A potato crop management service to promote new technology in Tasmania

Chris Russell
Simplot Australia Pty Ltd - Tasmania

Project Number: PT05027

PT05027

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A potato Crop Management Service to promote new technology in Tasmania

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Purpose of this report:

This final report will illustrate the outcomes from project PT05027 for the benefit of the Tasmanian potato industry. The project spanned three seasons (2004-2005, 2005-2006 and 2006-2007) but benefited from data collected in the 2003-2004 season, as the project was initiated in anticipation of HAL funding which did not eventuate.

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Simplot Tasmanian potato growers
Horticulture Australia Limited
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Contents:

Media Summary:

Simplot Australia with assistance from Horticulture Australia Limited and Tasmanian potato growers conducted an intensive three year project to identify yield driving factors and implement new technology to achieve productivity gains. Potato yields in Tasmania had remained relatively constant over multiple seasons, threatening industry viability as alternative supply regions in other countries achieved strong productivity gains after adopting new technology. CMS crop yields did not increase as expected during the project, as freak weather conditions including severe frosts, flood, drought and destructive winds affected yields. A database was established to store and compare multiple variables on each CMS crop over the various seasons, and is now the basis for research and extension activities within the industry. Environmental benefits around the rational use of irrigation water, pesticides and fertilisers were also suggested. The project was extended to 2007-08 for evaluation of the Potato Calculator, a crop model (decision management tool) from New Zealand Crop and Food Research. The Potato Calculator supported the CMS findings of the previous three years, whilst revealing other areas in need of additional research, in particular soil compaction, soil water management and nitrogen fertiliser management. In essence CMS revealed trend lines for numerous factors that influence processing potato yield and quality. A generic document of average CMS data against the Top-5 crops was created each season and supplied to all growers. Any grower could use this document to compare against his or her own information.

Technical Summary:

Tasmania produces around half of Australia's French fry processing potatoes, but has struggled to replicate the gains experienced recently by other production areas within Australia and overseas. This project aimed to reveal which management practices produced the highest processing yield and quality under Tasmanian conditions. Agronomic data on over 300 potato crops (mostly Russet Burbank) was collated, including: soil tests; fertiliser application; plant nutrient analysis; irrigation/rain data; soil moisture; soil and air temperature; insect and disease data; yield and quality data. Representative soil samples (0-15cm) were collected for nutrient analysis including trace elements at a laboratory selected by the grower. Soil moisture monitoring equipment owned or leased by the grower was installed in a representative area of the paddock away from tractor spray tracks and irrigation ends and runs. Paddock inspection (scouting) was performed fortnightly for insects and disease and general crop condition and soil moisture status. For data analysis the collective average processing yield was 'standardised' by assuming a constant average industry yield year-to-year to minimise the influence of season upon the data set. Irrigation management was a major yield determinant, with gun irrigation systems averaging 55 t/ha, pivot/lateral/boom systems averaging 52 t/ha, and solid set averaging 58 t/ha. Inadequate soil moisture early in the crops life reduced yield, whilst excess water late in the crops life favours tuber rots, also reducing yield. Fertiliser rates (nitrogen-N, phosphorus-P and potassium-K) were not well correlated with yield, but the rates that produced the highest yields were: 300-330 kg N/ha; 240-270 kg P/ha, and; 300-320 kg K/ha (for Ferrosol). Potato plant stem (haulm) length increased with N fertiliser rate, but was not correlated with other yield or quality parameters. Disease management is difficult to correlate against yield and quality since all growers apply the necessary chemicals as required. Higher plant populations were associated with higher yielding potato crops, possibly as younger (physiologically) more vigorous seed is normally planted closer together. Soil type and condition strongly influences potato yield, as available soil water storage capacity links closely with yield – assuming it is replenished as required. Russet Burbank yields declined as planting date moved from early to late October and into November, in line with maximum canopy development by the summer solstice. Later planting produced more stems per plant, meaning plant spacing must increase to maintain the same stem count per unit area. Crop rotation effects were examined but with eight different crop options (then by summer and winter planting) the number of possible combinations reduced the value of the data set. Extending the potato rotation increases the yield potential, particularly when stretching from four out to six years. New Zealand Crop and Food Research have developed the Potato Calculator™, an internet based decision management tool using the following inputs: soil data – for nitrogen content, water holding capacity and penetration resistance (all to 60 cm); climatic data – temperature and solar radiation (historical and in-season); irrigation and rain data (daily, not weekly or monthly); variety; planting date, and; nitrogen fertilisation (rates and timing). Earlier work with the Potato Calculator (2005-06 and 2006-07 external to this project) suggested two substantial yet previously unquantified yield impediments – hardpans restricting root development, and lack of access to water in the root zone. As an extension to the original project the Potato Calculator was used in 2007-08 to model the growth and yield of 41 potato crops from across the north of Tasmania representing a number of soil types and irrigation systems. Predicted yields were not always comparable to the achieved yields generally due to rain/irrigation data inaccuracy and/or ,

non-representative deep soil samples. Soil type variability within paddock can be problematic in Tasmania, with between two and five soil types commonly forming one management unit. The ramification of such variability upon nitrogen requirement and water holding capacity make striking a ‘happy-medium’ to satisfy the whole paddock very difficult. Future work focusing on variable rate irrigation technology should reduce water and nitrogen wastage, whilst increasing potato yield and quality.

Introduction:

Tasmania produces around half of Australia's French fry processing potatoes, worth an estimated $85 million to Tasmanian farmers. The downstream value of such an industry to a state with less than half a million people is obvious. Growers in Tasmania have struggled to replicate the gains experienced recently in other growing areas both within Australia and overseas. With the ease of long distance transportation combined with lower production costs in many locations around the globe, local growers can no longer rest assured a processing company 'must' retain a presence in Tasmania. Indeed most processed agricultural commodities do not feature highly in the 'Buy-Australian' campaign.

To assist the local processing potato industry remain viable a three year program was jointly funded by Simplot Australia Pty Ltd, Horticulture Australia Limited and Tasmanian potato growers to identify the local drivers of yield and quality. During the project this information was extended to all potato growers via presentations and documentation, to keep them abreast of any developments with potential. Being a commodity crop, any yield increases, or production cost decreases translate into greater long term viability for the local processing potato industry.

High rates of fertiliser are often applied to Tasmanian processing potato crops, and with the recent increases in fertiliser cost, these high rates need to deliver yield to be justified. Other countries enforce crop nutrient budgets to restrict the over application of fertiliser to crops that have no capacity to use the nutrients some farmers are willing to apply. The excess applied nutrient almost always finds it way to water, which means it has off-site implications in addition to those on the farm itself. Nearly all agricultural consultants have a preferred nutrient approach for processing potato crops, but no two consultants recommend exactly the same blend or rate. The yield and quality achieved by the different blends is typically 'average', since no market forces have lead to a predominance of one over another. If CMS reflects the HAL funded Sweet corn Crop Management Service project in NSW (2001-2004), processing potato growers in Tasmania may begin eliminating some of the fertiliser excesses of the past. Applying only the required nutrients will reduce production costs, and potentially increase the raw material quality as luxury up-take of potentially problematic nutrients is minimised.

Strategies for maximising crop production include scientific application by consulting agronomists, adoption of overseas crop husbandry, and generational methods of the farming locality. The combination of multiple variables with different interactions becomes so complex the only reliable means to make sense of this is a computer model, assuming the model is correct! The Potato Calculator from New Zealand Crop and Food Research forecasts N requirements taking into account potato variety, planting date, soil N and rainfall/irrigation (leaching). This is modelled for the season based on localised historical climatic data, but is updated daily from the Bureau of Meteorology weather stations. If weather conditions remove or reduce the need for additional N, the Potato Calculator will indicate the most cost effective strategy to maximise return, without causing nutrient leaching.

The irrigation scheduling component of the Potato Calculator determines crop water demand based on the rain/irrigation and local weather data via the modelled stage of development. Once the Potato Calculator has been validated to growers in Tasmania (as has been done in other locations) much of the confusion around fertiliser and irrigation will be clarified.

Materials & Methods

Processing potatoes have been grown in Tasmania for several decades, and considerable effort has been extended by various agencies to reveal the factors responsible for producing high yielding crops. Most research examines one or two factors in isolation using a limited amount of data, whilst other potential factors are ignored. The intent of CMS was to gather data on as many variables and paddocks as possible to encompass the major factors, and the smaller less obvious interactions that can mask the 'big-ticket' items. Hence detailed agronomic data from over 300 potato crops (mostly Russet Burbank) spanning four seasons was collected in an attempt to reveal which factors have reliable correlations with yield and quality.

Agronomists involved with the CMS were provided with a booklet describing the CMS concept and requirements expected of those involved (Appendix I).

Growers enlisted an agronomist of their choice, who conducted a pre-plant discussion with the grower (Appendix II), collected soil samples prior to planting, plant nutrient samples on five occasions during the crop, and completed a scouting sheet fortnightly (or weekly) for both the farmer and the CMS database (Appendix III).

The data collected for each CMS potato crop included:

- Soil test for Nitrate (NO_3), Ammonium (NH_4), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), Copper (Cu), Zinc (Zn), Boron (B), Manganese (Mn), Iron (Fe), pH, Organic Carbon (OC), salinity (EC), Sodium (Na), Chloride (Cl), Cation Exchange Capacity (CEC);
- Plant tissue tests (x5) for N, P, K, S, Ca, Mg, Zn, Cu, Fe and Mn. (Other elements, such as Molybdenum were measured for some crops);
- Soil moisture;
- Soil and air temperature;
- Pest and disease incidence;
- Yield and quality data.

The four years of collected data was reviewed extensively to determine which factors reliably contribute to yield or quality. Basic regression analysis was performed on correlations of interest, with multiple regression analysis being performed on the data set by Dr Alistar Gracie from the Tasmanian Institute of Agricultural Research (UTas – Hobart).

In 2006-07 the number of growers involved in the CMS dropped to 60 due to a lack of water and increased production costs, well below the budgeted number. To justify the original budget the Potato Calculator was evaluated in 41 paddocks during the 2007-08 season. New Zealand Crop and Food Research have invested millions developing the Potato Calculator, a decision management tool using inputs including: soil data (to 60 cm) – for nitrogen content, water holding capacity and penetration resistance; climatic data – temperature and solar radiation;

irrigation and rain data; variety; planting date, and; nitrogen fertilisation. The collected data was emailed to New Zealand, where it was entered into the program and the results sent back to Tasmania. This proved less than ideal due to the time delay, while the data trail became difficult to manage. Some equipment issues with the rain/irrigation logging devices saw some data lost, while the deep soil test for texture and nitrogen was not always representative of the paddock. Season summary reports consisting mostly of graphs were provided to growers with complete or close to complete data sets, but some growers did not receive a report as insufficient data meant the Potato Calculator outputs were nonsensical.

For season 2008-09 the Potato Calculator has developed into an internet based tool, accessible from anywhere in the world, and configured to update the weather files daily from multiple weather stations.

Results

Unfortunately as with many projects of this type the effects of ‘mother-nature’ cannot be counteracted. Freak weather events including severe frosts, flood, drought and destructive winds affected the potential project outcomes, but this ‘noise’ was mostly excluded during data analysis.

The four years of data has been summarised into a generic report for growers not in the CMS (Appendix IV). This report details most trends of interest, and discusses the results in detail. In summary the results include:

- Effective irrigation is the biggest single factor determining yield;
- Fertiliser rates of 300-330 kg N/ha, 240-270 kg P/ha and 300-320 kg K/ha produced the highest yields;
- Higher nitrogen application rates increased foliage growth, but was not well correlated with yield;
- Earlier planting (late October) increases yield potential;
- Following cereal or pasture produces the highest yields;
- Higher soil organic carbon levels increase yield potential;
- Potatoes irrigated with gun type systems averaged 55 t/ha, compared with pivot/lateral/boom systems averaging 52 t/ha, and solid set averaged 58 t/ha;
- Increasing plant population can increase yields;
- No correlation between plant population and tuber size;
- Consistent tuber numbers per plant regardless of population;
- Higher populations increase tuber number per stem;
- Higher yielding crops have larger tubers;
- Tubers per stem does not influence tuber size, but tubers per plant does;
- Extending the potato rotation increases yield potential.

The Potato Calculator predicted ‘potential’ Tasmanian potato yields of 20-30 t/ha above those typically achieved. Soil measurements revealed a hard pan (>3000 kpa) between 35-40 cm below the top of potato moulds. Other information from New Zealand Crop and Food Research indicates only 10% of the water stored in the root zone is available per day, typically 3-4 mm when plant requirement can be 7-8 mm/day.

Discussion

As with many rural enterprises the timing of key activities is nearly as critical as actually performing the key activities, for instance; sufficient water is essential to produce a high yielding quality crop, but timing of its application can make the difference between an average yield and one that makes a considerable contribution to enterprise profitability.

The enlisting of agronomists by growers to aid decision management was achieved without question by CMS, whether the association between farmer and agronomist continues beyond the CMS program remains to be seen. Some farmers consider a good agronomist is only necessary for a couple of years until the ‘bugs’ have been ironed out of the system, but this negates the benefit of additional eyes on the crop, and access to information that can be difficult to source otherwise.

From a project management perspective, utilising multiple agronomists (from several firms) with varying ideas around data collection, and different analytical laboratories, presented some issues that could not be overcome. Future projects could prevent this problem by engaging one service provide, and one analytical laboratory, along with one type of equipment (e.g. moisture monitoring devices from one manufacturer). If large volumes of information are required for analysis, some method of automating data entry would also reduce transcription errors.

Effective irrigation management for maximum potato yield needs to maintain sufficient available water to maintain optimum growth with minimal over-application. Different irrigation systems (gun, pivot/lateral or solid set) produced average yields from 52 to 58 t/ha. Insufficient water early in the crop and during tuber bulking, and/or excess water at later growth stages often restricts yield. Growers can be hesitant to commence irrigation as this signifies the beginning of a tedious and drawn out yet essential function for high yielding potato crops.

The water demands of small yet developing potato plants can be ignored unless things are particularly dry, especially as other crops at critical irrigation growth stages take priority. The Potato Calculator determines a yield and return penalty if any necessary irrigations are not applied as required. This information can stimulate growers into action as previously no quantitative data was available.

Excess water in later growth stages favours disease and tuber rots, increasing costs and reducing yield. At this stage of growth many other crops no longer require water, allowing greater quantities to be applied to potato crops, but potatoes also require less water during later growth stages. Potatoes can produce close to maximum yield potential with irrigation rates below daily evapo-transpiration rates.

Supplying sufficient water to the crop as required is still largely a guessing game. Most soil moisture monitoring devices can be quite accurate, assuming they are installed properly, are operating correctly, and are representative of the paddock. Interpreting the data can be more involved than the explanation most growers are given, and then extensive field validation is needed regularly to ensure the device is continuing to function properly. Even so, there was still no information available to indicate the yield effects of water shortage at various stages of crop growth.

When planting conditions are very dry (late 2006), the benefit of pre-plant irrigation becomes evident, as irrigating post planting is less effective at wetting the entire mould (set and fertiliser) sufficiently.

Fertiliser is touted as the main driver of potato yields, but unless irrigation is effectively managed applied fertiliser can be unavailable. Although fertiliser rates influence yield, the high rates applied to many processing potato crops are poorly correlated to yield. Mid range fertiliser rates (300-330 kg N/ha, 240-270 kg P/ha and 300-320 kg K/ha) were associated with the highest yielding CMS crops, but would often be considered low by industry standards.

Increasing the nitrogen fertiliser rate increased the amount of foliage grown by the crop, this could increase yield if the leaf/green area index is below three. Exceeding a leaf area index of three does not intercept significantly more sunlight, and the metabolic expense and additional transpiration losses of the additional foliage could be detrimental to yield. Excessive foliage increases the disease risk (additional humidity) and the likelihood of wind damage, which can also lead to disease issues (*Sclerotinia*).

Phosphorus fertiliser is rapidly 'locked-up' on Ferrosol soil in Tasmania, and higher application rates at planting do not alleviate the problem. Pre-spreading low analysis fertiliser can reduce the 'lock-up' issue, and is commonly practiced if available soil phosphorus is low.

Increasing the plant population increases the crop nutrient and water requirement. If the plant population is increased without increasing water and nutrient inputs tubers are likely to be smaller, and yield lower. Seed producing more stems per plant at a lower population generate a similar return to seed producing lower stems per plant planted at a higher population. The advantage of seed producing more stems per plant is the potential to reduce seed cost per hectare. Higher plant populations tend to produce higher yields, possibly as younger more vigorous seed is planted closer together. Seed from different sources may well have different ideal spacing characteristics, but was beyond the scope of this project.

