved. The reasons being; difficulties in sourcing the desired legume seed and securing the appropriate equipment & operator to sow the small plots, getting the sowing timing right in the "window of opportunity", inadequate weed control post-sowing which resulted in sites over-run by weed infestations and lack of knowledge & resources to conduct post sowing assessments ie. legume identification to be able to measure and critically analyse in a scientific sense the link between fertility and legume performance. Compounded by budget and time constraints.

(ii) Several alternative S fertiliser types or products were trialled and examined and the issue of retention in the top 0-10cm of the soil profile was addressed leading to interpretation and evidence based conclusions made possible. Results (see below) are discussed against the following;
-perspective of sulphur form, particle distribution & residual properties
-soil test results (all sites soil tested approximately every 6 months)
-dry matter results (granite & shale sites)

3. Three legumes were established in a small plot area, at all three sites (prima gland sub clover, antas sub clover and a scimitar burr medic). The clovers were sown in strips of 1.5 m wide by 20m long and replicated three times. As explained above, the challenges faced prevented any meaningful data from being collected to address the issue of "best adapted" legumes for the Monaro. MFS as a group, has identified this issue in their R & D Strategic Plan and documented possible causes for poor legume persistence include;

The issues thought likely to be affecting legume persistence:
(i) Are the growth and seed production requirements of subterranean clover mismatched with seasonal conditions that are typical of the Monaro?
(a) available soil moisture is often only sufficient for germination after growing season temperatures have dropped to suboptimal levels (winter),

(b) frosts and /or droughts at flowering time,
(c) summer rainfall leads to large loss of seeds,
(d) high residual dry matter in autumn block subclover germinations due to shading and/or allelopathy,
(e) pests and diseases (?)
(f) suboptimal soil fertility (*see later discussion of soil fertility issues*).
(g) rhizobia survival in hostile soils
(h) soil temperature ie. heat for sub-clover survival at autumn break
(i) pasture canopy / "shading" issues for sub-clover establishment at critical times ie. Autumn, especially where tussocks are present
(j) trace element deficiencies ie. *boron* affecting seed set and *molybdenum* affecting nodulation

(ii) Are there alternative legumes, better adapted to the Monaro climate?

(iii) Dominant species on the Monaro are drought tolerant perennial grasses - should the emphasis shift to use of drought-tolerant perennial legumes?

MFS R & D Strategy re alternative legumes: there are a limited number of alternative legumes that have or are showing promise in terms of density of persistence (Caucasian clover, arrowleaf clover??) all of which are likely to have establishment, seed availability, rhizobia issues that may require attention if they are to be adopted on the Monaro. Merit must first be established and a plan to cover any "issues" developed provided the merit tests indicate value to Monaro farmers.

In hindsight, this issue, to be explored adequately would constitute a Project on its own and require significant resources and expertise to be invested. For example, NSW DPI did previously, conduct a Monaro Grasslands trial over 5 years which explored the performance of 52 alternative legumes (*Belinda Hackney et al*.) In order to explore this issue, an additional funding source would be required.

In light of this realisation, MFS recently submitted an expression of interest as part of the *MLA Participatory Research & Development Projects* initiative. MFS was successful in securing funding for a three project which will team together researchers & producer groups to investigate the issue of "*Establishing & managing new legume species"* linking in longevity of seed banks and animal production.

4. The vehicle for (i) reinforcing the theory and practice of soil fertility management for members as well as (ii) a wider Monaro producer audience has been the MFS Soil Club. The activities of this "Club" over the previous 4 years has targeted this objective very specifically and has been backed up by the results from the paddock demonstration trials. Although primarily focussed on MFS members, the success of the Soil Club can be attributed as a major factor in increasing MFS membership over the previous four (4) years from an initial 35 farm businesses to 50 farm businesses (increase of 40%). This equates to an increase from approx. 70,000 to over 80,000 ha privately owned and managed by MFS members and hence this project has helped reach a wider audience on the Monaro.

   An annual, soil testing program implemented over the previous 4 years has resulted in a data base of 1055 soil tests with 680 paddocks tested and engaging 55 farm businesses. [See **Appendix A** - MFS Soil History Table].

   Out of the 680 paddocks tested, 18 of these have 4 annual, consecutive soil test results, 23 paddocks have 3 annual, consecutive soil test results, 105 have 2 consecutive soil test results and 534 have been sampled once.

The testing history has been reinforced by four (4) annual grower discussion meetings, mentored by Richard Simpson, CSIRO, in which the group's results have been analysed, interpreted and presented by Richard highlighting the inherent deficiencies on each soil type. Related topics explored include: correct soil collection procedures; whole farm fertility planning; understanding soil variability on a paddock and property scale; understanding soil test results and standard, critical nutrient levels; relationships between soil nutrients ie. S, K, N & P and principles of maintenance and capital fertiliser applications; setting nutrient targets; fertiliser targeting and variable rate spreading; fertiliser budgeting and paddock monitoring strategies; linking soil fertility targets with sustainable increases in stocking rates. [see **Appendix A**].

5. The Soil Club has evolved over 4 years to move from recognising soil paddock deficiencies to actually implementing strategies to correct these deficiencies, improve legume composition of pastures and apply the concept of matching a rising soil fertility plane with aligned increases in stocking rates.
   The lack of animal production data to go with the soil and biomass data collected in this trial has long been recognised. This can be attributed again to time, budget and resource constraints of both the host farmers involved and MFS project management. As well as an underestimation of the time and effort required to set this up in the initial project planning and application. The planning and time commitment required to accurately record grazing days and weights of animals rotating on and off pastures, coupled with the fencing needed to achieve adequate grazing pressure at the appropriate times, proved very challenging and hence was not completed.

   In an effort to rectify this lack of production data, MFS used project funds to contract Doug Alcock of Graz Prophet Consulting (formerly NSW DPI livestock specialist) to use Grass Gro modelling to look at the impacts of fertility in Monaro farm systems using actual trial soil and pasture information and simulating the animal production component using animal production data from a current MFS wether trial.
   Doug Alcock used grassgro to model cumulative profit in a farm business comparing several different fertiliser products and strategies over a ten year period on both native and improved pastures [**see Appendix C**]. The report highlights the differences in farm profit and economic returns underpinning the various fertiliser strategies and shows the impacts of maintenance versus capital applications, comparing several different fertilisers, rates and bi-annual versus annual applications.

6. The Soil Club over the previous four years has been successful in achieving all the following objectives;
   - Lifting confidence in soil test interpretation.
   - Documenting soil fertility trends.
   - Characterising inherent soil deficiencies on basalt, shale and granite soil types.
   - Looking at fertiliser response curves & using paddock soil test history to guide future fertiliser applications.

   This is evident in both the soil results collected, information that has been presented and also the producer feedback comments as well as the MFS Survey results. Out of all the MFS Projects the Soils Club showed the biggest response for actually instigating practice change (see **Appendix D, Page 6**). There is an obvious link between the information and skills being acquired over the previous

four years, and the adoption of more targeted approaches to soil fertility management.

Emerging issues include;

- K deficiency on the granite and shale soils
- In the 2013 data set of 244 soil tests, there is a wide range of pH ranging from 7.4 to 4.3 (CaCl sub script). Soil acidity was also identified as an issue with having very high Al levels (>20%). Soil acidity on some soil types is the major limitation to pasture growth.