The Potato Calculator revealed 'potential' potato yields far above what was normally achieved across most soil types in Tasmania. Various causes were responsible for the difference between the 'potential' and achieved yield, but usually soil parameters and/or irrigation was the issue(s).

The main soil issue was a hard pan (or tight soil >3000 kpa) that typically formed just below the deep ripper tynes. This restricted most if not all paddocks to around 35-40 cm of soil from the top of the mound that plant roots could penetrate. Given ideal condition potatoes can form root system 70 cm deep, but none of the 41 Potato Calculator paddocks would facilitate this. Given the restricted root zone the irrigation methodology required to maximise yield changes significantly. A root zone of 35-40 cm may store 35-40 mm of water (depending on soil type), but only 10% of any soil water is available per day (3.5-4.0 mm/day), and this declines markedly if irrigating once a week. Irrigation systems are normally operated to replace the 3-4 mm per day used by the plant, but with evapo-transpiration losses of 7-8 mm per day, the plant experiences a short fall around 3-4 mm per day, and potentially more. This difference between what water is required and what is available translates into the difference between the 'potential' and achieved yield.

Processing potato yields did not increase as expected during the project, but the information collected and trends observed will enable growers to increase yields in a 'semi-normal' season. Even so, the CMS project outcomes will assist growers to maximise yield potential given a certain set of circumstances – good or bad.

Technology Transfer

To assist growers understand and data and implement any potential changes a detailed report was compiled for each CMS grower. The reports consisted of two sections; the first summarising all the CMS data from the current and previous seasons; the second was specific for each CMS paddock and enabled easy comparison to the growers other CMS paddocks, either in the same or previous seasons. Data on the district average, and the average for the Top-5 crops of the season was also visible for comparison. A generic report was compiled for growers not in the CMS by averaging the CMS results for each season, set against the average for a district and the average of the Top-5 crops of that season (Appendix IV).

Large group presentations were made in each of Tasmanian's major growing regions each year to allow all growers the chance to ask questions about the results, or make suggestions on future work. Numerous focus workshops lasting three hours with around five CMS growers at a time were conducted to provide a more personal explanation of the results and opportunity to examine their data in greater detail.

The Potato Calculator has opened new possibilities with the internet based system to model crop requirements for water and nitrogen on a daily basis. Many older farmers are not comfortable using the internet, but the necessary information can be faxed to them weekly or as required from a central data entry point. All that is required is the rain/irrigation and nitrogen data, which can be phoned into a message bank for entry into the Potato Calculator for report generation. Simplot Australia has since increased its evaluation of the Potato Calculator, and can see potential for this technology.

The CMS project functioned as a catalyst for many growers, encouraging them to critically examine their practices, with personalised information to determine what worked best under their management structure. Outcome adoption by growers not directly involved in the project can require several years of 'over-the-fence' monitoring to convince some of the merits of any new approach. This is particularly evident considering some enterprises are into the third generation of potato production.

Published articles relating to CMS:

Tasmanian Country, Nov 14, 2003 – "Potato firm's stocks grow" page 4

Tasmanian Country, Nov 14, 2003 – "Spud team spends up on support" pages 3-4

The Examiner, Nov 13, 2003 – "Farmer's boon crops up" page 65

Recommendations

The CMS project examined multiple yield and quality influencing factors for processing potato production. Although many factors appear correlated with yield, the basics need to be taken care of before the more intricate issues are addressed. The major controlling factor for processing potato production in Tasmania is irrigation management. Years ago, before plant and soil diseases were commonplace, a high potato yield could generally be achieved by irrigating more often. Today the application of additional irrigation almost certainly will cause disease issues that can be difficult to control even with the advanced chemistries available.

The Potato Calculator from New Zealand Crop and Food Research provides a predictive irrigation tool without the need for in field electronics to reveal soil moisture levels. Provided accurate water application data is entered into the Potato Calculator, the water demand modelling will reliably predict the required rate and frequency to maximise yield and minimise leaching. The Potato Calculator utilises: variety; planting date; soil characteristics; weather conditions, and; nitrogen fertiliser application, as all these factors influence the crop water requirements.

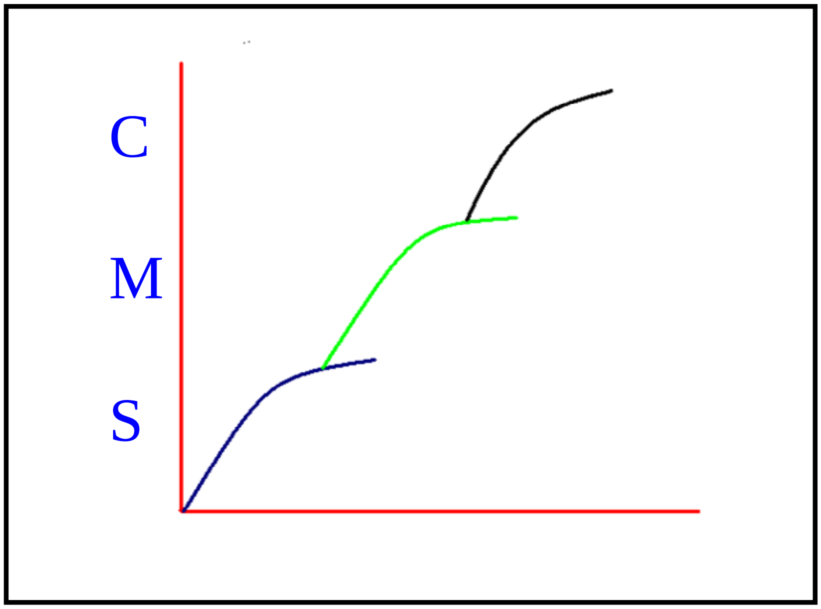
With the recent community focus on natural resource management, the need for responsible water and fertiliser management has never been more pertinent. CMS provided a starting point for understanding many of the factors involved with processing potato production in Tasmania, and the Potato Calculator has extended this understanding and provided a decision management tool to assist growers. The Potato Calculator is the perfect platform to build upon to provide a complete crop management tool for potato production. Additions to the Potato Calculator may include but should not be limited to:

- Specific Gravity (SG) prediction by date – especially for early production;
- Total yield monitoring – a season snapshot for processing companies;
- Spray diary and paddock recording system – reducing paper recording duties;
- Blight forecasting and prediction – to reduce unnecessary chemical application;
- Disease flagging – so problem crops can be easily identified;
- Hollow heart prediction and prevention – to increase quality and returns;
- Tuber size distribution prediction – matching market requirements;
- 7 day weather forecast – for proactive irrigation and crop management;
- Physiological age management – crop management tailored to seed age;
- Tuber rot prediction/prevention – warn against excess water application;
- Phosphorus and Potassium fertiliser recommendation – the missing links;
- Tuber bruising prediction/prevention – to increase quality/value;

The above can form ‘add-ons’ to the Potato Calculator, and used as required by either growers or processing companies. Some items on this list are already under-development by New Zealand Crop and Food Research, but others will require several years of research to amass the required data.

Soil variability will continue to cause problems for processing potato production, but if irrigation application can be varied accordingly this problem is diminished. A centre pivot in Tasmania's north east has been modified to apply variable rates of irrigation across pre-determined areas of the paddock. Jason Hall (previously of Scottsdale) developed the system, and its success has spurred the interest of others dealing with in- paddock soil type variation in other parts of Tasmania. Additional work around accurately mapping soil variability and providing this data to the software controlling the centre pivot is required to fully appreciate the benefits it will provide.

Appendix
I – CMS Guidelines Booklet



CROP MANAGEMENT SERVICE
2005 – 2006 Season

POTATO

For the benefit of the processing vegetable industry in Tasmania

Simplot AUSTRALIA

Introduction to the CMS – 2005/2006 Season

Potato and vegetable processing industries in Tasmania face a strong challenge to remain viable, due in part to a stalling in the productivity of raw material supply. The long-term future of some vegetable processing industries in Tasmania may be at risk as alternative supply areas embrace new technology and reap the advantages of strong productivity gains.

An example of this is French fry potatoes where the average yield of tubers in Tasmania has been 49 t/ha over the last 5 years, whilst competitors in New Zealand average 65 t/ha. These higher yields are also achieved in Tasmania by a small number of innovative growers, who are characterised by strong crop management skills. Their plant nutrition, irrigation and disease management decisions are often based on quantitative measurements of soil and plant nutrients, soil moisture and plant health.

Faced with these challenges we initiated the CMS in the 2003/2004 season. Extensive amounts of data was collected and analysed. The findings were communicated to the industry through feedback sessions and reports.

The major findings for the 2003/2004 potato CMS season were:

- ✓ The gross margin gap between high and low performing CMS crops was about $8,000 per hectare.
- ✓ Soil moisture management has a large impact on profit. The gross margin gap between stressed crops and well irrigated crops was about $4,000/ha!
- ✓ Soil moisture monitoring is important.
- ✓ Plant nutrition data has provided some great possibilities to boost profits for growers. Relationships between nitrate-N and yield are impressive.
- ✓ Opportunities to improve nutrition management are often related to other management areas, particularly irrigation.
- ✓ Disease management strategies are more successful when the basics of irrigation and nutrition are "on track".
- ✓ The 2003/04 crop (51.9 t/ha) was an improvement over the 5 year average (48 t/ha). The 59 CMS potato crops averaged 53.7 t/ha.

The major findings for the 2004/2005 potato CMS season were:

- ✓ The influence of plant nutrition on return has been further revealed.
- ✓ Manipulating plant population may boost yield.
- ✓ Higher soil organic carbon levels increase yield potential.
- ✓ Earlier planting (late October) increases yield potential.
- ✓ Following pasture or cereal produces higher yields.

The **goals** of the CMS remain unchanged in the forthcoming season.
We still aim to:

- ✓ Boost the international competitiveness of the Tasmanian vegetable processing industry by the rapid adoption of new crop management technology and the widespread use of professional agronomists. A key outcome of this aim will be more profitable farming enterprises.

- ✓ Collect, record and analyse key agronomy data from the crops as a valuable research tool for the whole of industry.

- ✓ Achieve a favourable environmental outcome through the rational use of irrigation water, chemicals and fertilisers.

We are pleased to have received positive feedback from the growers involved with the service in the first two years.

The redesigned format of the service worked well last year and we will be following the same format in the 2005/2006 season.

Market Failure

The vegetable processing industry in Tasmania is very fortunate to be serviced by some excellent agronomists/consultants.

Despite this, a degree of "market failure" is apparent at several levels:

- ✓ The adoption of new technology is slow for much of the industry.
- ✓ The use of agronomists is not widespread. Consulting agronomists have a strong impact on only about 20% of growers. Many other growers interact with agronomists in a spasmodic way and fail to build a complete picture of crop performance.
- ✓ Existing agronomists work closely with their clients, collecting data for individuals. The consulting agronomists have probably built large and very valuable data bases with client data. Unfortunately there is little evidence of the promotion of the R&D outcomes the pooled data to the broader industry to drive widespread change.

Simplot is keen to foster the development of stronger industry benefits through the rapid adoption of improved technology, the widespread use of professional agronomists by growers.

Description of the Service

Simplot has spent a large amount of time considering different approaches to getting the job done. They ranged from Simplot employing an agronomist and conducting a service for growers "in house" to providing money and co-ordination for the provision of the services by existing consultants. The latter was chosen because it will provide the data required to assist the growers and industry and also strengthen the position of existing consultants as well as growers. It is not Simplot's intention to enter the agronomy consulting market or to undermine the existing services.

The project in 2005/2006 will provide funds and coordination to service approximately 95 potato crops.

For each crop the project will provide funding for:

- ✓ A consulting agronomist (number of hours as per attached schedule)
- ✓ A pre-plant soil test
- ✓ 5 plant tissue nutrient tests
- ✓ Crop monitoring reports (as per attached schedule)
- ✓ Soil moisture data (logging)
- ✓ Soil and air temperature data (logging)
- ✓ Access to expert pest & disease diagnostic services (if required)

Potato

Crop Stage	Consultant	Scout
Pre-Plant	2	
Moisture & Weeds (Weeks 2-3)	1.5	
Moisture, Disease & Weeds / **1st** Petiole & Tuber specs (Week 5)		1.5
Moisture, Disease & Weeds / **2nd** Petiole & Tuber specs (Week 7)	1.5	1.5
Moisture, Disease & Weeds / **3rd** Petiole & Tuber specs (Week 9)		1.5
Moisture, Disease & Weeds / **4th** Petiole & Tuber specs & Consultant Review (Week 11)	1	1.5
Moisture, Disease & Weeds / **5th** Petiole & Tuber specs (Week 13)		1.5
Consultant Review (Week 15)	1	
Moisture, Disease & Weeds (Week 17)		1
Moisture, Disease & Weeds (Week 19)		1
Pre-Harvest Burnoff / Grub / Moisture / Plant/Stem Count & Tuber specs	1	1
Total Time Commitment (Hrs.)	**8**	**10.5**

The details of these services and the data collected for each participating crop is defined, (including minimum requirements) in the following pages.

Financing the Service

The project will provide:

- ✓ $2,300 per participating potato crop

This money is provided to pay for a consulting agronomist (based on hrs/crop), laboratory fees, scouting costs and the provision of soil moisture, and temperature measuring equipment. The funds allocated for each element of the service are listed below:

Service	Level of Service	Value ($)
Consulting Agronomist (Salary + on costs)	8 hrs/crop – 2 hrs. pre-plant talk and 5 visits @ 1 hr. to 1.5 hrs each as per schedule	$ 800.00
Crop Scouting (wages + car)	8 visits @ 1 hr to1.5 hrs. each (incl. travel time and car costs)	$ 400.00
Soil Test – Lab Fees	1 test	$ 90.00
Tissue Analysis – Lab Fees	5 @ $60.00 / test	$ 300.00
Soil Moisture Monitoring	Amortised cost + installation & training	$ 600.00
Soil & Air Temperature Recording	Amortised cost + installation	$ 100.00

It would be pertinent to clarify that if a higher level of service is required; the growers are free to negotiate with their consultants to suit their particular requirements.

The source of funding is the grower contribution of $0.25 per ton which is being matched 1:1 by Simplot. This fund is supplemented with a HAL contribution and a participating grower contribution.

- ✓ ***Each participating potato grower will contribute $650 and the Industry/Simplot/HAL fund will contribute the balance of $1,650 per crop.***

In addition Simplot will provide $ 72,400 of "in kind" assistance through the input of existing staff and resources to the CMS which also includes crops such as peas, beans and broccoli.

The participating grower and the agronomy consultant will provide a specified level of service and make available the specified crop agronomy data for pooled analysis. The data will be used as a research tool and to produce a technical report to be made available to all processing growers in Tasmania in each year. **The data will not be used to disadvantage individual growers, and the identity of individual growers will not be divulged in the R&D reports following analysis of the data.**

Payment

Simplot Australia Pty Ltd is administering the project. Payment will be made to growers/consultants in a "staged" manner as major items are completed to a satisfactory standard.

The participating growers' contribution will be deducted from the first cheque due to them after commencement of the harvest of their crop.

A discussion is held with growers before planting to:

- Identify potential problems (e.g. weeds, diseases, irrigation capacity, herbicide residues etc.).
- Plan specific technical programs in advance (e.g. fertiliser strategy, pest and disease management program, irrigation scheduling).
- Assist the grower's planning process, leading to the production of a "TIM" sheet.

Whilst the discussion may be wide-ranging and follow specific interests of the grower, allowing a degree of "tailoring" of services provided, certain elements are important to the CMS outcomes and the checklist below should be formally covered in the discussion and the attached data sheets filled out.

PLEASE USE THE LATEST VERSION OF THE PRE-PLANTING DATA SHEET – AS THE SHEET HAS CHANGED FROM THE FIRST CMS SEASON.

Timing Is Money (TIM) Checklist

The TIM Checklist is an aid to the pre-planting planning process. It aims to improve the value of the Agronomist's time spent with the grower in pre-planting discussions. The TIM sheet should be as simple as possible, representing the items that the grower feels is important to achieve success. A laminated copy to be carried "in the ute" is helpful.

THE BASIC AIM IS TO ENCOURAGE A GROWER TO INVEST AT LEAST 2- 3 HOURS IN:

1. REVIEWING PROGRESS

2. THINKING AHEAD, CONSIDERING THE OPTIONS

3. PRODUCING A SIMPLE PLAN – TO REMAIN FOCUSSED AND ORGANISED WHEN THINGS GET BUSY

The resultant plan is not a "recipe" for growing crops; it is a record of the grower's crop management intentions. Some notes concerning TIM and the attached checklist.

- ✓ Successful businesses invest time and resources to review their progress and producing plans for the future. The rapid rate at which technology develops means that "planning for change" in a continuous cycle.

- ✓ The review and planning process identifies problem areas, or opportunities, and considers the options available. The planning process also helps to ensure that important activities are not forgotten and are done on time.

- ✓ **The aim of the TIM approach is to help growers work through and discuss issues before planting to produce a basic crop management plan. It does not tell vegetable growers how to grow their crops. We respect them and leave that in their hands.**

In the last 15 years we have seen more money made and lost related to attention to detail and the timely application of key crop management operations…………than from the results of research carried out in Australia in the same period.

Attached is an Excel spreadsheet "example" of a TIM sheet for a potato grower. Feel free to adapt the TIM approach to suit your circumstances.

Paddock Work Sheet **Grower :**

Paddock : **Variety : Russet Burbank**

Action	Week After Planting	Date Planned	Date Actual	Pre-Season Grower's Choice	Pre-Season Rate	Actual Fertiliser/Spray	Actual Rate
Pre-Planting							
Planting		Sat-1/11/03					
Base Fertiliser				14:18:18	1.3 t/ha		
Pink Rot Control							
Pre-Emergenece							
Burnoff	Week 3	Sun-23/11/03		Sprayseed	3 l/ha		
Other Chemicals	Week 5	Sun-7/12/03		Sencor 480 SC	1.1 l/ha		
Re-moulding (if desired)	Week 5	Sun-7/12/03					
1st Petiole Sample (10mm Tubers)	Week 6	Fri-12/12/03					
Topdress 1	Week 6	Fri-12/12/03		Urea	123kg/ha		
Delay this operation only if N levels high Apply extra K or traces if petiole analysis indicates the need							
THIS FUNGICIDE PROGRAMME IS A GUIDE ONLY ADVERSE WEATHER CONDITIONS MAY REQUIRE AN EARLY START TO THE PROGRAMME OR SHORTENED SPRAY INTERVALS IF IN DOUBT CONSULT YOUR AGRONOMIST							
1st Fungicide (50% row coverage)	Week 6	Sat-13/12/03		Bravo	1.4 L/ha		
2nd Petiole Sample	Week 7	Fri-19/12/03					
Sample again now if first topdress operation not yet carried out							
2nd Fungicide	Week 8	Thu-25/12/03		Bravo	1.4 L/ha		
3rd Petiole Sample	Week 9	Fri-2/01/04					
Topdress 2	Week 9	Fri-2/01/04		Urea	123kg/ha		
Time this operation as guided by petiole analysis DO NOT WAIT UNTILL N LEVELS ARE LOW Apply extra K or traces if required							
3st Fungicide	Week 9	Tue-6/01/04		Bravo	1.4 L/ha		
4th Petiole Sample	Week 11	Fri-16/01/04					
This 4th sample may need to be taken to determine the need for the 3rd topdressing							
4nd Fungicide	Week 12	Sun-18/01/04		Bravo Score	1.4 L/ha 300 mls/ha		
Topdress 3	Week12	Fri-23/01/04		Urea	123kg/ha		
The neccessity or timing of this operation will depend on seasonal conditions Be guided by petiole analysis							
5rd Fungicide	Week 13	Fri-30/01/04		Bravo Score	1.4 L/ha 300 mls/ha		
5th Petiole Sample	Week -90	Wed-6/02/02					
The fifth sample is a useful tool to help develop future fertiliser programmes and may help determine the cause if early dieback is a problem							
6th Fungicide	Week 15	Wed-11/02/04		Bravo	2.2 kg/ha		
7th Fungicide	Week 16	Mon-23/02/04		Bravo	2.2 kg/ha		
Watch for signs of target spot Further applications of score may be necessary Consult your agronomist if unsure							
8th Fungicide	Week 18	Sat-6/03/04		Bravo	1.4 L/ha		
As the crop approaches senescence watch for the presence of potato moth If lack of water for grub control is a problem spray now							
Haulm knock down							
Irrigate to control potato moth							

System Description and Capability

See the Pre-Plant Planning Module.

Applied Irrigation and Rainfall

Irrigation and rainfall can be measured by a range of devices, from the simple plastic rain gauge through to electronic logging devices. Regardless of the system chosen, useful data will only come from devices placed in the right spot. Sprinkler patterns can be extremely variable. CMS needs accurate measures of rainfall and irrigation applied – date and amount.

A useful exercise would be to examine and map the water distribution pattern for the irrigation system. This can be done in theory using computer models, or in practice using catch-cans.

Soil Moisture Measurement

Many soil moisture measurement devices are available. As with rain gauges, their placement is critical to obtaining useful data. Devices placed in swamps or dry sand hills can generate some interesting data, but are not normally a good indicator of the soil moisture for main cropping area.

Logging devices are preferred. Non-logging devices do not provide the degree of information required by the grower, and do not allow detailed data analysis.

Common "main-stream" devices include:

- ✓ Capacitance probes (eg. GreenLight-RedLight, EnviroSCAN)
- ✓ Logging Gypsum blocks (granular matrix)

Sensor depths

Sensors should be installed **within 15 days of planting or 5 days of emergence** at the following depths:

- ✓ **Potatoes** **20-40-60 cm**

If more sensors are available they can be arranged as desired, provided the above are included, unless data indicates the above spacing is not suitable eg, duplex soil.

Sensors should be installed after consulting with the grower on the preferred position in the paddock. This prevents the collection of non-representative soil moisture data. **If this is not done, the consultant will be required to shift the probe at the grower's discretion and at the consultant's cost.**

As much as practicably possible, moisture reading should be synchronized with irrigation scheduling.

Feed back to growers on soil moisture is required at each visit, or faxed to growers within 24 hours of download.

PLANT NUTRITION

CMS aims to collect, combine and analyse key plant nutrition data for individual and whole of industry benefit:

- Maximise crop performance (yield and quality) through superior plant nutrition.
- Minimise fertilizer costs.
- Meeting community expectations on farming impact on the environment.

The technology available to growers for managing plant nutrition has developed in leaps and bounds. Financial rewards are high for those who use the new technology, such as advanced soil and plant tissue analysis and interpretation systems, and use skilled agronomists.

The Approach

Added fertiliser is an easily controlled and powerful tool to influence crop performance. The science of determining crop nutrient needs is complex, and a good nutrition strategy is not just about applying plenty of fertiliser to combat deficiencies. Excess fertiliser is a waste of money and may also cost the grower through reduced crop quality. The challenge is to apply the best technology to keep fertiliser costs to a minimum, and maintain the amount and balance of nutrients needed to maximise crop productivity.

CMS does not aim to produce fertiliser recommendations for crops. It aims to:

- **Promote the use of technology to predict and measure crop nutrient status.**
- **Encourage the use of agronomists to interpret crop nutrition data.**
- **Analyse the pooled data collected as an industry R&D tool to identify plant nutrition issues and trends.**
- **Assist individual growers to tailor a plant nutrition strategy.**

For experienced growers, major changes to fertiliser strategies are best made after the collection of a full set of data for a cropping cycle. I.e. avoid modifying with the existing system until good records are available.

Whilst some "in season" adjustments can be made in response to plant tissue test results to fix emerging problems (especially nitrogen, potassium, zinc, copper and manganese), **past experience shows that dramatically changing a fertiliser strategy week by week in response to the latest test results can be destructive.**

The results are best used to review the existing strategy at the end of the season with your agronomist and planning changes in the next cycle.

Soil Test

See the Pre-Plant Planning Module.

Plant Tissue Analysis

Two major technologies are commonly used to measure nutrients in plant tissue:
- ✓ Dry tissue analysis
- ✓ Sap analysis

Both techniques have keen followers in Australia. The pooled data analysis function of CMS would be simpler if all crops used the same technology. However CMS is keen to be "inclusive" of all views and will develop approaches to allow the combination and analysis of data from both techniques.

Minimum requirements for plant tissue analysis:

- Nitrate
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulphur
- Copper
- Zinc
- Manganese
- Iron

Results are to be returned to growers in a numerical and graphic format. Numbers alone are not well understood by growers, and trends are difficult to assess. **Results are to be provided to the growers within 5 working days in case of a Dry Ash Test and 2 working days in case of a SAP Test.**

Minimum number and timing of plant tissue samples:

Potatoes – 5 samples:
1. 10 mm king (biggest) tuber (~6 weeks after planting) (average from 4 plants)
2. +2 weeks
3. +2 weeks
4. +2 weeks
5. +2 weeks

On each sampling occasion it is important to record:
- ✓ **Grower, paddock name**
- ✓ **Variety**
- ✓ **Date of sample**
- ✓ **Stage of growth**
    - o **Potatoes - average king tuber size from 4 plants**

CROP MONITORING

The examination of factors affecting crop performance will rely heavily on information gained at the weekly crop monitoring visits made by scouts.

The CMS approach to crop monitoring is very formal, with strict procedures and printed recording sheets for crop monitoring data. Without this approach, crop monitoring can quickly degenerate into a "quick look around" which fails to generate or record the data needed for analysis.

Growers should not base their control (pest, disease and weeds) solely on the crop monitoring sheets. Many problems, such as target spot in potatoes, need pre-emptive management programs.

The Approach

The CMS crop monitoring program is based on a trained crop scout visiting each crop weekly to examine the crop and complete a crop monitoring sheet.

A crop monitoring sheet (see attached) has been designed for each crop (potatoes, peas and beans). **The sheet is filled out "on the spot" by the scout in duplicate. One copy is left in an agreed location in a waterproof sleeve for the grower; the other is retained for the agronomist – many growers did not receive this last season.**

Data from all of the sheets will be entered into a database to assist with the identification of factors impacting on crop performance.

The Scout

Crop scouts need to be reliable people with significant "on the job training" to perform the tasks and recognise the pests, diseases and weeds. Scouts need to have good eyesight, be physically fit and able to walk long distances.

The scout should have access to back-up help (agronomist or pathology laboratories) to help identify unusual cases.

It is important that the scout is trained in farm hygiene procedures and follows these and other grower requests closely. Scouts are at risk of being blamed for disease outbreaks.

The Crop Monitoring Sheets

The sheets (attached) are pre-printed and taken on a clipboard to the crop. Writing on crop monitoring sheets can become difficult in wet-muddy conditions and some scouts have preferred to use a small voice activated tape recorder whilst in the crop. The data is transcribed (with clean hands) before moving on to the next crop.

- ✓ The top of the sheet records the grower, paddock, date and crop growth stage.
- ✓ The next section records the general appearance of the crop.
- ✓ Some notes (such as "plants wind damaged" or "leaves very pale") can be added in the next box.
- ✓ Pests and diseases of interest are specified in the large table. The scout (after examining the crop) records either "nil", "light", "moderate" or "high" for each pest or disease. A comments box is available next to each entry if needed.
- ✓ Weed infestation is noted in the same way. The identity of the worst weeds should be entered under comments for crops with moderate or high weed ratings.
- ✓ Crop development observations are made in the next table. In the case of potatoes, 4 plants are dug up across the paddock and the number, size and health of the tubers are entered.
- ✓ Soil moisture (spade, by feel) is assessed at two depths by the agronomist/scout at each visit as a check against data recorded by the soil moisture device.
- ✓ Scouts generally collect plant tissue samples and take soil moisture readings at the visits.

Crop Monitoring

Scouts should plan to spend 30 minutes actually walking and examining a crop per visit. This is in addition to time spent collecting samples, reading moisture probes or travelling.

Experience has shown that "mindlessly" walking every 10th row (or similar strategy) is not the best use of a scout's time.

A "mud map" should be drawn to highlight potential trouble spots, often identified in the pre-plant talk:

- ✓ Poorly drained areas
- ✓ Existing soil borne pathogen hot spots
- ✓ Areas exposed to damaging winds
- ✓ Low fertility soil areas
- ✓ Areas that "look poor"

One approach is for the scout to keep a close eye on the trouble spots and also rotate (weekly inspections through other areas in the crop. Records of crop development (tuber size etc) and plant nutrition samples should be taken from normal/typical areas.

Temperature Loggers

CMS is very interested in looking at the effect of soil and air temperature on crop development and performance. Modern temperature loggers have become cheap and reliable. The agronomist will install and download a soil temperature logger and an air temperature logger.

Temperature loggers should be **installed within 5 days of planting and set to log at 2 hour intervals**. They should be positioned at:

> **At sett depth for soil temperature and 1 metre above mould height for air temperature (under a white plastic cup or similar).**

Other Crop Data to be Recorded

Potatoes

✓ Number of plants per m of row. ✓ Number of stems per plant	Based on 10 counts of 5 metres (covering both sides of the planter)

For all crops – grower to record all crop management activities, including:

- ✓ **Planting date**
- ✓ **Fertiliser applied (type, rate and date)**
- ✓ **Chemical applied (type, rate and date)**
- ✓ **Cultivations**
- ✓ **Irrigations**

A scouting sheet has to be filled in by the consultant and the scout independent of each other on EACH visit to the paddock. Please use the latest version of the scouting sheet – as the sheet has changed from the first season.

IRRIGATION

Studies of vegetable cropping in Tasmania have consistently identified irrigation management as a major driver of crop performance.

Whilst many enterprises have irrigation systems that are not very flexible, measuring and understanding the financial impact of irrigation management is an important tool for growers weighing up the benefits/cost impact of upgrading their system or changing their scheduling approach. Some experienced sweet corn growers in NSW received a shock (beneficial) from the financial analysis of moisture stress on crop performance.

CMS aims to collect and analyse key irrigation and soil moisture data. In addition to improving financial returns, this data will help growers to meet the increasing community pressure to maximize returns per mega litre of water and minimize waste.

The technology available to growers for scheduling irrigation has rapidly improved and become cheaper over the last 5 years. Logging capacitance probes (which measure soil moisture in mm) are becoming a common option, replacing the old tensiometer and neutron probe technology. Revamped versions of gypsum blocks are also making a come-back.

The Approach

Modern irrigation systems have used technology to bring a lot more precision to the job of applying water to crops. Unfortunately the irrigation decision-making process has remained "an art" with some growers – and many have developed high levels of skill in the "kick the dirt" approach. Whilst a critical and experienced eye will still be needed to check on even the most technologically advanced system, progress depends on change.

Measurement will be the driving force of improved profits from better irrigation. Measurement of:

- ✓ Irrigation applied
- ✓ Rainfall
- ✓ Soil moisture

These measurements will be combined with improved estimates of weather (a week ahead) and crop water use models.

CMS does not aim to tell growers when or how much to irrigate. It aims to:

- **Promote the widespread use of technology to measure and record soil moisture, irrigation applied and rainfall.**
- **Promote a better understanding of crop water use at different growth stages.**
- **Encourage the use of agronomists to combine advanced weather forecasts with crop water use models and soil moisture information.**
- **To analyse the pooled data collected as an industry R&D tool to identify irrigation issues and trends.**

II – CMS Pre-Plant Discussion Form

PRE-PLANTING DATA SHEET (page 1 of 4)

Personal Details

- Names of grower, spouse, and other people involved with crop management

Grower	
Spouse/Partner	
Other	

- Postal address

- Telephone/mobile/fax/Email

Mobile: Phone: Fax:
Email:

- Preferred method of communication

Method:
Best Time (if applicable):

Crop Details

- Paddock name and location (needs to be identifiable in the future – mud map)

- Crop area ______ acres or ______ ha
- Variety ______ Seed Inoculated y n

(note method and timing)

- Planned planting date / /

PRE-PLANTING DATA SHEET (page 2 of 4)

- Seed spacing

Potatoes Distance Between rows: & Between sets:	**Peas** Seeds/m^2:	**Beans** Seeds/row m:

- Soil types

Main type: Other types: • • •	(% area)	e.g. Sandy loam (60%)

- Soil test (also needed for Nutrition module)

Minimum requirements: • Soil nitrate • Ammonium • Phosphorus • Potassium • Calcium • Magnesium • Sulphur • Copper • Zinc • Manganese • Iron • Boron • Chloride • pH (water and $CaCl_2$) • Organic carbon • Salinity • CEC • Electrical Conductivity	Note that CMS is flexible with units/methods employed to measure these attributes. However it is important to use “mainstream” approaches where possible to make analysis of the pooled data easier. **N.B. Please include a copy of the soil test - do not record the information here**

PRE-PLANTING DATA SHEET (page 3 of 4)

- Irrigation

System description: System capacity (mm/hr): Volume of water available: Preferred irrigation approach: (e.g. 20 mm applied per irrigation, minimum turnaround time 4 days)

- Notes on the grower's preferred fertiliser application strategy (pre-plant, plant, post plant). (e.g. "no fertigation capacity" or "does not like to drive over crop after planting to spread fertilizer" or "wants to keep planting fertilizer below 750 kg/ha to speed planting")

Pre-plant *Broadcast or drilled*	
At planting	
Top dressing	
Fertigation	
Foliar application	

PRE-PLANTING DATA SHEET (page 4 of 4)

Paddock History

Rotation history, use over the last 5 years	Summer - Winter • -5 - • -4 - • -3 - • -2 - • -1 -
Known weed problems	
Known disease problems (especially soil borne)	
Physical issues: eg. hard pan, erosion, swamp, steepness, aspect, stones, etc	
Residual herbicides previously used (type, rate and date)	
Fertiliser, lime and gypsum history	
Notes on the last time a crop of this type was grown in this paddock: • Yield and quality performance • Pest, disease and weed issues • If available - Attach copies of past records and crop data (fertiliser program, plant tissue tests etc.)	