- **Members comments**

Questions asked

Q1. What benefits have you gained from your involvement in the Soil Club?
Q2. Have you increased your soil tests as a result of the Soil Club?
Q3. Have you made any changes to your stocking rates?
Q3. Have you changed your fertility program as a result of the Soil Club?
Q4. What have been the economic benefits?
Q5. Do you use the P-Tool as part of your soil fertility management?

Benefits gained

- "Understanding the responsiveness of pasture growth to the different elements has meant that the business is now better allocating its fertiliser dollar."
- "Access to cheaper soil tests has enabled much of the farm to be tested. Previously only 1-2 paddocks would be tested at a time."
- "Now able to compare results across the region and soil tests to see where my farm compares."
- "Access to knowledgeable scientific and farm advisor input to determine the merit of increasing P and S levels in soils."
- "Gained insight into the importance of using soil tests to monitor soil fertility."
- "Understand the importance of correct sampling technique."
- "Access to tools to determine critical P and S and K levels for my farm and also to determine the cost of addressing those nutrient needs."
- "Scott and I consider that our membership of the MFS soil club is most useful and that its value to us has increased as our experience has grown and as the records over time are now beginning to show longer term trends. We feel we are now in a position to make science-based decisions on applications of P, K, S and lime and have greatly improved confidence in making those decisions. Having been introduced to us only on Friday, the Holbrook Fertilizer Tool is already in use at Wallendibby."
- "Richard Simpson's presentations have enabled easier interpretation of the soil test data, not only in reading the basic figures but also in applying them to different soils and pastures."
- "By using indexes for the different elements, it becomes easier to see where levels really are. I have created a spread sheet to follow year-on-year changes to P, S and K."
- "It allows us to tailor fertilizer applications according to pasture type and animal management needs."
- "The requirement to have testing done by a certain date brings with it the discipline to get it done, despite being in the middle of lamb marking etc."

- "The value for money is obvious, but I'll continue soil testing with or without that assistance."
- "I have both enjoyed The Soils Club as well as learning many new skills in collecting, interpreting and implementing the results."
- "P budgeting, better understanding of soil type monitor soil fertility more regulary observe pasture species mix and response to fertilizer"
- "Certainly increased our understanding of the soil fertility and understanding our results, reinforced the message of importance of monitoring over time."
- "Soil Club gives us much more confidence to lift stocking rates, excellent program."
- "Reinforced the message of importance of continuous monitoring and annual soil tests that has become part of the farm program."
- "No better able to interpret the results and make (hopefully) informed decisions on fert rates, type, etc."
- "Has been very interesting to see the data on a district scale ie. breaking soils into basalt, granite, shale."
- "On the agronomy side, pastures are much more competitive against invasive weeds such as love grass and thistles with the more targeted approach to fertiliser."
- "Have a much better appreciation of the difference between "maintenance" and "production" levels of fertilizer application."
- "Have gained a better understanding of soils and fertiliser needs and use."
- "I would go so far as to say that, for me, the Soils Club has had the most immediate impact on my farm out of all the MFS projects. It has been the perfect balance of knowledge building (made possible by Richard Simpson) and being able to bring that knowledge to bear immediately back to my farm through the soil tests. It has also been of great benefit to look at my soils on a wider basis by being able to compare it with like type soils from my area."
- "I have gained a far greater understanding of soil phosphorus requirements. An understanding of the buffering index and soil phosphorus levels means I can vary the application rate of superphosphate on different paddocks around my farm."
- "Being involved in this program has resulted in "actual or real" targeted fertiliser applications, a much better understanding of our P levels and how this looks long term, and better understanding of the soil capabilities of the region in general."

Practice Changes On-ground

- "We have cut back applications on some pastures."
- "The changes I will make from these test results will be to closely monitor each paddock and fertilize to match my livestock production. These changers will help my financial returns by using less of the costly Superphosphate and identify areas to benefit from Sulphur only."
- "We have purchased a lot more fertiliser this year as realised we have just been maintaining paddocks rather than increasing fertility…this has not yet increased stocking rates but hope to put into practice next year."
- "We are using the P-tool more as a guide as when we used it for our situation it did indicate that stocking rates could be doubled and knowing our environment and systems, that would not be sustainable (Monaro climate extreme, growing season quite short) We feel that the P Tool over estimated stocking rate potentials."
- "Now we have "core" paddocks tested each year along the same transect to create a "baseline" from which to judge other paddocks that don't have such a comprehensive fertiliser history ie. perhaps only 1 test."

- "Adopted a much more targeted fertiliser spreading, our better paddocks are now always kept at an optimum fertility level."
- "For all our lower quality paddocks we have balanced fertiliser inputs with less than optimum stocking rates ie. supply and demand therefore being more efficient in our fertiliser usage."
- "I now use elemental sulphur rather than sulphate sulphur because of the leaching issue which has been demonstrated by the trials."
- "More aware of "noise" in soil testing, important to do regular soil testing, take more soil tests now. Ensure we test the core paddocks every year to limit the amount of noise."

- "From Doug Alcock's presentation….realised need to look at "whole farm" system profitability and much more aware of other major profit drivers which you have to get right, not just the fertiliser….the whole farm system concept has been put into context."
- "As well as getting the stocking rate tied in right with fertility, also need to get right labour productivity and genetics otherwise its very hard to be profitable."
- "We now monitor 2 or 3 paddocks every year now so we can graph trends over time."
- "More strategic use of fertiliser on the better, newly improved pastures, rather than our usual, standard practice of 125kg over everything. For example some of our better paddocks now get 200 – 250kg/ha annually."
- "Now using the same transect lines each year in paddocks to take samples to try and improve consistency."
- "No hard figures but on the lighter granite soils, where P is inadequate, started adopting capital input applications rather than the 125kg/ha and this is definitely getting a return on investment."
- "We have definitely lifted stocking rates from 2 DSE / ha to 8 DSE / ha over a three year period."
- "We reduced fertiliser on some paddocks and increased it on others, we have also lifted our stocking rate overall."
- "Realised that S and P fertilizers need to be considered together."
- "Begun a more widespread topdressing regime."
- "Have started fencing according to land class."
- "Changes made on-farm include a complete record of all soil tests undertaken to date, together with treatments applied. Resulting improvements to stocking rates are also documented. Access to the database which Richard referred to in his talk would be valuable, as the amount of data will become difficult to manage without it."
- "Through the soil tests and with the use of Richard's interpretation of those tests, I have been able to more accurately focus what type of fertiliser I need to use and where I am going to get the best result."
- "I now have a better understanding of what a "maintenance" application of fertilizer is for a whole range of different paddocks on my farm. This means I have confidently reduced the kilograms of superphosphate I apply per hectare on many of paddocks on my farm (equates to approx. 450ha)."
- "We now have a much more cost effective fertiliser budget, and have revised and modified some of our fertiliser rates on several paddocks (approx. 500 ha)."

Economic benefits

- "Our annual fertiliser order is approx. 50-120 tonnes of product every year, budget of $60 – 80,000. I believe you need to have a change of 10-20% before you see the real economic impacts and we can definitely see economic benefits from decisions made as a

result of our involvement with Soils Club. With a budget of this size, we are still in-front with one decision."

- "I would estimate we have made a $15,000 benefit per year based on $1,000 investment."
- We have allocated resources in a better way to save money and have more confidence in pasture growth which has in-turn meant an increase in stocking rate."
- "Too short a time period to determine if either stocking rate or wool cut has been improved."
- "It is too soon to make meaningful comments on the effect on our bottom-line, though we are confident these will show through in due course."

- "No hard figures but on the lighter granite soils, where P is inadequate, started adopting capital input applications rather than the 125kg/ha and this is definitely getting a return on investment."
- "Very broadly, there have been two (2) impacts to my farm which both are favourable. The first is that when sowing pasture, I have been able to target any soil deficiencies aggressively, which have improved germination and establishment rates for perennials (so far, this has not been favourable to the bottom line as input costs increased but it will have enormous impact throughout the life of the pasture.) The second is that the rate in which we come out of times of slow to no growth has increased."
- "Being involved in this project has reduced my fertiliser bill. It has meant that superphosphate is now much closer to being a fixed cost (because I can afford it) rather than a variable cost which it has tended to be in the past."

- **Results and interpretation**

Demonstration Trials

-Soil Test Results and Biomass Results are provided for each site in **Appendix F**.

Basalt Site

S Trial

Soil sulphur levels started at 15 mg/kg (KCL – 40) at the beginning of the trial year in the 0 – 10 cm test. This fell to 2 mg/kg in the nil P treatment by Sept 2013.

Both element elemental sulphur products (supplying about 30 kg of Sulphur) have maintained sulphur levels above 8 mg/kg by Sept 2013. The sulphate sulphur, elemental combination with 9 kg of elemental and 21 kg of Sulphate had declined to 4 mg/kg by September 2013. These results clearly show that elemental sulphur has some very strong residual ability and resits leaching, compared to straight sulphate sulphur products. This in particular has advantages where farmers are applying fertilizer every 2 – 3 years and on soils which are very low in available sulphur and prone to leaching.

Key messages & recommendations: Elemental sulphur based products can provide long term sulphur supply to pastures providing the elemental sulphur is of a particle size less than 250 micron for at least 60 % of the product and less than 10 % is smaller than 30 micron.

Not all elemental sulphur products are the same and need to be treated with caution, farmers must know particle sizing.

Granite Site

Main Trial Site:

- P went from marginal to adequate;
- K went from deficient to marginal;
- S levels went from deficient to adequate; and over the three year period S levels declined back to deficient;
- P levels declined to marginal, K levels remained marginal.

S Trial Site:

Granite Swinglebar Site									
	Applied Nutrient	P Colwell		Colwell K		S - KCL			
Tment	kg/ha	10/12/12	13/09/13	10/12/12	13/09/13	Initial	25/06/12	10/12/13	13/09/13
T1	95P, 50K, 7S	44	46	110	160	6.7	6.8	3.5	4.3
T2	50P, 50K, 31S as Tiger 90	33	29	87	190	6.7	7.3	3.3	4
T3	50P, 50K, 31S as Brimstone 90	29	37	87	200	6.7	6.5	2.3	4.4
T4	50P, 9Se, 50K, 21SO_4	36	44	54	150	6.7	6.3	5	7
T5	50P, 50K, 31SO_4	24	32	110	170	6.7	12	3.9	13
T6	50P, 50K, 68SO_4	21	39	110	170	6.7	24	4.1	6.8
T7	50P, 50K, 62Se as Brimstone 90	29	32	84	160		23	3.3	6.9

Note: S = Sulphur**,** SO4 = sulphate sulphur, Se = elemental S, P = Phosphorus, K = Potassium

T1 = TSP@472 kg/ha + M of P @100kg/ha
T2 = TIGER 90CR@30kg/ha + TSP @ 250kg/ha + M of P @100kg/ha
T3 = BRIMSTONE 90@34 kg/ha + TSP @250 kg/ha + M of P @ 100 kg/ha
T4 = SuPerfect 26S@ 115 kg/ha + TSP @ 210kg/ha + M of P@ 100 kg/ha
T5 = SSP @ 290 kg/ha + TSP @ 250 kg/ha + M of P @ 100kg/ha
T6 = M of P @ 100 kg/ha + SSP@ 580 kg/ha
T7 = BRIMSTONE 90@68 kg/ha + TSP@ 250 kg/ha + M of P@100kg/ha

TIGER 90 CR sulphur is a high analysis granular degradable elemental sulphur product that can be used both as a source of plant nutrient sulphur and / or as a soil amendment for correction of problem alkali soils.

Brimstone 90 is a 90% elemental sulphur (225% SO3) fertiliser and soil amender, it is a season long term source of sulphur due to its non-leaching characteristics in the soil.
Trials have shown Brimstone 90 to have the smallest particle size of any sulphur product on the market. This enables Brimstone 90 to become more quickly available to the plant when it's needed most.

Shale Site

S Trial Site;

Shale Rye 1 0-10cms					
Tment	Applied Nutrient kg/ha	KCL Sulphur			
		Initial	27/06/12	15/02/13	13/0913
T1	45P, 58S	5.2	10	6.2	5.8
T2	45P, 31Se as Tiger	5.2	4.5	5.3	5.1
T3	45P, 31Se as Brimstone	5.2	9.8	4.1	15
T4	45P, 9SO_4, 21Se	5.2	7.2	7	5.8

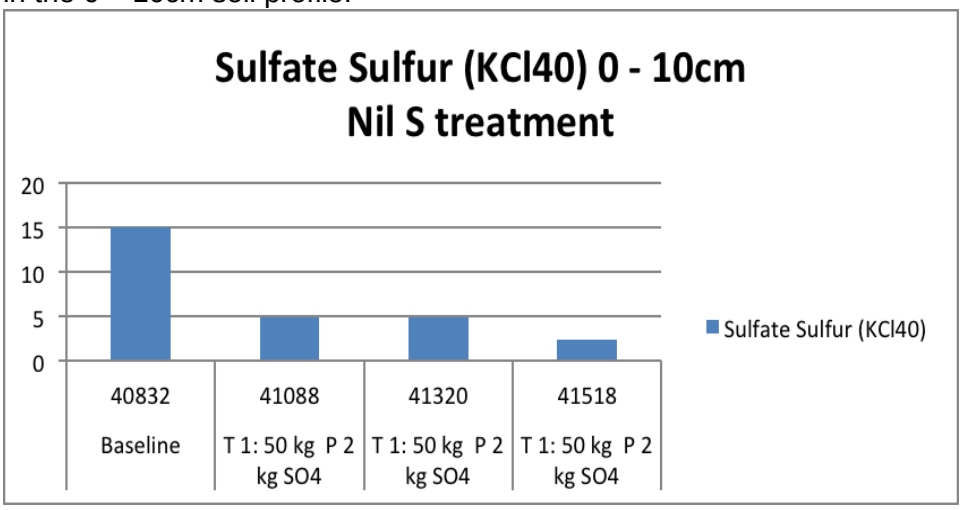
Note: S = Sulphur**,** SO4 = sulphate sulphur, Se = elemental S, P = Phosphorus

T1 = SSP@525kg/ha
T2 = TIGER 90CR @34kg/ha + TSP @ 225kg/ha
T3 = BRIMSTONE 90@34kg/ha + TSP@225kg/ha
T4 = Superfect 26S@115kg/ha + TSP@185kg/ha