III – CMS Potato Scouting Sheet

CMS CROP MONITORING SHEET – POTATOES 2006-07

GROWER: ____________ **INSPECTION DATE:** ____________

PADDOCK: ____________ **GROWTH STAGE*:** ______

*P = pre emergent
*E = young emerged
*H= hook stage
* (mm) of Av. king tuber

General Appearance of Plants (circle)
Plant Vigour and Colour: **Poor** **Fair** **Average** **Good** **Excellent**

General Notes:

Nil=not found Light=difficult to find (easily controlled) Mod=easily found /controlled High=hard to miss/control

Pests & Diseases	Nil	Light	Mod	High	Comments
Common Scab					
Powdery Scab					
Rhizoctonia					
Target Spot					
Late Blight					
Fusarium					
Sclerotinia					
Virus Leaf Roll					
Virus – Other					
Verticillium					
Black Dot					
Black Leg / Soft Rot					
Botrytis					
Pink Rot					
Pythium					
Nematodes					
Aphids					
Potato Moth					
Leafhoppers					
Weeds					
Other					

Tuber Development	No. of tubers				***Notes (also at last visit)***
At Petiole sampling	Plant 1	Plant 2	Plant 3	Plant 4	
Haulm Length mm					(above ground)
Number of Stems					
0-50 mm					
50-100 mm					
100 + mm					
Total # tubers					
Hollow Heart					
Brown Centre					
Second Growth					

Soil Moisture (by feel)					
	Dry (not form ball)	Fair (ball just holds)	Good (ball holds together)	Wet (free water)	Notes
0-20 cm					
20-40 cm					

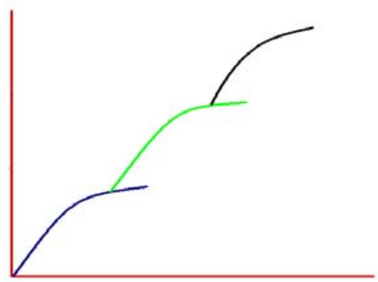
Samples taken this week: **Samples to be taken next week:**

IV – Generic CMS report

Crop Management Service

PROFIT FROM EXPERIENCE

C
M
S



….YOUR OWN

Gull C

Potatoes

2006-07

ACKNOWLEDGEMENT

Crop production is a demanding business. Growers must deal with rapidly changing technologies, community expectations, “Mother Nature” and, in the end, obtain a financial outcome in a competitive world.

Simplot would like to thank their growers for the on-going support shown to the Crop Management Service concept. Thanks also to the Agricultural Consultants of Tasmania, who passed on the collected data. I would also like to thank Sharon Saunders for entering the 2006-07 data and other field service staff who assisted with data validation and organising meetings.

This is the culmination of four seasons of potato data collected from various growing regions of Tasmania. It is hoped this process has stimulated interest in the local potato industry, and assisted in the adoption of new technology and information through agronomists and others.

Developing trends from the collected data is often difficult due to “mother-nature” and other unforeseen challenges, but now the large data set allows exclusion of seemingly erroneous data while still providing sufficient data for statistical purposes.

FOREWORD:

The Crop Management Service (CMS) concept was created in early 2003 by Mark Heap and Nikhil Tandon.

CMS was intended to collect and provide data to growers to assist with crop management decisions – NOT to give advice or take responsibility for crop performance.

Funding was provided by Horticulture Australia Limited (HAL), participating potato growers and Simplot Australia.

"Fee for service" consultants, chosen by each potato grower, were used to gather data from the large area of Tasmania that supplied potatoes to Simplot. This report examines data for 59, 97, 90 and 60 potato crops from 2003-04, 2004-05, 2005-06 and 2006-07 respectively.

Ideas on how to improve CMS have always been welcome, please contact Chris Russell on 03 6422 6512 if you have any questions or comments.

STOP PRESS! 2003-04

- The gross margin range was $1,000 to $9,000 per hectare for CMS crops.
- Soil moisture management has a large impact on profit. The gross margin gap attributed to irrigation management was $4,000/ha!
- Soil moisture monitoring is important.
- Plant nutrition data has provided some great possibilities to boost profits for growers. Relationships between nitrate-N and yield are impressive.
- Opportunities to improve nutrition management are often related to other management areas, particularly irrigation.
- Disease management strategies are more successful when the basics of irrigation and nutrition are "on track".
- The 2003/04 crop (51.9 t/ha) was an improvement over the previous 5 year average (48 t/ha). The 59 CMS potato crops averaged 54.5 t/ha.

2004-05

- The influence of plant nutrition on return has been further revealed.
- Manipulating plant population may boost yield.
- Higher soil organic carbon levels increase yield potential.
- Earlier planting (late October) increases yield potential.
- Following pasture or cereal produces higher yields.

2005-06

- Irrigation frequency can increase yield up to 5 T/Ha (~$1,000 /Ha).
- Increasing plant population may increase yields 5 T/Ha (~$1,000 /Ha).
- Plant nutrition offers opportunities to increase yields.
- Cropping frequency could increase yields by 5 T/Ha (~$1,000 /Ha).

2006-07

- Plant population could increase return by $2,000/ha.
- Plant size (haulm length is correlated with return – $3,000/ha).
- Calcium to Magnesium ratio can return $4,000/ha.
- Nitrogen fertiliser rate could return $1,500/ha.
- Banded Phosphate rate could return $1,000/ha.
- Potassium application is best made at planting or soon after.
- Higher soil organic carbon can increase return by $2,000/ha.
- Lengthening rotation can increase return by $2,000/ha.

END OF SEASON SUMMARY

After the potato harvest was completed, the entire crop monitoring information was compiled into databases for interpretation and comparison.

Your paddock report contains the following:

- Overall summary
- Paddock record
- Irrigation summary
- Soil nutrient trends
- Crop summary
- Crop fertiliser summary
- Pest, disease and weed summary
- Plant population summary
- Climatic data summary

Key benefits of the End of Season Summary:

⇒ The collected information from your paddock is compared with data from other growers over three seasons.

⇒ The review will allow profitable changes to be planned for next year.

⇒ Enable better R&D programs to be planned for industry benefit in the future.

The first section of this report examines the combined data for all CMS crops in 2003-04, 2004-05, 2005-06 and 2006-07. The second section focuses on each of your paddocks individually (or the CMS program average), and the performance factors with the greatest influence on yield and profit.

POTATOES IN TASMANIA – SUMMARY

Drought reduced the total production level in 2006-07. Yields were above average provided growers had sufficient access to water and suitable infrastructure to meet crop water requirements, as little relief came from above. The lack of abundant water caused problems with grub damage prior to digging, affecting quality and yield. Surprisingly rots associated with water application were evident, emphasising the importance of irrigation management even when water levels are low.

Recurring frosts punished some early crop yields, the lowest being 17.5 T/Ha.

Figure 1 shows the spread of processing yield for CMS potato crops from the four seasons (2003-04, 2004-05, 2005-06 and 2006-07).

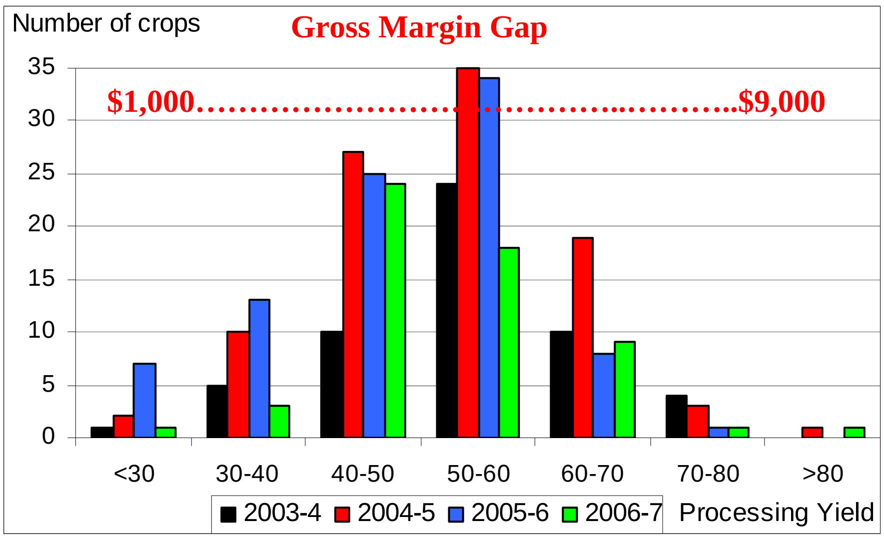


Figure 1. Tonnes per hectare for CMS potato crops.

The minimum, average and maximum CMS potato yields are summarised in table 1.

District	Year	Minimum	Average	Maximum
Midlands	2003-4	41.9	47.7	52.5
	2004-5	26.4	43.4	58.0
	2005-6	29.1	41.5	61.5
	2006-7	43.8	53.6	62.3
North East	2003-4	35.1	48.6	63.8
	2004-5	39.2	50.5	64.7
	2005-6	26.5	45.8	62.9
	2006-7	17.5	46.1	57.3
North West	2003-4	29.5	56.6	80.0
	2004-5	24.2	53.4	82.0
	2005-6	21.4	50.7	74.2
	2006-7	34.6	52.6	87.2

Table 1. Processing yields for CMS potato crops by district.

Table 2 summarises the Yield, Specific Gravity, Reject, Size and Bruise Free data from all CMS potato crops by season.

	2003-4	2004-5	2005-6	2006-7	Average
Yield T/ha	**54.5**	**51.9**	**48.2**	**51.6**	**51.6**
Specific Gravity	**1.085**	**1.085**	**1.086**	**1.084**	**1.085**
Reject %	**3.0%**	**2.4%**	**2.8%**	**3.2%**	**2.9%**
Size %	**57.8**	**55.0**	**48.5**	**58.7**	**55.0**
Bruise Free %	**87.7**	**89.6**	**91.1**	**88.6**	**89.3**

Table 2. Yield and Quality data for CMS potato crops (four seasons).

Specific gravity has shown virtually no change while size and bruise free appear inversely related, with smaller tubers being more resistant to bruising. Reject levels have remained generally low but were the highest in 2006-07.

Plant diseases such as *Rhizoctonia* and the resultant rough potatoes caused some significant losses, suggesting the need for Amistar or other chemical control if problems are expected.

Common scab appeared worse this season than normal, possibly related to the dry start, but powdery scab was a problem as well, which requires wetter conditions – probably after the soil was final wetted up.

White Fringed Weevil was typically not an issue where chemical control was used.

Eelworm/Nematode appeared worse in 2006-07 than for many years previously, possibly related to the very dry summer conditions. Chemical control is an option (not preferred), but using rotation may provide acceptable control – more information and work is required for a satisfactory answer.

Tuber slug damage occurred if paddocks were not dug early enough.

Potato moth/grub damage was significant where water was not available to prevent moth movement down cracks in the soil.

Pink rot and tuber rots not initially resembling pink rot caused considerable losses for some, even where excessive water was not applied. Ridomil granules and foliar applications would be advisable if in doubt, but enhanced bio-degradation is becoming an issue.

Pre-cutting is being used by more growers each season, with the logistical and insurance benefits justifying the additional cost. Timing of pre-cutting is being examined in replicated experiments this coming season.

Later planted crops suffered some breakdown issues due to weather conditions, but overall the season was not hampered by significant seed breakdown issues.

DATA COLLECTION

CMS has helped growers to fund consultants to gather key soil, moisture and crop data during the season. The data collected for each potato crop includes:

- Soil test for Nitrate (NO_3), Ammonium (NH_4), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), Copper (Cu), Zinc (Zn), Boron (B), Manganese (Mn), Iron (Fe), pH, Organic Carbon (OC), salinity (EC), Sodium (Na), Chloride (Cl), Cation Exchange Capacity (CEC)
- Plant tissue tests (x5) for N, P, K, S, Ca, Mg, Zn, Cu, Fe and Mn. (Other elements, such as Molybdenum were measured for some crops).
- Soil moisture
- Soil and air temperature
- Pest and disease incidence
- Yield and quality data

The data has been examined to determine which factors influence potato profitability through yield and quality. Literally hundreds of relationships/interactions were examined to assess the relationship of most factors on yield and quality.

CMS now has detailed data from over 300 crops over four quite different seasons, which allows more accurate determination of the major factors contributing to potato productivity. Yield and return have been "standardised" where necessary to remove the seasonal effect on various parameters.

A cost analysis for both fertiliser and fungicides has been included in this final report. This information is based on the list price of Urea for Nitrogen, Triple Super for Phosphate and Muriate of Potash for Potassium. The fungicide costs have been based on typical retail costs, but no "special-rates" have been factored in!

On most graphs shown in this document a trend line is drawn (usually in **red**) where appropriate. Trend lines illustrate potential relationships in the graphed data (X axis – horizontal and Y axis – vertical). Other statistical tests have been used to justify the trend line if necessary.

The R^2 value (if shown) reveals how close the graphed data is to the trend line, with 1.0 being perfect (but very rare). If you have any questions about this document please contact Chris Russell.

IRRIGATION

Irrigation is **the major factor influencing potato profitability** that can be controlled. This section aims to help growers profit through better irrigation management decision

There was insufficient winter rain during 2006 to fill water storages and subsoil moisture was low come planting time. Weather conditions did not hinder planting, although dry soil in the mound caused staggered emergence in some crops. Getting the centre of the mould wet was then a real struggle, and required more water than if it had been applied prior to planting.

Maintaining ideal soil moisture during the growing season was also difficult as no relief came from above. Stretching any limited water supplies caused yield and quality penalties, and moth/grub damage was sometimes severe as cracks opened up and could not be sealed by irrigating. Rolling is one alternative, but digging is really the only sure fire remedy.

Irrigation systems vary in their water use efficiency, with the most efficient (drip tape) not being used locally. If water shortages continue causing the cost of water to increase markedly the more efficient irrigation alternatives may become attractive. Unfortunately more water efficient irrigation equipment is more expensive than the "old-traveller" which has served Tasmanian farmers well in the past. Other advantages such as in season labour savings combined with ease and speed of watering should be considered when evaluating new and/or different irrigation systems.

New technologies to reduce evaporation, both from water storages and the crop, along with moisture retention products (Zeba®) have emerged, and will be evaluated more thoroughly in the coming season. Zeba® is particularly interesting, it retains 400 times its own weight in water for release to the crop as required. Applied at 5 kg/ha ($33/kg) it will hold an extra two tonnes (2,000 L) of water which may have been potentially lost from the root zone (along with the nutrients in solution). For **sandy soil** this will reduce potential water stress, while allowing larger irrigations to be applied less frequently. Higher yields of better quality potatoes are expected. Incorporating Zeba® with the fertiliser may reduce phosphate lock-up on **heavier soil** by limiting the normal wetting and drying cycle, especially for Ferrosols.

Another product called Floragard is applied by sprayer and designed to restrict evaporative losses from plants. Trials on potatoes and sweet corn last season were plagued with problems (not enough water in Tasmania, and rains in NSW), so repeat trials are planned for the coming season. Combined with Zeba® it may well make sandy/lighter banks in paddocks more productive while reducing the likelihood of over watering the heavier soil to keep the lighter banks wet.