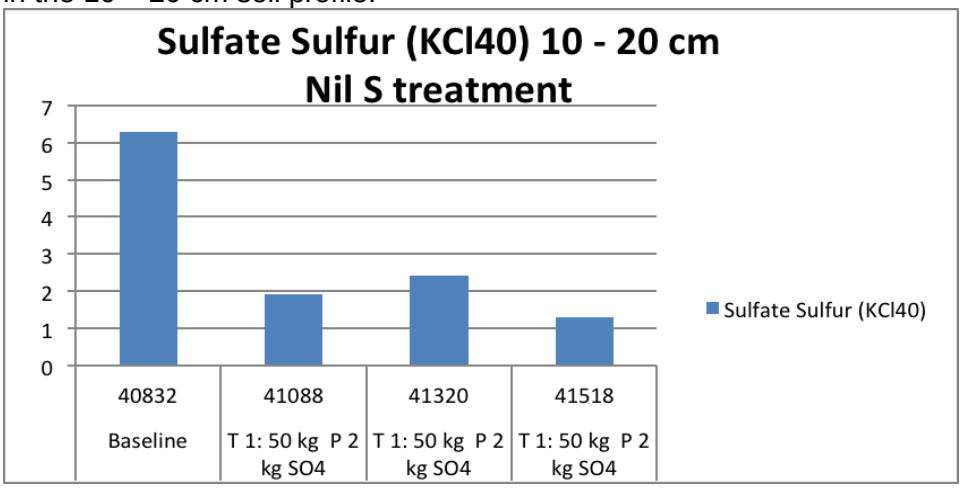
Shale Site pasture composition

S Trial

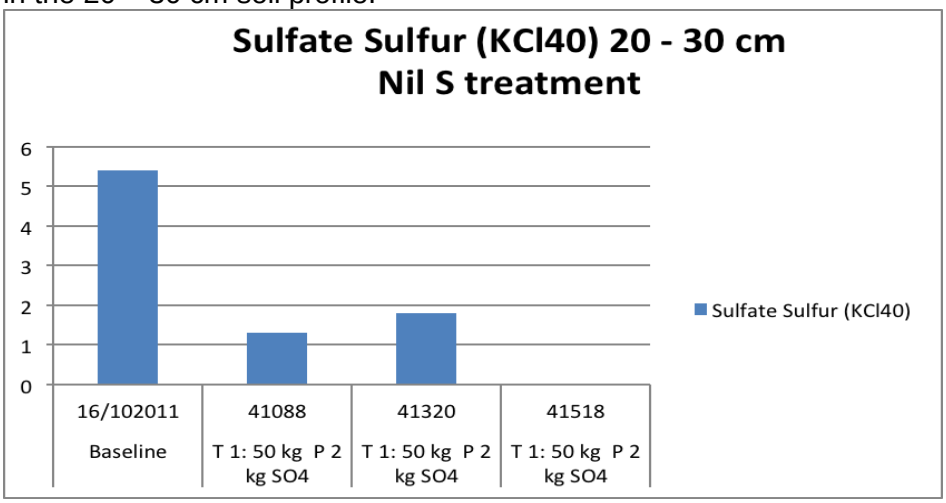
Graph 1: For **Treatment 1**(SSP@525kg/ha), shows the reduction over time of sulphate sulphur in the 0 – 10cm soil profile.



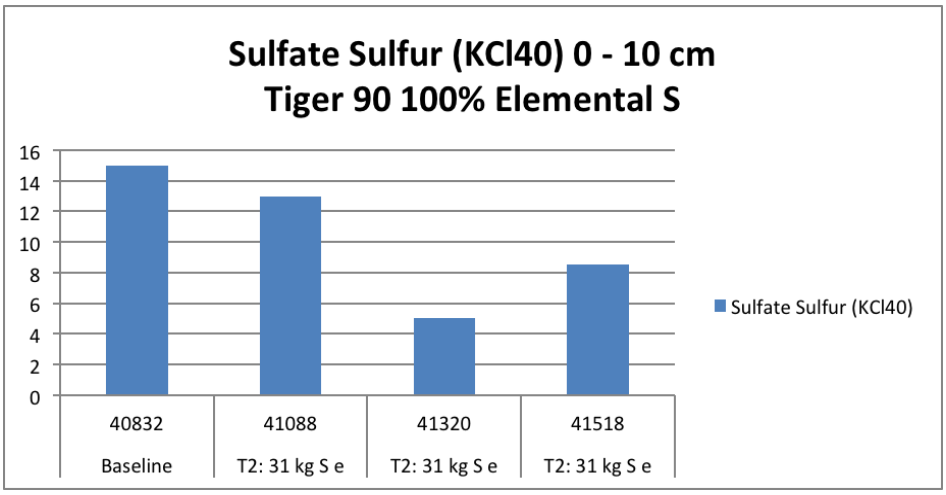
Graph 2: For **Treatment 1**(SSP@525kg/ha), shows the reduction over time of sulphate sulphur in the 10 – 20 cm soil profile.



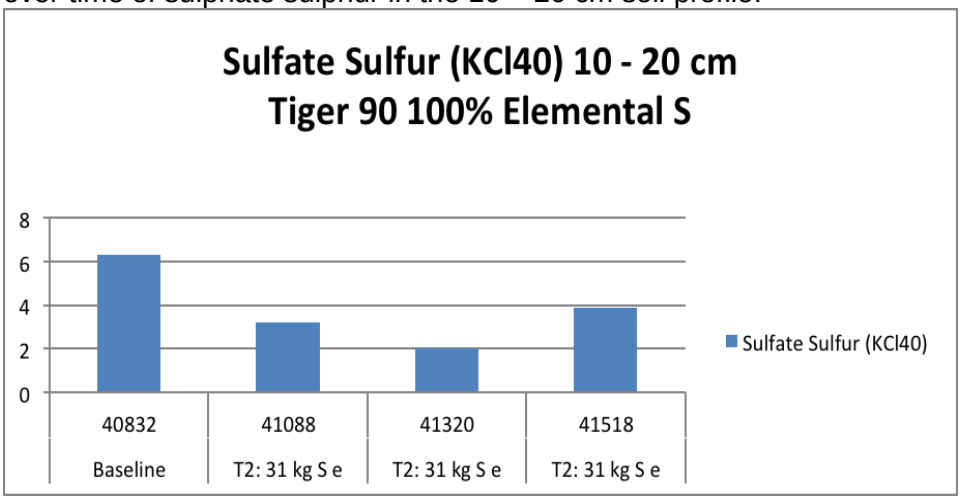
Graph 3: For **Treatment 1**(SSP@525kg/ha), shows the reduction over time of sulphate sulphur in the 20 – 30 cm soil profile.



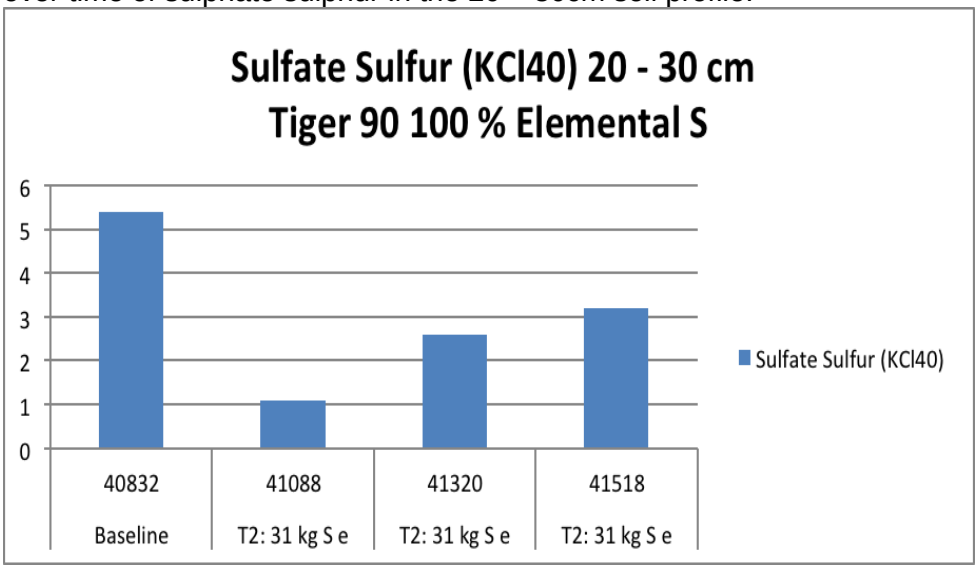
Graph 4: For **Treatment 2** (TIGER 90CR @34kg/ha + TSP @ 225kg/ha), shows the reduction over time of sulphate sulphur in the 0 – 10cm soil profile.



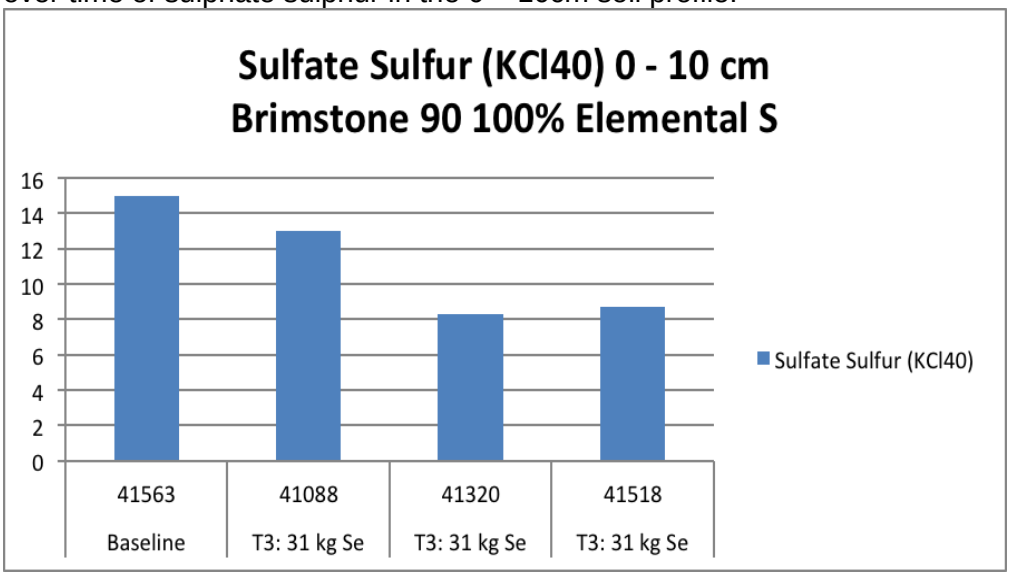
Graph 5: For **Treatment 2** (TIGER 90CR @34kg/ha + TSP @ 225kg/ha), shows the reduction over time of sulphate sulphur in the 10 – 20 cm soil profile.



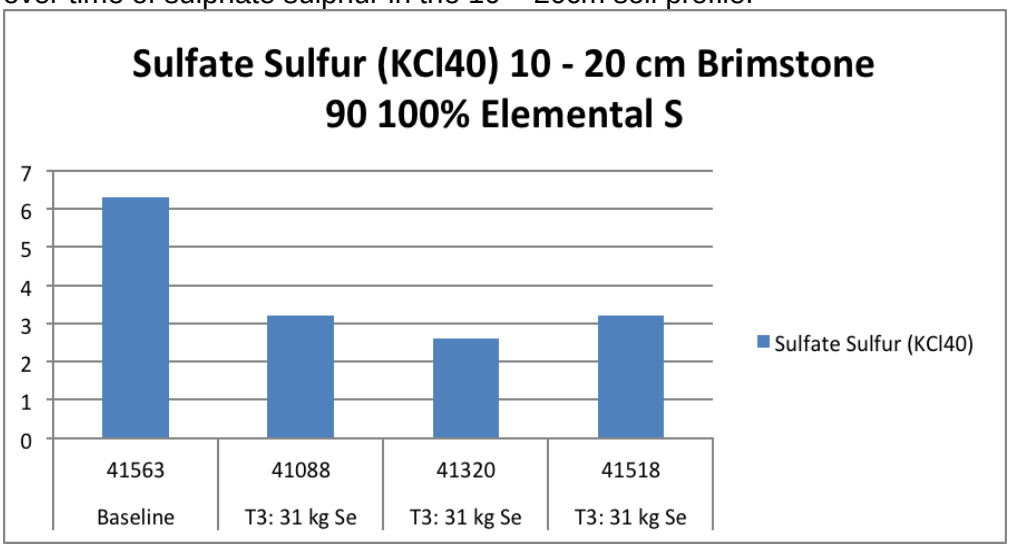
Graph 6: For **Treatment 2** (TIGER 90CR @34kg/ha + TSP @ 225kg/ha), shows the reduction over time of sulphate sulphur in the 20 – 30cm soil profile.



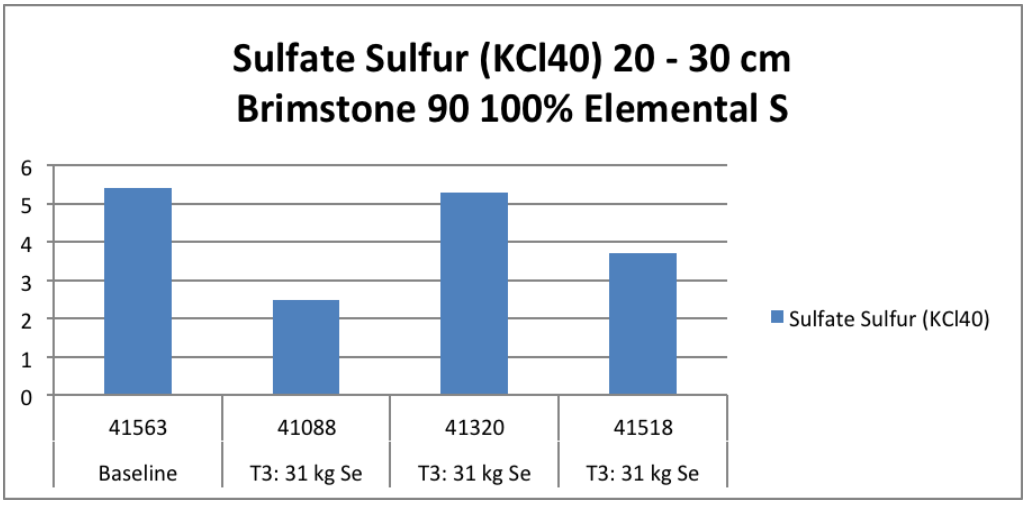
Graph 7: For **Treatment 3** (BRIMSTONE 90@34kg/ha + TSP@225kg/ha), shows the reduction over time of sulphate sulphur in the 0 – 10cm soil profile.