The effect of moisture stress depends upon timing, severity and duration, and listed below is a summary of the consequences of water stress for Russet Burbank throughout the season:

1. The early vegetative stage: Moderately dry soil is common at this stage and has been shown to reduce the number of tubers set, mildly reduce the total yield, but often increases the average tuber size.
2. Tuberisation: Water stress at this stage can substantially reduce tuber yield and quality, with a particularly severe impact on tuber shape and other defects.
3. Early – mid tuber bulking: Water stress at this stage is the most damaging, resulting in significantly lower yields, reduced tuber quality (poor shape, dark ends/sugars), lower % size and lower specific gravity.
4. Late tuber bulking: Water stress is less damaging than stress during early – mid tuber bulking, but can still cause a large financial loss.
5. Maturation: Extremely dry soil at this stage can reduce dormancy and limit storage life, reduce the amount of carbohydrate transferred from the dying vine to the tuber, and increase the incidence of blackspot bruising.

Table 3 contains standardised CMS potato yields from different irrigation systems across various soil types and seasons.

ator Type	Main Type	2003-4	2004-5	2005-6	2006-7	Grand Total
	Clay/Clay Loam	56.0	54.8	54.6	54.4	54.9
	Sand/Sandy Loam	62.6	56.2	53.7	43.3	54.2
	Total	**56.8**	**54.9**	**54.5**	**53.2**	**54.8**
t/Linear/Boom	Duplex	49.6				49.6
	Clay/Clay Loam	46.1	59.4	55.3	51.3	54.2
	Sand/Sandy Loam	47.1	48.8	48.2	47.6	48.2
	Total	**46.9**	**54.4**	**53.3**	**47.8**	**51.9**
l Set	Clay/Clay Loam	47.1	60.5	61.4	57.3	56.6
	Sand/Sandy Loam	55.0	64.2			59.6
	Total	**51.0**	**62.4**	**61.4**	**57.3**	**57.6**

Table 3. Standardised Processing yields for CMS Potato crops vs' irrigation type for soil types and seasons.

Unfortunately the solid set data represents only one paddock per year per soil type, so this data could be argued as non representative, but has been included nonetheless.

Theory suggests yields should be higher for pivot/linear/boom systems, and solid set as the water delivery is potentially more "rain-like". Optimising the management of these different irrigation systems may see the expected yield differences be realised, assuming no other limiting factors are present – see below.

Additional access to water within any soil should increase potato yields, and the irrigation system could influence this in the following way. The effects of compaction are somewhat elevated when soil is saturated. Saturated soil has lower resistance to root penetration, and hence the rooting depth increases. Irrigation systems that deliver smaller quantities of water reduce the likelihood of soil saturation, restricting potential rooting depth, limiting crop yield.

Ideally compaction issues would be remedied prior to planting, maximising yield potential regardless of the irrigation system. Over application of water is fraught with danger, especially late in the season when tuber rots can devastate the crop, combined with additional nutrient leaching losses. The importance of using monitoring tools to manage this delicate balance can not be overstated.

Heavier soil holds more water than lighter soil, allowing larger irrigations to be applied less often. However, information from New Zealand Crop and Food Research (NZC&FR) suggests only a fraction (10%) of the water stored in the soil is available in any one day. This means even a heavy soil holding 40mm of water in the rooting zone can only supply 4mm after irrigating, reducing to 3.6mm the following day and so on. Even immediately after irrigation the water available for crop growth is lower than required on a typical summer's day, resulting in water stressed crops. This may explain why even recently watered crops can appear to wilt.

Irrigation frequency appeared to influence yield until the final seasons data was added to the database, but now no correlation is evident.

Irrigation "thoughts"

- ✗ Avoid planting into dry soil
- ✓ Set up irrigation systems as early as possible
- ✓ Invest in good probes – know what is happening
- ! Don't get left behind at 4-6 weeks, remember that crop water uptake increases very quickly around hook stage

Simplot in association with Rural Development Services with support from Natural Resource Management (Landcare) have established a project to assist growers with water management and budgeting. It is planned to establish a demonstration farm within each Simplot Grower Business Group.

PLANT POPULATION

Plant population determines the amount of sunlight intercepted, and can reduce weed pressure through shading. Population also determines the need for fertiliser and water, and influences the number of stems. Figure 3 shows plant population against CMS returns.

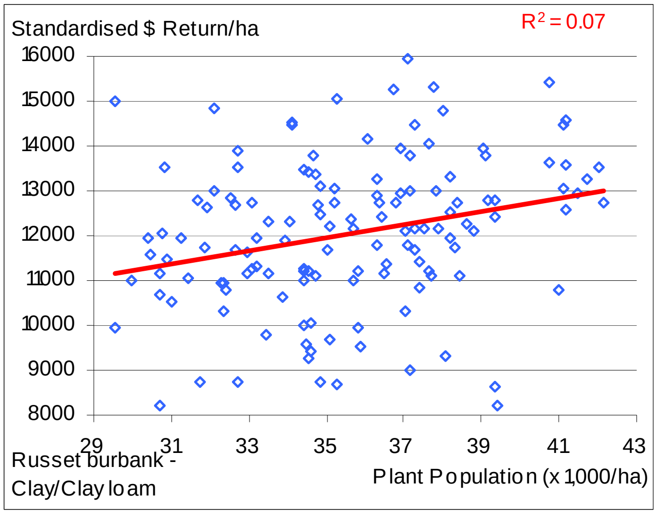


Figure 3. Plant Population vs' Standardised CMS Return (four seasons data).

Allowing $450/t for seed, and 60 gram setts, with 100% emergence, every extra $100/ha of seed returns $590/ha (Figure 4).

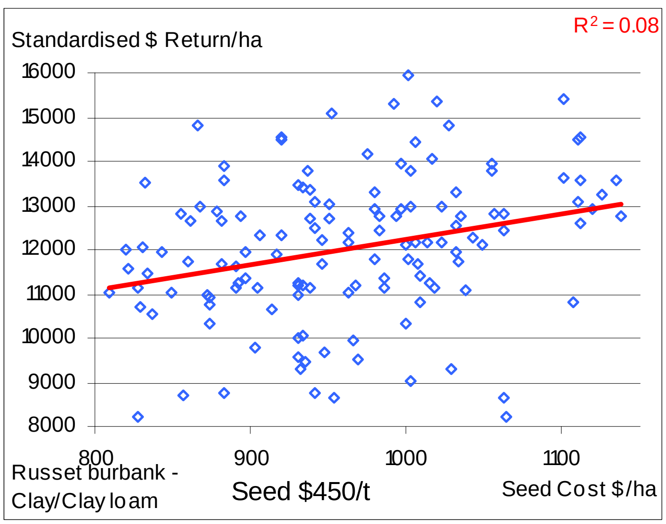


Figure 4. Seed Cost/Ha vs' Standardised CMS Return (four seasons data).

However, the lower populations shown above were potentially the result of seed breakdown, rather than good seed planted at a lower density, so this trend line could well be flatter than shown above.

Seed physiological age determines stem numbers, but it appears plant population has some influence (Figure 5).

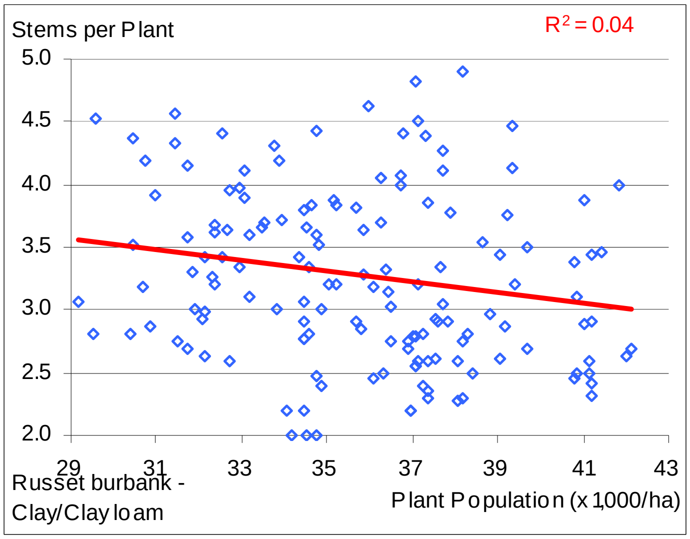


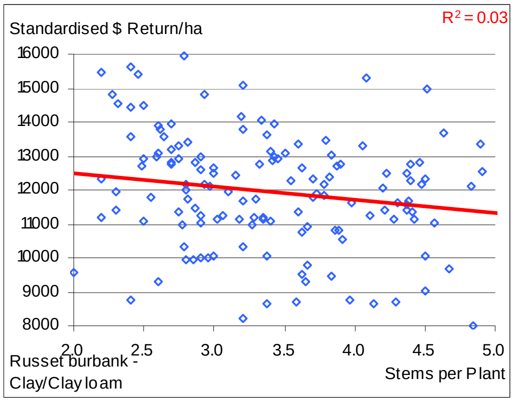
Figure 5. Plant Population vs' Stem number (four seasons data).

This may reflect lower P-age seed being planted at a higher density, but higher plant populations increase the level of competition between plants for the available nutrients and moisture, potentially restricting stem numbers.

CMS data shows:

- **<u>No</u> correlation between plant population and tuber size!**
- Consistent tuber numbers per plant regardless of population.
- Higher populations increase tuber number per stem.
- Higher yielding crops have larger tubers.
- Tubers per stem does **<u>not</u>** influence tuber size, but tubers per plant does.

Four years of CMS data suggests plants with a higher stem number produce lower returns (Figure 6), and smaller tubers (Figure 7).



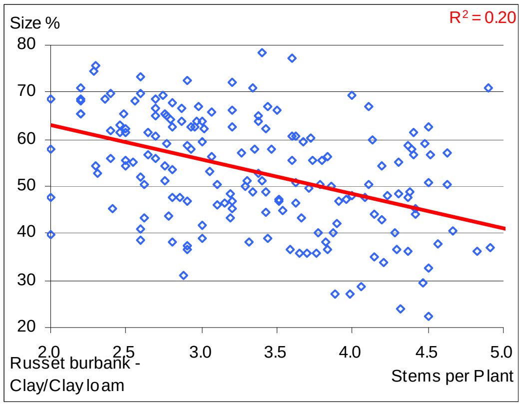


Figure 6. Stems per plant vs' Standardised Return

Figure 7. Stems per plant vs' Average Tuber Size

Increasing the plant population increases the crop nutrient and water requirement. If the plant population is increased without increasing water and nutrient inputs tuber size is likely to be lower, along with yield.

CMS data indicates return/ha is consistent regardless of the number of stems/ha – which is the European approach (Figure 8 Stems/ha).

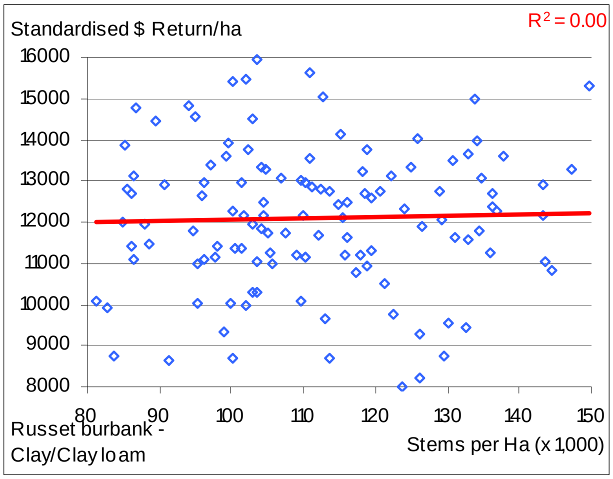


Figure 8. Stems/ha vs' Standardised CMS Return (four seasons data).

Seed producing more stems/plant at a lower population should generate a similar return to seed producing lower stems/plant planted at a higher population. The advantage of seed producing more stems/plant is the potential to reduce seed cost/ha.

The length of haulm (kilometres/ha!) is correlated with return, as shown in Figure 9.

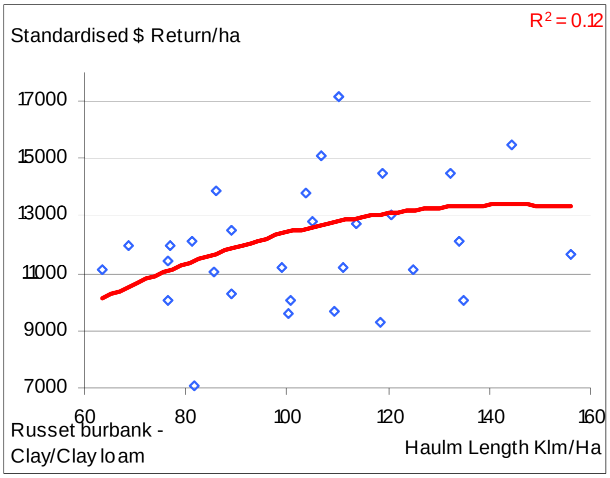


Figure 9. Haulm Length/ha vs' Standardised CMS Return (one seasons data).

Additional haulm (plant material) per hectare increases the crop photosynthetic capacity, to the point where no additional sunlight can be intercepted (shading). Maybe younger P-Age seed is not as essential for high yield as thought?

SOIL AND PLANT NUTRITION

CMS acknowledges the complexity of interactions between the soil and plant, and notes the dangers of advocating change based on small data sets. The relationships in this section are presented to stimulate thought, discussion and pave the way for future work.

Fertiliser is a significant cost of crop production, and a major driver of yield and quality. A good nutrition strategy draws on information from soil and tissue tests, in conjunction with local grower and/or consultant experience. Maximum profit is achieved when the cost of additional fertiliser does not exceed the additional income generated.

Soil pH – Calcium (Ca) and Magnesium (Mg)

Soil pH shows no link to CMS potato yields spanning four seasons. However, the combined tuber disease score declines as soil pH rises.

Theory suggests the most productive pH is 6.4 (water), which maximises the availability of trace elements in the soil (and tuber Specific Gravity see below).

pH does not determine soil fertility, and does not dictate the need for lime. Soil with a pH above 6.4 may still need lime if the Calcium (Ca) level is low – Calcium to Magnesium ratio (Ca:Mg) below 4:1.

The soil Calcium to Magnesium ratio is often ignored when assessing soil fertility. CMS potato data over four seasons suggests a Calcium to Magnesium ratio around 4:1 is the most like to maximise yield (Figure 10), and Specific Gravity (Figure 11).

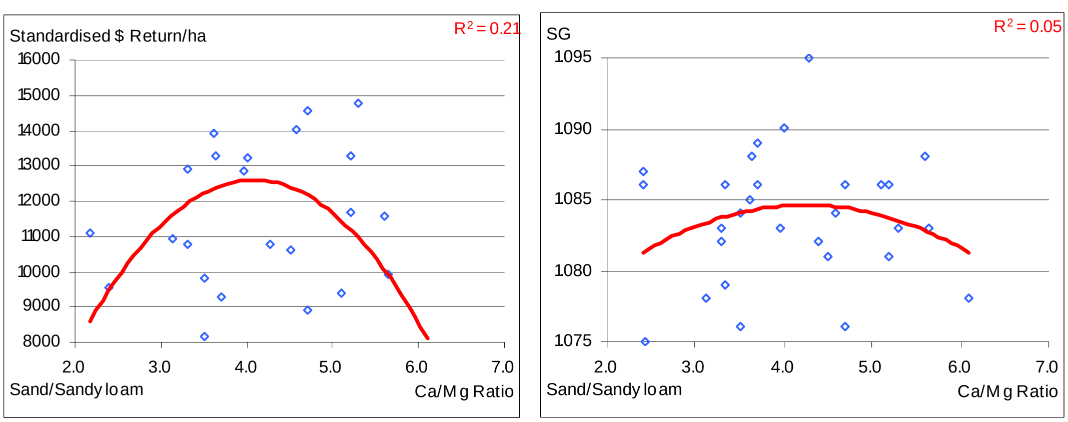


Figure 10. Soil Calcium (Ca) to Magnesium (Mg) ratio vs' Standardised Yield and Specific Gravity Figure 11 (four seasons data).

Figures 10 and 11 refer to sand and sandy loam soil – all varieties

Nitrogen (N)

Soil and fertiliser N is normally a powerful driver of crop yields.
Inadequate N can have a big effect on income through:

- •Reduced total tuber yield.
- •Reduced tuber size.
- •Increased susceptibility to some diseases, such as early blight, *Verticillium* and *Rhizoctonia.*
- •Reduced specific gravity in extreme cases where early plant death occurs.

Excess N can reduce tuber quality by:

- •Reduced specific gravity.
- •Increased chance of hollow heart and fleck.
- •Increased chance of knobby shaped tubers.
- •Increased chance of common scab, late blight and *Sclerotinia*.