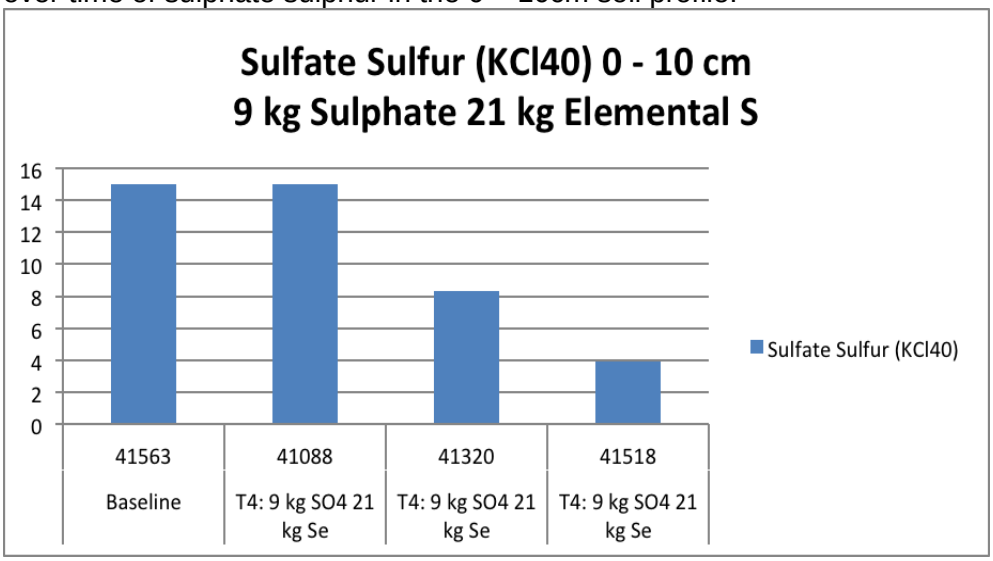
Graph 8: For **Treatment 3** (BRIMSTONE 90@34kg/ha + TSP@225kg/ha), shows the reduction over time of sulphate sulphur in the 10 – 20cm soil profile.



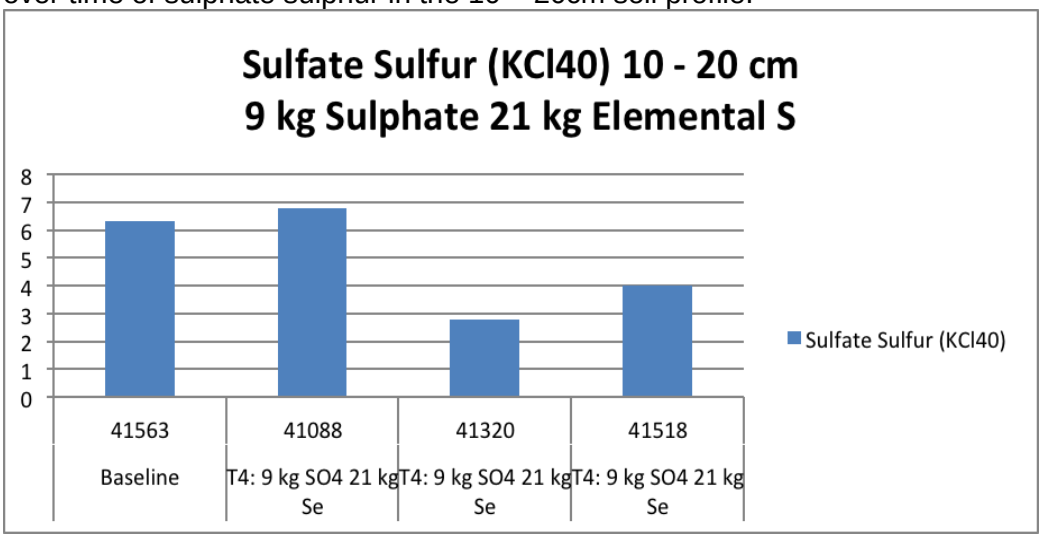
Graph 9: For **Treatment 3** (BRIMSTONE 90@34kg/ha + TSP@225kg/ha), shows the reduction over time of sulphate sulphur in the 20 – 30cm soil profile.



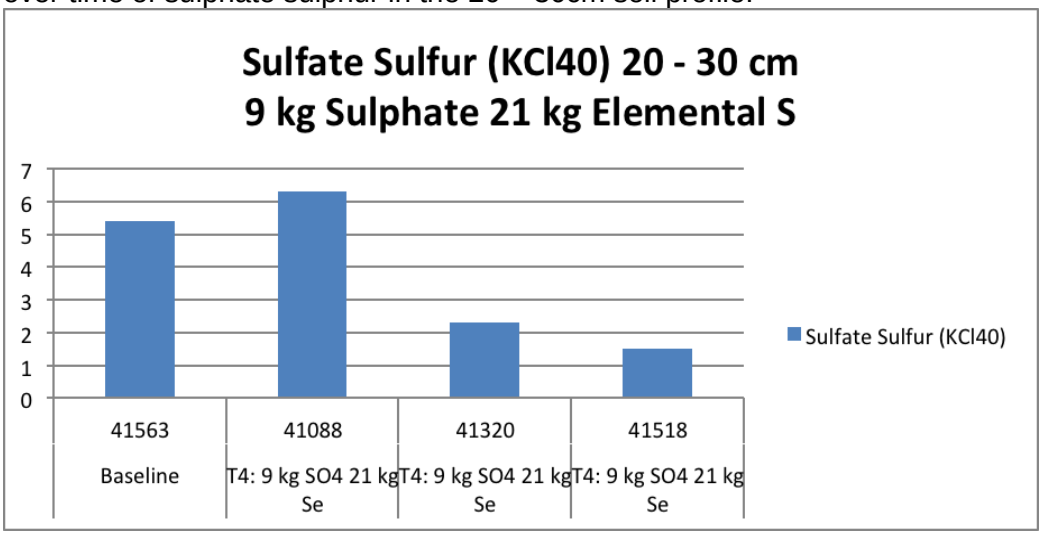
Graph 10: For Treatment 4 (Superfect 26S@115kg/ha + TSP@185kg/ha**)** shows the reduction over time of sulphate sulphur in the 0 – 10cm soil profile.



Graph 11: For Treatment 4 (Superfect 26S@115kg/ha + TSP@185kg/ha**)** shows the reduction over time of sulphate sulphur in the 10 – 20cm soil profile.



Graph 12: For **Treatment 4** (Superfect 26S@115kg/ha + TSP@185kg/ha**)**, shows the reduction over time of sulphate sulphur in the 20 – 30cm soil profile.



Biomass

-See Biomass Data Sheet **Appendix F**
-See Statistical Analysis Report (SARDI) **Appendix E**

-regular biomass cuts were collected for the granite and shale sites, both for the S trial and the main site to measure pasture response to fertiliser.
-the basalt site was not cut due to the lack of uniformity of the site, large poa tussocks (see photo) infested the sites and made it impossible to cut quadrants.