International data suggests a crop yielding 100 T/ha (40 T/ac) would require 350 kg N/ha, and unfortunately our yields are well below this.

CMS data on total Nitrogen fertiliser (and cost) suggests around 350 kg N/ha produces the highest return under local conditions (Figure 12).

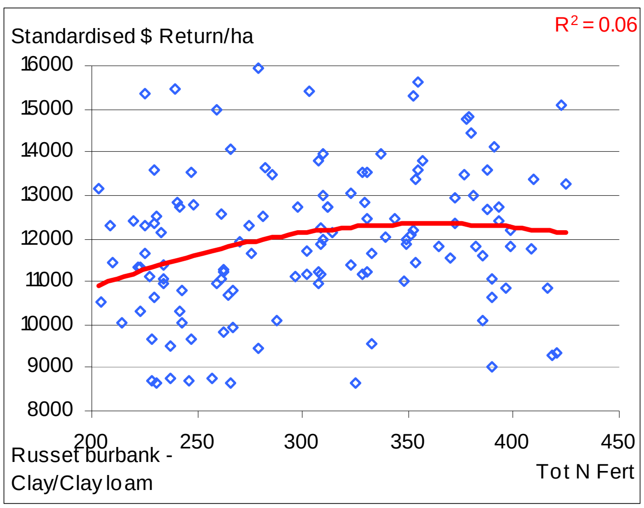
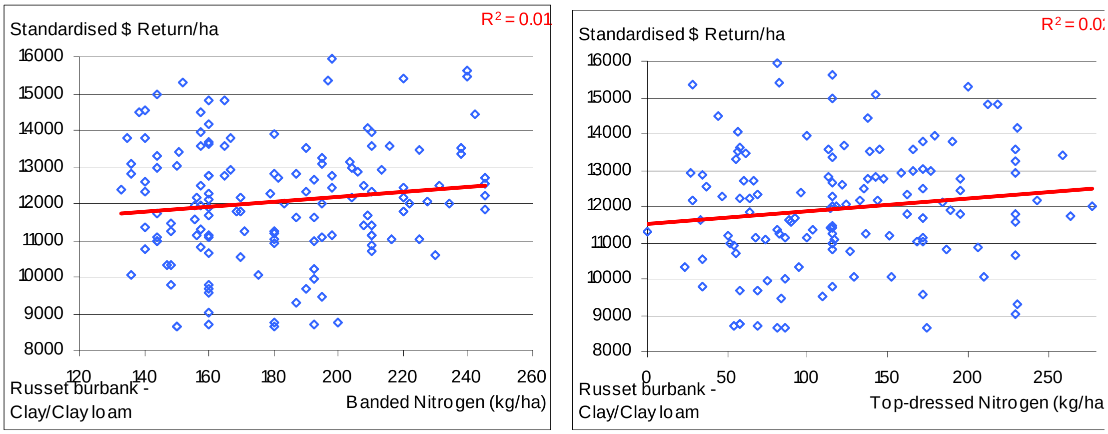


Figure 12. Total Nitrogen Fertiliser vs' Standardised CMS Yields (four seasons data) (combining soil Nitrogen makes little difference to the trend in Figure 12).

The application of sufficient Nitrogen to maximise crop yield is difficult to determine considering the multitude of influences, whilst attempting to minimise potential issues both within the crop and effect upon the environment.

Soil conditions and irrigation practices determine how effectively Nitrogen (or any fertiliser) is accessed and utilised (Nitrogen Use Efficiency). Nitrogen moves easily with water down the soil profile, but unlike plant roots it continues to move through any hardpan or impediment to root growth that may be present. Since the applied Nitrogen moves quicker and further than plant roots can penetrate it leads to Nitrogen application above that required if NUE was closer to 100 percent.

Increasing the crop NUE and reducing Nitrogen losses is achieved by reducing the planting Nitrogen mix, and more frequently applying smaller quantities, eg. fertigation. Figures 13 and 14 show the minimal response to higher Nitrogen rates at planting and as a top-dress.



Figures 13 and 14. Banded and Top-dressed N vs' Standardised CMS Yields (four seasons data – no statistical correlation with either).

Recent work with NZC&FR suggests **compaction** in Tasmania is reducing yield by up to **30 T/ha**, even under seemingly optimal conditions. Even slight compaction (packing – high bulk density) slows the rate of root growth, restricting plant access to water and nutrient and potential yield by limiting the amount of foliage produced to intercept sunlight and produce starch.

Unfortunately compaction is not corrected long term by simply continually ripping the soil to a greater depth. Soil with an imbalance in Calcium to Magnesium or with poor biological activity rapidly returns to its pre-ripped condition.

Gypsum is often applied to correct soil structure, but extreme caution should be used if applying gypsum, and application rates should never exceed 300-400 kg/ha.

A reduction in soil organic matter also causes structural decline. Every kilogram of Nitrogen (whether from fertiliser or legumes) not used by any crop causes a significant decline in soil organic matter.

Particular soil microbes (mycorrhiza) form associations with the roots of most crops (all but Brassica), adding to the effective crop root system. This beneficial relationship can be promoted using products such as VAM, but suffers when chemicals are applied to control weeds and diseases. In no way is it recommended that weed control is ignored, and most would think returning to mechanical weed control was a significant backward step. However, it may be worth comparing the soil and crop properties of the two systems in light of the potential soil and crop benefits.

Nitrogen fertiliser increases haulm length, as shown in the final CMS year (Figure 15).

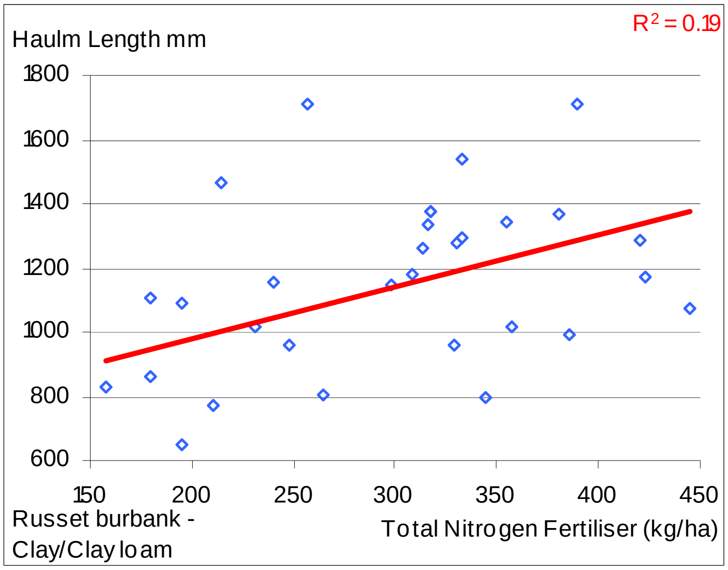


Figure 15. Total Nitrogen Fertiliser vs' Haulm length (one seasons data). (adding soil Nitrogen to Figure 15 strengthens the above trend).

Neither the planting nor the top-dressed Nitrogen rate alone was correlated with haulm length, only the total. In situations where wind and other diseases can cause problems for big/bulky plants, a lower Nitrogen rate may be one management option worth considering.

None of the plant nutrient testing methods (dry or sap) for Nitrate (at any stage or averaged) showed any correlation with CMS return. This contrasts the perceived value of the different methods which many growers swear by and rely heavily upon. Many crop modelling programs around the world do not rely upon plant nutrient testing, preferring to test for soil levels, and scheduling sufficient nutrient application to feed the plant formed.

If a disease or other issue is limiting the amount of nutrient taken up and present in the plant, the simple application of more fertiliser does nothing to rectify the cause of the problem. Using plant nutrient testing as a day-to-day management tool is fraught with danger considering the potential un-avoidable variation even when following the designated protocol.

The average dry tissue Nitrate level was correlated to total Nitrogen fertiliser application (Figure 16), but not for sap Nitrate.

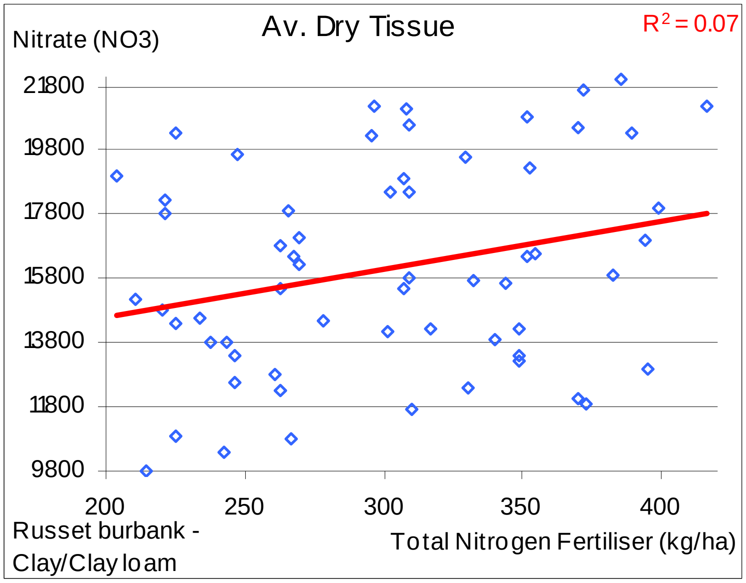


Figure 16. Total Nitrogen Fertiliser vs' Average Dry Tissue Nitrate level.

Although Figure 16 is expected, it is not particularly useful when no correlation to return exists.

No correlation between sap and tissue Nitrate and specific gravity or reject levels were apparent in the CMS data.

Higher tissue Nitrate levels correlate with better bruise free results (not so for sap).

Phosphorus (P)

Potatoes typically have root systems with poor vigour (especially Russet Burbank), restricting the value of soil nutrient (and water) stores unless soil conditions are near ideal. This problem is exaggerated for P on red soil (Ferrosol) which rapidly locks-up the applied phosphate.

A 60 T/Ha crop removes only 30 kg P/Ha, but application rates often exceed 300 kg P/Ha to ensure sufficient P is available during the season. Low P can result in reduced yield, tuber size and specific gravity following early death.

Soil P levels were **not** correlated with CMS potato returns on any soil type, indicating soil reserve P is of little use to potato crops.

Higher Phosphorus application correlates with increased haulm length (one seasons data).

Pre-spread Phosphorus is beneficial where soil reserves are low and where lock-up on clay/clay loam occurs, as shown in Figure 17.

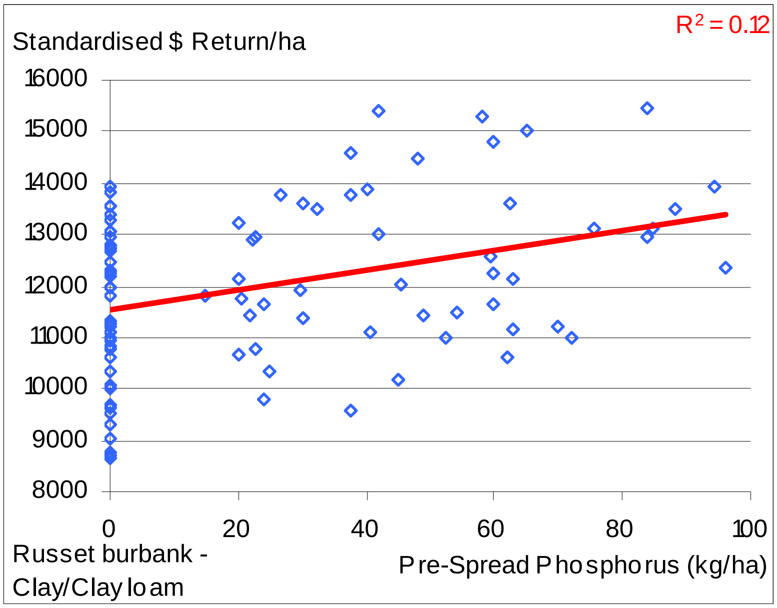


Figure 17. Pre-spread Phosphorus vs' Standardised CMS Yields (four seasons data).

The form of Phosphorus typically applied as a pre-spread (low analysis) has a lower tendency to lock-up, appearing to offer some benefit.

The banded Phosphorus form is typically different from the pre-spread form, and is more prone to lock-up. Figure 18 shows a trend for increasing return to a point (270-290 kg P/ha), which is only slightly higher than the work conducted years ago by the Ag department (220-250 kg P/ha) for clay/clay loam soil.

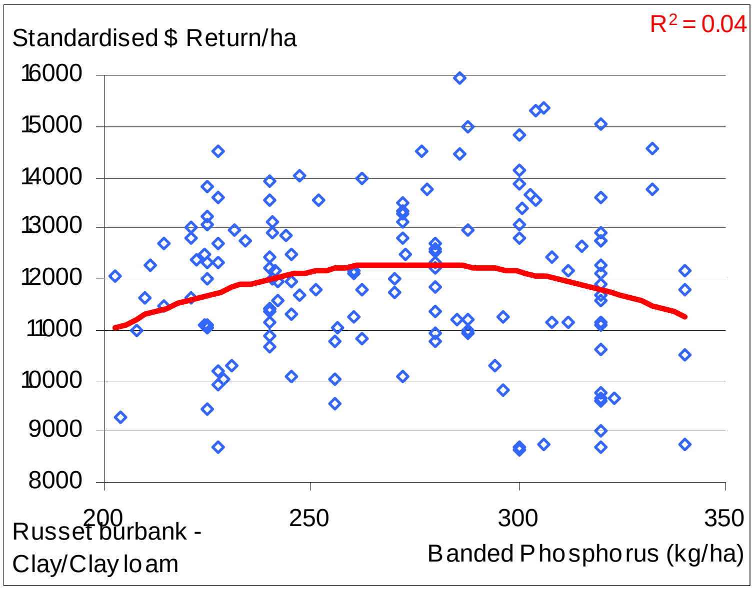


Figure 18. Banded Phosphorus vs' Standardised CMS Yields (four season's data).

The response to additional Phosphate fertiliser is particular poor, Figure 19 shows a remarkably flat trend – based on cost.

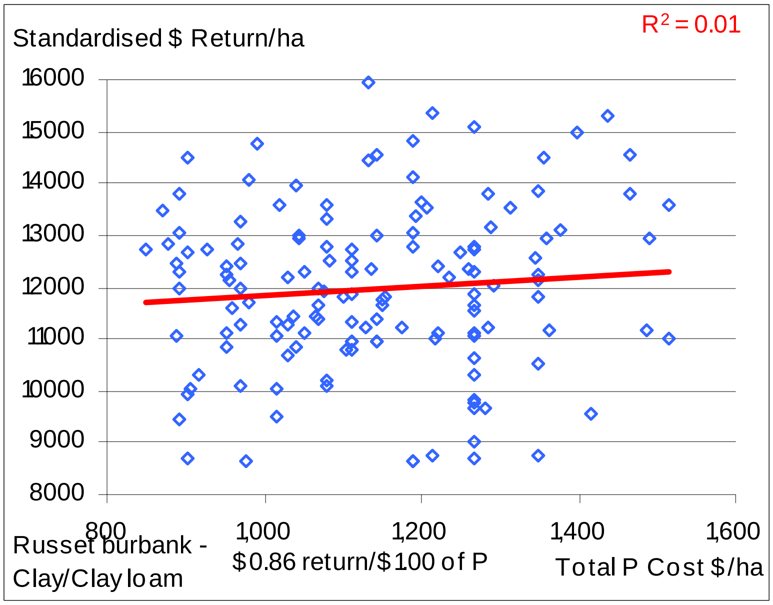


Figure 19. Total Phosphorus Fertiliser Cost vs' Standardised CMS Return (four seasons data).

18 of the 138 clay/clay loam CMS crops covering four seasons received any top-dressed Phosphorus, but no definite response was observed. 7 of the 28 sand/sandy loam CMS crops received some top-dressed Phosphate, with the trend suggesting a benefit but the lack of data has prevented statistical validation.

Sudden drops in P levels in plant tissue can often be related to poor irrigation management. Unexpected low P levels often result from periods of low soil moisture.

Although the average **tissue** P levels were **not correlated** with CMS potato yields, the average **sap** P levels **were correlated** (Figure 20).