Granite site – Swinglebar pdk

S Trial

	Treatments	Total Weights (kg/DM)
5*	SSP @ 290kg/ha + TSP@250kg/ha + MOP@100kg/ha	8870
2*	TIGER 90CR@30kg/ha + TSP @250kg/ha + MOP @100kg/ha	8740
6*	MOP @100kg/ha + SSP@580kg/ha	8724
7*	BRIMSTONE 90@68kg/ha + TSP @250kg/ha + MOP @100kg/ha	8688
4	SuPerfect26S@115kg/ha + TSP @210kg/ha + MOP @100kg/ha	8366
3	BRIMSTONE 90@34kg/ha + TSP @250kg/ha + MOP @100kg/ha	8068
1	TSP@472kg/ha + MoP @100kg/ha	7831

-Treatments 2,5,6,7 were significantly different (better) than Treatment 1 over the whole trial.
-Treatment 1 was the only treatment with no applied sulphur. So over all there is a response to rate and form of sulphur. [Least Significant Difference 5 % 792 cf T1]

Main Site – Mean Yield (kg/ha)

Date	Main Trial Site (non-limiting nutrients)	Control
Dec 2011	4043	Not measured
May 2012	1867	1549
Dec 2012	2426	2016
April 2013	2548	2013

-although the mean yields (kg/ha) were consistently higher in the main trial site compared with the control area, because no scientifically validated replication was done, statistical analysis could not be under taken to determine if these differences were significant.
-Visually there was a response observed between the trial area and the control (outside) ie. the trial area had greater biomass, looked greener and had abundant legume content. However this could not be scientifically validated.

Shale site – Rye One pdk

S Trial

	Treatments	Total Weights (kg/DM)
1	Brimstone90 @ 34 kg, 225 kg of TSP	6900
2	SSP 525 kg of SSP	5335
3	Superfect 26S 115 kg + 185 kg of TSP	6740
4	Tiger 90 @34 kg + 225 kg of TSP	6446

-Treatments 1,3 and 4 were significantly different (better) than Treatment 2 over the whole trial.
-However no significant difference between treatments 1,3 and 4. So over all there was a repeated response in biomass to the rate and form of sulphur. [Least sig diff at 5% level 711 kg.]

Main Site - Mean Yield (kg/ha)
- because no scientifically validated replication was done, statistical analysis could not be under taken (only two cuts taken in one of the trial years).

Basalt site

-Due to the inconsistency of the sites, impossible to take biomass cuts accurately for both the main trial area and the S Trial therefore no data recorded.

Summary of biomass data results
This trial shows a strong response to elemental sulphur demonstrating its residual value over the trial again showing farmer's product choice of sulphur form is very important. In this trial, 31 kg of Elemental sulphur significantly outperformed 58 kg of sulphate sulphur in Single Super. Also remember if pastures had had better legume content it would have been even more important, once legumes are in the system the sulphur requirement and responsiveness is even more important. This demonstration work supports trials from G Blair (UNE) and Fresian i.e. Scientific trials confirm practically that capital P works also supporting R Simpsons (CSIRO) Phosphorus pasture response calculations, and the residual value of the correct Sulphur source.

Legume Establishment Counts
**sown May 2012, establishment counts done following 8 weeks

Basalt

	plants / sq m
Scimitar	22.29
Antas	3.43
Prima Gland	26.86

Granite

	plants / sq m
Scimitar	5.14
Antas	1.71
Prima Gland	10.29

Shale

	plants / sq m
Scimitar	28
Antas	26.29
Prima Gland	18.86

Soil Club – Overall Results (2010 - 2013)

An annual, soil testing program implemented over the previous 4 years has resulted in a data base of 1055 soil tests with 680 paddocks tested engaging 55 farm businesses.

- On the **basalt** soils, 20% are below optimum for P, 80% are below optimum for S and 20% of soils are P & S deficient. There is adequate to high K levels.

- On the **granite** soils, **60%** are below optimum for P, **80**% below optimum for S and **25**% are below optimum for K. 55% are P & S deficient and 25% are P, S and K deficient.

- On the **shale** soils, **80**% are below optimum for P, **80**% below optimum for S and **50**% are below optimum for K. 70% are P&S deficient and 35% are P, S & K deficient.

  The MFS data base created by CSIRO, is a manageable way of collating and storing MFS soil test data, as well as am efficient and rapid way of extracting soil test information and individual paddock history or farm reports.
  Future MFS Soil Club annual bulk submissions estimated at 200 to 500 soil samples being tested each year, each analysed for 21 different soil tests, equates to capacity to process and handle 4000 – 10,000 data values annually.

Capacity of the MFS soil database (current and future enhancements);

- Excel spread sheet reports generated for individual properties over several years
- Future enhancements will enable automatic data analysis for certain nutrients ie. actual nutrient levels plotted against built in critical levels
- Charts of paddock soil fertility trends
- Property / district soil fertility maps
- Secure, web access to your personal soil test data via MFS website, nutrient budgeting tools and farm soil fertility reports

Questions individual producers can **query the data base**;
1. What are the P, S and K level “trends” per paddock?
2. What is the current P level; where do you want to take it?
3. What is current annual carrying capacity?
4. What will it be at the target P level for next year?
5. Do you need to adjust fertiliser / strategy based on S, K, pH results?

- **What were the member’s benefits? Have any practice changes on-ground resulted or planned?**

  See producer comments above.

- **Economics of outcomes, ie. how will members improve bottom line?**

  - See **Appendix C** – “Getting value from Fertilising Monaro Pastures – Nov 2013 Doug Alcock - Graz Prophet Consulting.

  - See members comments above.

- **Environmental benefits?**
  -diverse, productive, resilient, good quality pasture systems which results from getting fertility right, will optimise ground cover and therefore limit run-off, loss of top-soil, water erosion and scalding and salinity issues. Deep rooted perennial pastures which are a result of optimal fertility, ensure healthy soils and contribute to balanced, robust, environmental systems.

- **What methods were used to extend results, numbers target audience engaged?**

  Communication methods used throughout the project included initial discussions of trial design and implementation process with Ron Horton and Oliver Cay, advice from Luke Pope (NSW I&I agronomist) and Richard Simpson (CSIRO).
  Members were kept regularly updated via email distribution lists, quarterly newsletters and phone contact with trial site producers.
  Quarterly visits to sites were made by the MFS Project Officer for trial measurement's and data collection ie soil tests and biomass cuts. Promotion of results was made by email, phone, flyers, newsletters and media releases. Direct contact and one face-to-face meeting was made with Andrew Speirs of MSA who provided technical advice and interpretation of results.

Regular progress reports were made to the MFS Board (6 meetings per year) by the MFS Project Officer.
Four annual, group interactive sessions were conducted with Richard Simpson presenting results, analysis and interpretation.

No.'s of participants at annual Soil Club events

2010 – 32 participants
2011 – 35 participants
2012 – 38 participants
2013 – 40 participants

Soil tests collected
2010 – 110
2011 – 255
2012 – 385
2013 - 244

Conclusions / Take home messages

Consistent soil testing, following the correct procedures, can give an indicative measure of the soil fertility status of a paddock. The accuracy of this overall picture is improved with the number of soil tests collected hence the importance of long term monitoring.

There is a huge ability to increase DM production via improving and optimising soil fertility which under pins more consistent and sustainable increases in stocking rates.

Soil test information is the key to making decisions about fertiliser priorities and the likely return

to investment in fertiliser. The MFS database of soil tests for a range of paddocks representing different pasture types and management histories will be a very useful tool for MFS members in the future. Now the trends are emerging it is time for producers to continue to become more proficient in the use of these tools to the best of their advantage.

The practice of applying nutrients to rectify soil deficiencies has been demonstrated by measuring soil test information over time. There is a clear relationship between S type and residual properties in the soil profile over time. The differences measured between elemental S products are a function of particle size. Elemental sulphur based products can provide long term sulphur supply to pastures providing the elemental sulphur is of a particle size less than 250 micron for at least 60 % of the product and less than 10 % is smaller than 30 micron. Note, farmers must first know particle sizing of the sulphur product as they are not all the same and need to be treated with caution and the right advice.

This project has demonstrated the use of soil test information and the P Tool to make informed decisions about the options which give the greatest and/or the most rapid returns. For an enterprise with limited availability of cash more modest and more immediate returns might be appropriate while enterprises with liquidity might choose to invest in strategies that have longer periods of negative cash flow but give higher overall return. The right combination of fertiliser choices will be unique to your farm what matters is using a robust and objective decision making process like 5 easy steps.

The fertilizer trails demonstrated productivity could be significantly increased with the right nutrient package, when applying corrective action based on soil test results.

It is important to remember the key point ie. even with the poorest sequences of seasons the use of fertiliser will still yield a profit over the 10 year period in both native and improved pasture systems.

Truly profitable enterprises are those that excel in not just one field but in all of the following;

- Top performers in both fields of animal productivity (genetics) and pasture management.
- Ensure they have responsive species in a site to help ensure they can extract the full benefit of sound pasture nutrition ie. have a critical amount of legumes present.
- Be able to apply adequate grazing pressure to utilise the extra feed created by correcting nutrient deficiencies ie. match increasing pasture quality with increased stocking rates.

Appendixes

App. A - Richard Simpsons Soil Club Presentation – 2013 (attachment)

App. B – Media Release – 2013 Soils Club

Media release

Nov 2013

More Mapping of Monaro Soils

Monaro Farming Systems (MFS) hosted a very successful field day last Friday for approximately 40 participants at Nimmitabel. The morning was the fourth annual meeting for the MFS "Soils Club" which now has a data base of over 1000 soil tests. This soils club, mentored by CSIRO's Dr Richard Simpson, has progressively collected and analysed soil tests on the three main soil types of the Monaro ie. basalt, shale and granite which has allowed mapping of these soils and has highlighted the deficiencies inherent on these soil types.

The day focussed on the capabilities of the data base to be able to provide producers with individual paddock history reports with their nutrient profiles mapped over several years. This function now allows producers to set targets for their soils for selected nutrients ie. sulphur & phosphorous and to visually see where their own soils sit in relation to standard targets for these nutrients. One of the main take-home messages was the enormous variability in soil at a paddock scale and the crucial importance of monitoring soils over a long period of time in order to get a picture of the paddocks overall fertility.

Participants comments included…"I have learnt more about my soils in the last three years through this Soil Club, than I have in the last 35 years of farming on the Monaro" and "Richard Simpson has taken us to the next level and shown us now what to do with our soil test information…"

The morning also included a presentation by Doug Alcock (Graz Prophet Consulting) who used Grass Gro modelling using Monaro specific data, to show the economic impacts of adopting a range of different fertiliser strategies both on native and improved basalt country. These different options were compared to highlight the benefits of long term investment in fertiliser and to show the various responses to cumulative enterprise profit.

Susan Orgill (NSW DPI) also gave an update on the MFS Soil Carbon Project and demonstrated again with her soil data, the variability in soil carbon and phosphorus at a paddock scale.
John Barilaro addressed the audience to give his view on how the new Local Land Services will work with grower groups such as MFS and David Mitchell, the new LLS Chair was present to comment on the structure of the LLS Board and how it will operate in respect to addressing local Monaro issues.

MFS would like to acknowledge Meat and Livestock Australia, Producer Demonstration Site initiative for contributing funding to this initiative.

For further information please contact the MFS project officer Nancy Spoljaric on 0438 066 322.

App. C: Graz Prophet Report – Getting Value from Fertilising Monaro Pastures Nov 2013 (attachment)

App. D: MFS survey data relating to soil club – **see Page 6** (attached)

App. E: Statistics Report (SARDI) (attached)

App. F: Summary of soil test & biomass data (attached)

App. G: MFS Newsletters - Project summaries (attached)

App. H: Collection of Images

Basalt Site

S Trial

Main Trial

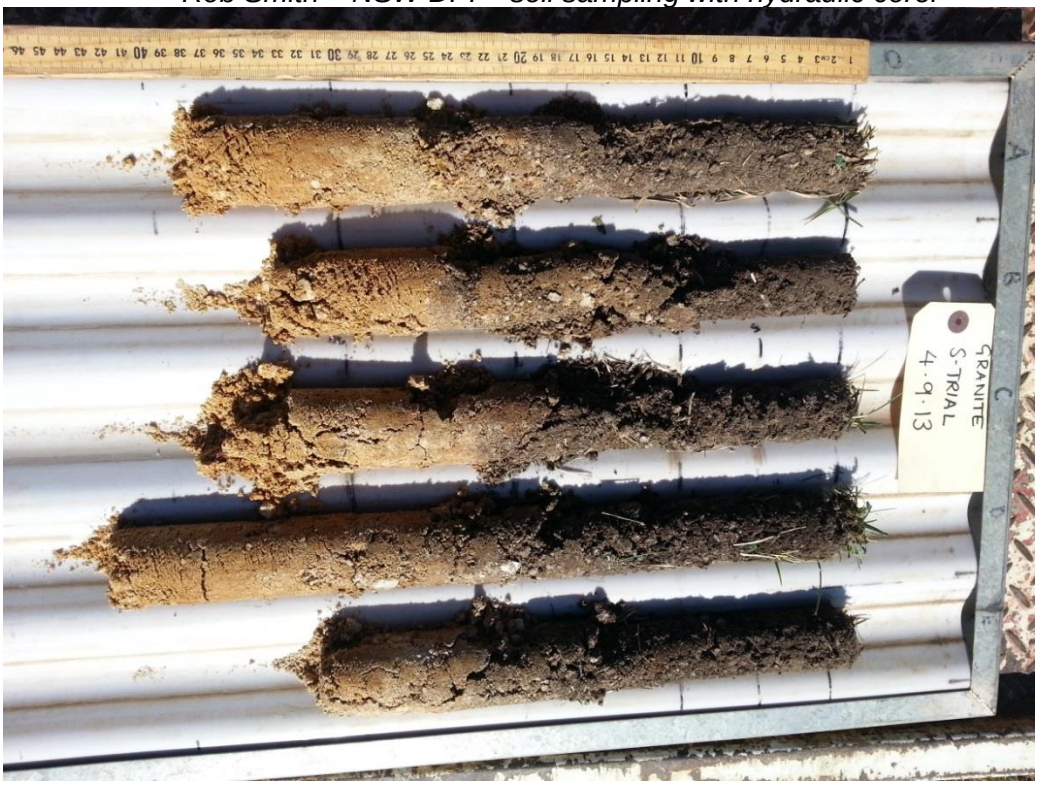
Granite Site

Sue Stephens mowing pegged plots prior to treatment applications

S Trial

Soil Sampling & Cutting Plots

Rob Smith – NSW DPI – soil sampling with hydraulic corer



Soil Samples to 30cm

Shale Site

Main Plot, Rye One paddock

Clovers

Antas

Prima Gland

Simitar

Soil Club Activities

Richard Simpson – Nov 2011 Presentation – "Greenlake" Shearing Shed

Richard Simpson – Nov 2012 Presentation – Nimmitabel Country Club

Richard Simpson – Nov 2013 Presentation – Nimmitabel Community Centre