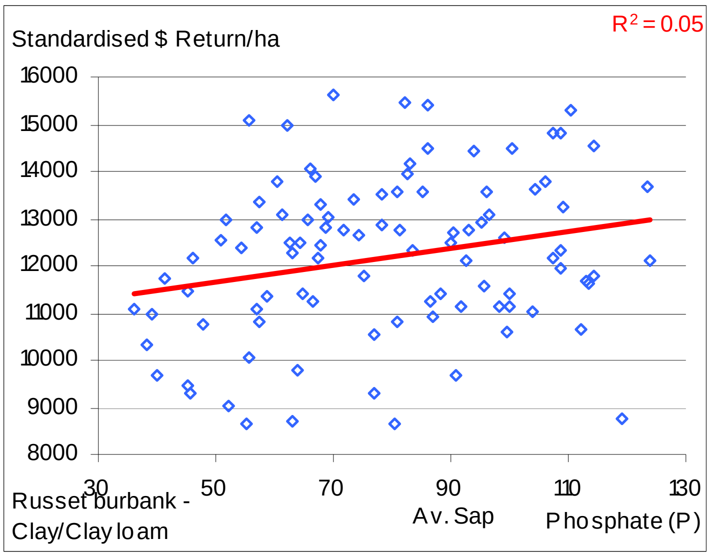


Figure 20. Average Sap Phosphate vs' Standardised Return (four seasons data).

Although the Phosphorus fertiliser rate/cost can be correlated with sap Phosphate, there is still no correlation between rate/cost and return!

Higher sap Phosphate correlates with:

- Higher return (Figure 20).
- More tubers per stem.
- Higher levels of brown centre/hollow heart.

The "real" value of sap or tissue testing is highly dependent upon intimately knowing your own "typical" levels, rather than comparing your results to all others, as a good yield can be achieved at sap or tissue levels that are considered "low" by industry standards.

Sap or tissue levels are possibly best used as a review tool of the previous season, rather than as a day to day management tool during the season – many bad decisions and expensive actions can be avoided when the tempting knee-jerk reaction is avoided.

For paddocks receiving no pre-spread or top-dressed Potassium, Figure 23 suggests around 320 kg K/ha produces the highest return.

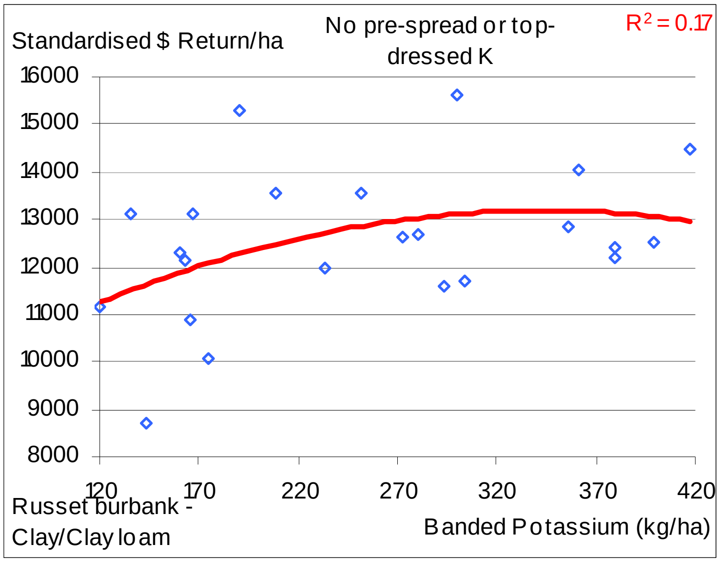


Figure 23. Banded Potassium vs' Standardised Return (four seasons data).

Higher Potassium application:

- Correlates with higher rejects (if only band placed).
- Increases tuber size.

Higher **soil** K levels were correlated with enhanced bruise resistance (Figure 24).

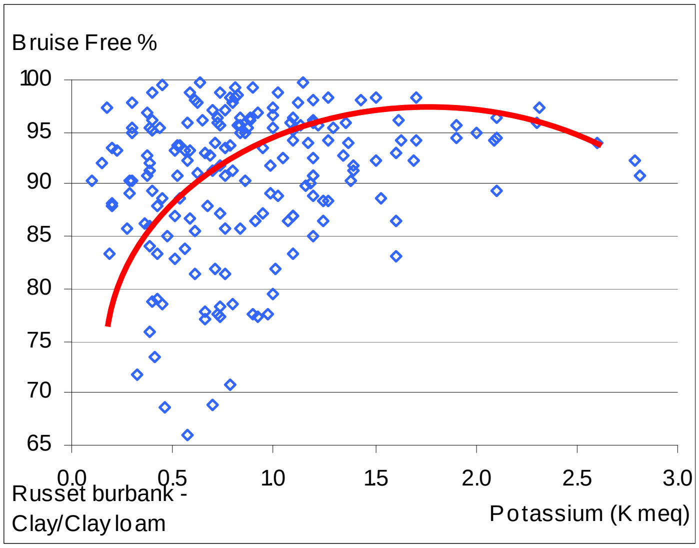
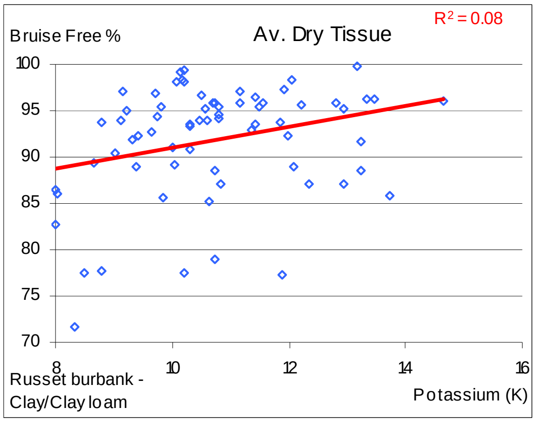


Figure 24. Soil Potassium vs' Tuber Bruise Free % (four seasons data).

A similar trend for soil K + fertiliser K exists, but not for fertiliser K alone.

Tissue K levels were **not** correlated with CMS potato yields, tuber size, reject levels or other scouting data (inc. foliar diseases such as target spot).

Figure 25 shows higher **tissue** K levels correspond with higher resistance to tuber bruising, while Figure 26 illustrates the correlation with specific gravity.



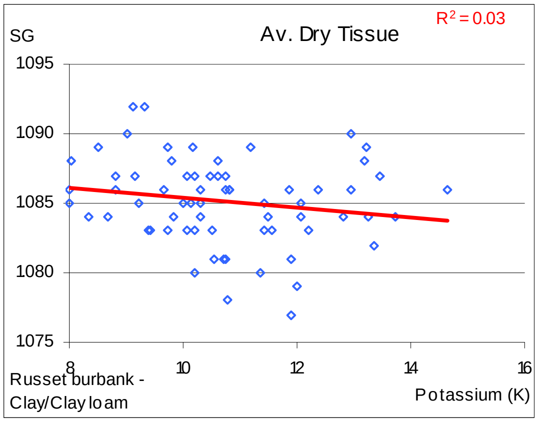


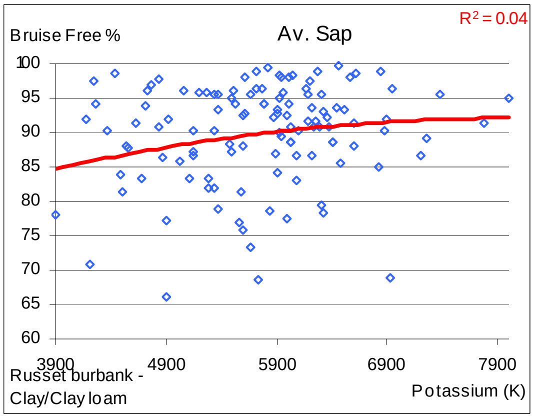
Figure 25. Average Tissue Potassium vs' Tuber Bruise Free.

Figure 26. Average Tissue Potassium vs' Tuber Specific Gravity

Higher average sap K levels correspond with higher stem numbers per plant.

Higher average sap K levels also correspond with lower combined foliar disease scores (inc. target spot), but increased second growth.

Figure 27 shows higher **sap** K levels correspond with higher resistance to tuber bruising, while Figure 28 illustrates the correlation with specific gravity.



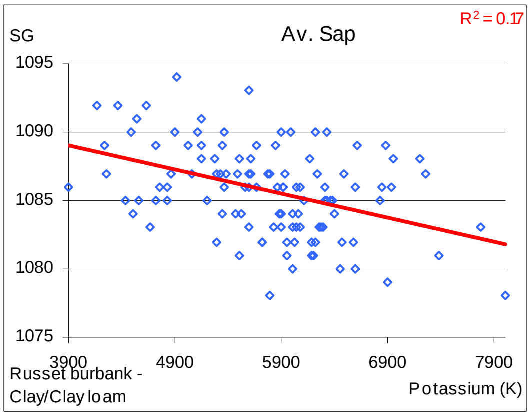


Figure 27. Average Sap Potassium vs' Tuber Bruise Free.

Figure 28. Average Sap Potassium vs' Tuber Specific Gravity

Soil K, and soil K + fertiliser K are correlated with the average sap K levels, but fertiliser K alone is not reflected in the sap levels. Tissue K levels do not reflect either the soil and/or fertiliser K levels.

Figure 29 reconfirms international and more recent local data indicating higher K fertiliser levels reduce tuber specific gravity.

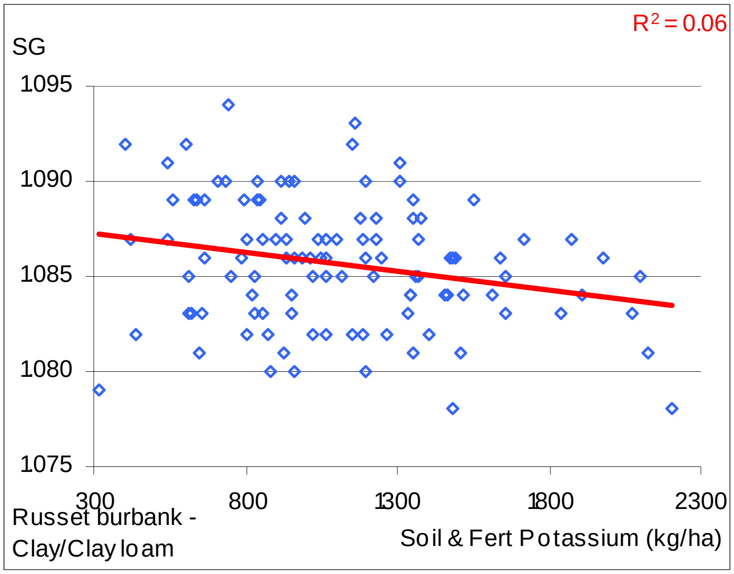


Figure 29. Total Potassium Fertiliser vs' Tuber Specific Gravity (four seasons data).

Soil types and paddocks that produce low specific gravity tubers should not be fertilised with higher K rates, or sulphate of potash should be used for part of the potassium requirement, especially if high K application rates are planned.

Figure 30 illustrates that higher specific gravity is associated with greater susceptibility to bruising.

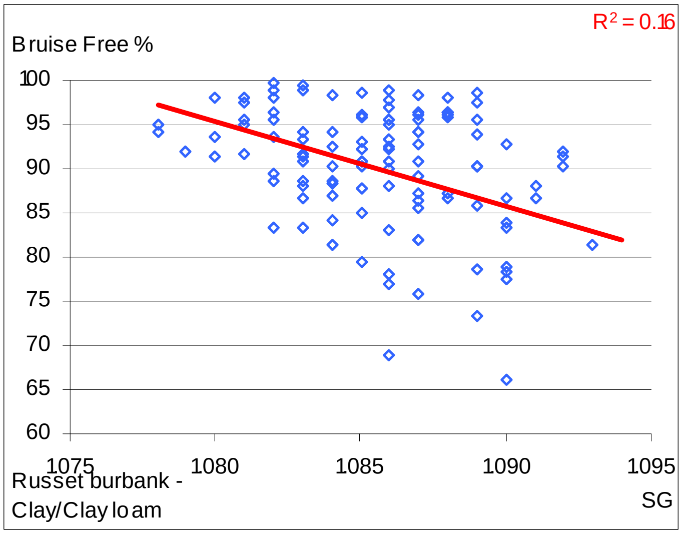


Figure 30. Tuber Specific Gravity vs' Bruise Free percentage (four seasons data).

Haulm length

Plant growth is determined by the availability of sunlight, nutrients and water. A shortage of the manageable inputs (nutrients and water) potentially restricts final plant size. Sufficient nutrient and water is normally applied, but access may be limited due to soil compaction.

Soil compaction may evident as an obvious hard pan, which restricts the depth of root penetration, or more difficult to detect as high bulk density which slows root growth (from low organic matter/poor structure). Hard pans and poor structure can be corrected/reversed, but typically there is not an overnight solution. Correcting the Calcium to Magnesium ratio, ripping, green manuring, and soil friendly fertilisers and chemicals will certainly help.

Particular fertilisers cause vegetative growth, whereas others cause fruiting growth. In the course of most crops there is a need to grow a plant (vegetative), followed by producing a fruit (fruiting growth).

Larger plants are thought to produce higher yields/return, but Figure 32 shows the maximum return is generated by plants of around 1,200 mm, or four foot, not nearly six foot.

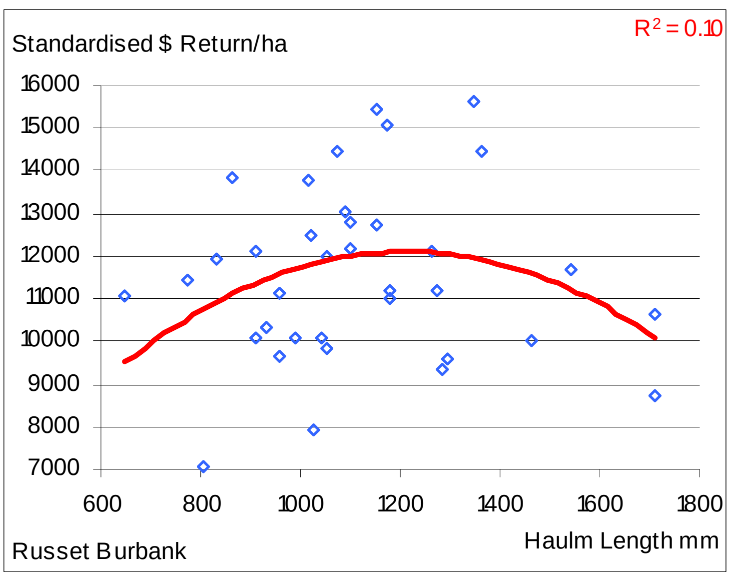


Figure 32. Haulm Length vs' Standardised Return (one seasons data).

Larger plants have a greater demand for nutrients and water, and could increase the crops susceptibility to wind damage. This greater demand for nutrients and water is partly just to keep the plant alive, and does not generate additional yield.

Foliar diseases should be worse for larger plants, considering the extra foliage creates additional humidity. But, CMS data suggests larger plants have enhanced resistance to foliar disease?

The development of haulm for Russet crops is shown in Figure 33.

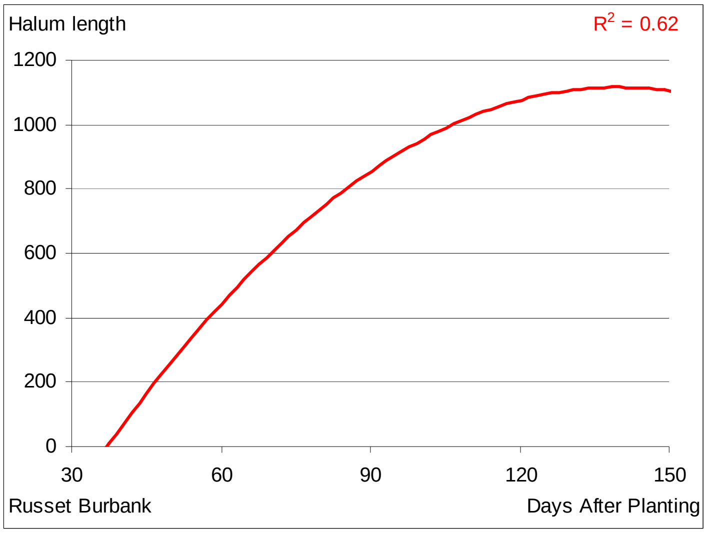


Figure 33. Days from Planting vs' Haulm Length (one seasons data).

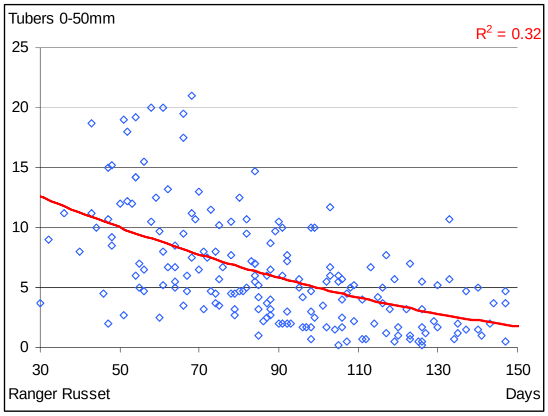
Haulm length is **not** correlated with:

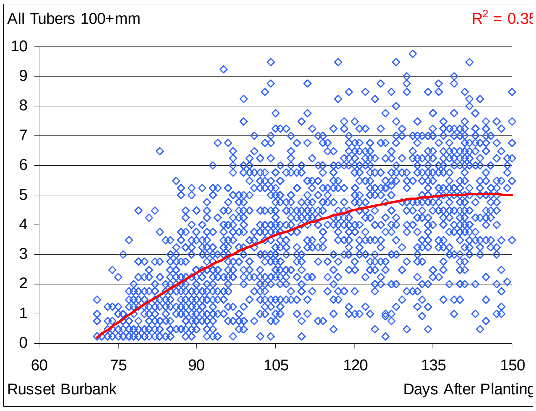
- *Rhizoctonia*.
- Plant population
- Stems/plant.
- Tubers/plant.
- Brown centre or hollow heart.

Haulm length/plant declines as the stems/ha increase.

Tuber Formation

The development of tubers occurs in accordance with variety/genetics, but is dependant upon the environment – gene expression is dependant upon the factors that affect crop growth. Figures 34 and 35 show the development of tubers over time.





Figures 34 & 35. Days After Planting vs' Tubers 0-50mm and 100+mm.

Tuber size was **not** correlated with **plant population**, but **was** with **stems/plant**, and **stems/ha**.

PLANTING DATE

The theoretical planting date for maximum potato yield, based on day length and sunlight interception is early October, but this can vary season to season. Figure 36 shows just how different the seasons can be, with the last two seasons being distinctly different from the previous two.

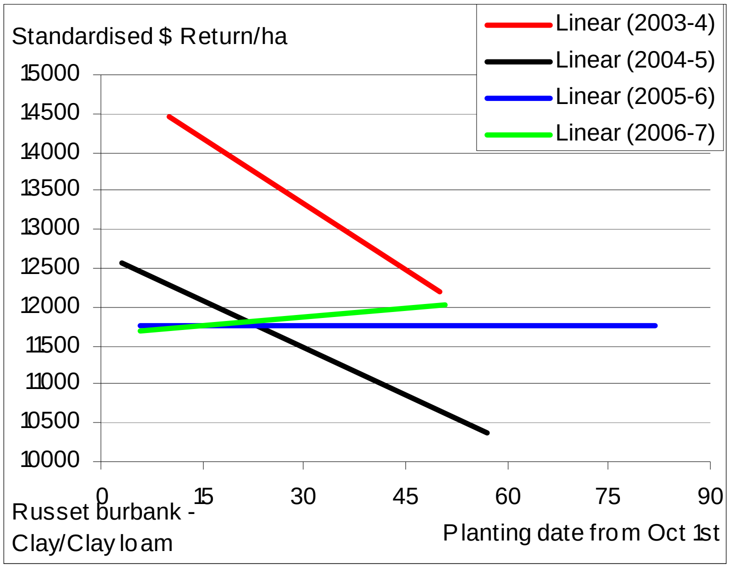


Figure 36. Planting Date vs' Standardised Return (four seasons data).

The ideal planting time for Russet Burbank remains around early to mid October.

Later planting does correspond with higher stem numbers per plant (Figure 37).

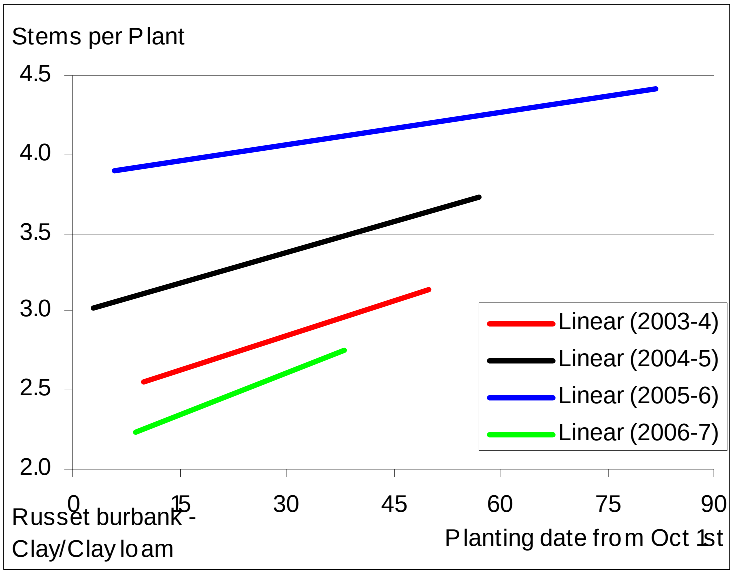


Figure 37. Planting Date vs' Stems per Plant (four seasons data).

Later planting:

- Increases:
    - Powdery scab.
    - Irish (late) blight.
    - Stem length – but not statistical.
- Reduces:
    - *Fusarium*.
    - *Sclerotinia*.
    - *Botrytis*.
- Increases stems per plant.
- Reduces tubers per stem.
-

(Increases stems per plant / Reduces tubers per stem:) But increases tubers per plant.

Hollow heart is becoming a major concern, with even small tubers developing the problem in some paddocks. Tuber size was not correlated with the level of brown cent and hollow heart. The basis of hollow heart issues is in theory related to the soil Calci level, and dependant upon the soil Boron level, but to complicate this Calcium needs to be functional, Potassium needs to be in balance and potentially other factors that currently make it too difficult to formulate a solution.

PREVIOUS CROP

Although the mechanism of crop rotation upon potato yields is unclear, the results can still be used to develop a preferable cropping sequence. Table 4 lists the previous summer crop and the following winter crop prior to the CMS potato crop.

Standardised Processing Yield (T/ha)

Previous Winter Crop

Previous Summer Crop	Brassica	Pasture	Fallow	Green manure	Cereal	Legume	Pye	?	Grand Total	num
Fallow								62.6	62.6	2
Root Crop	49.8	59.7			46.4			60.1	58.1	14
Cereal			57.7	56.7				57.8	57.7	18
Poppies		62.0	51.6	65.6	53.4	57.1		56.9	57.3	55
Brassica		61.5	66.2					43.6	57.1	4
Pasture	57.3	56.5		49.6		48.9		56.8	56.5	139
Pyrethrum				52.7		59.3	40.9	58.0	55.6	10
Legume	61.9	56.2		40.2				56.0	55.5	22

Table 4. Previous summer and winter crops vs Standardised CMS Potato yields (four seasons data – "?" covers the unknown winter crops from 2003-04).

Figure 38 shows the CMS data suggesting shorter rotations reduce potential Russet returns on Clay/Clay loam soil.

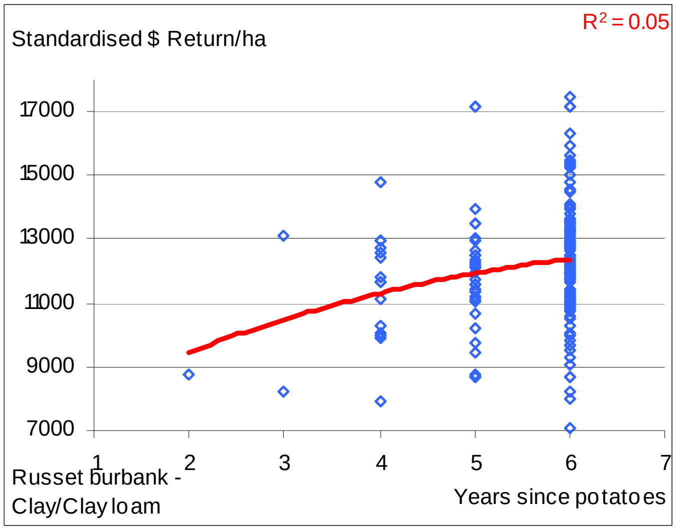


Figure 38. Years Since last Potato Crop vs' standardised CMS Potato Yields (four seasons data on Clay/Clay loam soil). N.B. 6 is all years above 5.

As the number of years of grass/pasture (over summer) increased, return increased as well, but not as strikingly as for years since potatoes Figure 38.

CONCLUSION

Although a lot of information has been presented in this document, there is still many more trends that have been excluded, otherwise the document would swell beyond being useful. Most factors with the largest influence upon crop performance and quality have hopefully been examined in some detail above.

Although inputs and management of potato crops have both increased in recent times, the yield/return has often failed to reflect this. Questions about seed quality and vigour continue to be raised, but the decline is more likely related to other factors. As mentioned previously in this document the work with NZC&FR has raised the issue of compaction in soils cropped consistently.

Post CMS Simplot is wishing to evaluate the New Zealand Crop and Food Research **Potato Calculator**, and we are looking for interested growers to be involved. The intensive scouting regime will be replaced with a greater focus on understanding the difference between the "expected-yield" and the theoretical yield. The theoretical yield is determined by the variety, soil type/condition, planting date, fertiliser strategy and irrigation capacity. As with the CMS a small cost to the grower would be likely (to ensure only the willing take part), and additional funding has been sought from other funding bodies such as HAL.

To be involved with the evaluation of this comprehensive new program or for additional information please contact Chris Russell on 0419 813 546.

As a final note I would like to thank once again the growers for their involvement and patience over the past four seasons, and I look forward to working with as many as possibly in the future to advance the Tasmanian Potato Industry.

Regards,

Chris Russell

Grower : Gull C

Paddock : House Paddock

Paddock	House Paddock	2005-6 House Paddock	2004-5 House Paddock	2003-4 House Paddock	2004-7 Top-5 Av.	2006-7 North-West
Variety	RB or RR	RB or RR	Russet Burbank	Russet Burbank	Russet Burbank	RB, RR or Uma
Row spacing (mm)	813	813	813	813	813	
Sett Spacing (mm)	349	380	335	321	320	346.5
Plant Pop (x 1,000)	30.6	33.4	34	37.2	38.45	32.2
Planted	19-Oct-06	12-Nov-05	26-Oct-04	14-Nov-03	27-Apr-05	20-Oct-06
Harvested			7-Apr-05	1-May-04	16-May-52	
ha	10.4	9.7	9.6	14.2	6.60	8.6
Paid Weight (t's)	531.5	438.5	488.7	730.4	449	441
Paid yield (t/ha)	51.5	48.2	51.9	54.5	68.1	52.3
SG	1.084	1.086	1.085	0.000	1.085	1.085
Bruise Free %	88.6	91.2	89.6	86.5	89.95	88.8
Size %	58.5	48.6	55	47.8	61	56.5
Reject %	3.2%	2.8%	3.4%	3.0%		
Stems/Plant	2.5	4.2	3.3	2.8	2.975	2.5
Rank	30 (of 60)	45 (of 90)	48 (of 97)	25 (of 59)		
Soil test Lab	Some lab	Some lab	Some lab	Some lab		
Texture		Ferrosol	Ferrosol	Ferrosol		
pH	6.1	6.2	6.2	6.1	6.3	6.2
pH CaCl	5.3	5.5	5.5	5.4	5.5	5.4
Nitrate	14.5	11.7	16.5	10.2	11.5	15.4
Ammonium	16.7	4.8	4.9		0.5	37.5
P Colwell	107.7	136	122.1	140	115	138.9
P Olsen	36.1	38.1	34.4	30.8	36.6	48.9
Potassium ppm	290	336	320	262	322	350
Potassium Meq	0.73	0.87	0.81	0.67	0.82	0.87
Sulphur	21.6	20.6	19.9		23.7	22.3
Calcium - meq	9.4	10.2	10.2	10	10.38	10.2
Magnesium - meq	2.3	2.4	2.5	2.5	2.33	2.5
Ca/Mg Ratio	5.9	4.8	4.6	4	5.1	6.4
K/Mg Ratio	0.36	0.4		0.27	0.3	0.39
CEC (no H)	12.3	14.2	14	11.7	13.9	13.4
Org Carbon %	4.2	3.9	3.7		4.1	4
Copper	2.07	1.88	1.76	2.80	1.5	2.53
Zinc	2.4	2	1.8	1.1	1.6	2.7
Boron	1.12	1.15	1.25	1.7	1.36	1.32
Iron	78.2	75.4	76.1	78	64	55
Manganese	38.2	29.5	32.7	27	37	42
Molybdenum	0.7	0.63	0.79			0.7
EC	0.09	0.1	0.1		0.115	0.1
Sodium - meq	0.23	0.22	0.21	0.60	0.25	0.21
Chloride	25.7	21.7	23.8		21	28.8

Grower Thoughts

Notes from this season may be very useful to look back on (especially when growing potatoes in this paddock again). Thinking about this crop, please take a little time to circle the numbers below. Make any additional notes in the space provided - topics only shown to help.

Seed Condition : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Pre-cut?
Well suberised?
Seed & sett size

Soil Conditions : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Depth of loose soil
Clod level/size
Soil Moisture

Crop Establishment : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Speed of emergence
Plant evenness
Early growth rate

Crop Growth/Colour : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Nitrogen green or Healthy colour
Paddock evenness

Tuber Condition : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Size/Shape
Uniformity
Quality

Weather : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Hot/Cold
Wet/Dry
Sunny/Cloudy

Irrigation : Poor 1 - 2 - 3 - 4 - 5 Good

Comments :
Breakdowns
Too little/much
Approach

Other Comments :

Insects/Diseases
Fertilisers
Intended changes

Paddock Record

If any of these details are incorrect please contact Chris Russell (6422 6512)

Crop Practices

Irrigation Method : Travelling gun
Intended application (mm) : 27

Act = Activator   St = Sticker   Zn = Zinc

Total kg/L per ha	*Sprayseed*	*Bravo*	*Score*	*Sencor*	*Penncozeb*	*Wallabi*	*Polyram*	*Lorsban*	*Ridomil Gold*

Lime etc. : Not applied

Kg or L /ha	Fertiliser :	Date :	Method : - Notes :
275	Single Super Phosphate		
360	Sulphate of Potash		
1750	10-15-13		
100	Sulphate of potash		
60	Urea		
50	MAP (Mono-Ammonium Phosphate)		
60	Urea		
60	Urea		
60	Urea		
60	Urea		
60	Urea		

Rotation :		Winter	Summer
	Previous crop :	Pasture	Pasture
	2 years ago :	Tamma	Carrots
	3 years ago :	Oats	Poppies
	4 years ago :	Blue Lupin	legume
	5 years ago :	Wheat	Broccoli

Known Weed Problems : Everything

Known Disease Problems : Scab

Physical Issues : Hard pan

Residual Herbicides : Brushoff 4 years ago

Crop Summary

This information is provided by your field officer to assist with planning next seasons crop

Adequate
Marginal
Poor

Comments relate to this seasons crop

	2006-7 House Paddock	**2005-6** House Paddock	**2004-5** House Paddock
Seedbed Preparation — Providing good soil structure, maximising crop potential	Adequate	Adequate	Adequate
Seedbed Moisture — Potentially slowing emergence, allowing other problems to develop	Marginal	Adequate	Adequate
Germination — Even though the seedbed moisture was not adequate	Adequate	Marginal	Poor
Plant Population — Maximising the potential number of tubers	Adequate	Poor	Marginal
Weed Control — Preventing competition for light, nutrients and moisture	Adequate	Adequate	Adequate
Major Plant Nutrition — Maintaining normal plant function during the growing season	Adequate	Adequate	Adequate
Trace Element Levels — Maintaining normal plant function during the growing season	Adequate	Adequate	Adequate
Insect Disease Control — Allowing potential damage to plants or tubers during the season	Marginal	Adequate	Adequate
Irrigation Management — Potentially impacting yield and/or quality	Marginal	Adequate	Adequate

Soil Nutrient and Fertiliser Summary

+/- 20 % | Higher | Similar | Lower

Major elements :

	Paddock	Soil kg/ha	Fertiliser Applied kg/ha	Total kg/ha
Nitrogen (N)	House Paddock	40.7	348	389
	Top-5 Average	*19.7*	*330*	350
Phosphorus (P)	House Paddock	269	295	564
	Top-5 Average	*234*	*402*	637
Potassium (K)	House Paddock	716	412	1128
	Top-5 Average #	*529*	*343*	871
Sulphur (S)	House Paddock	54	63	117
	Top-5 Average	*54*	*44*	98
Calcium (Ca)	House Paddock	4712		
	Top-5 Average #	*4762*		
Magnesium (Mg)	House Paddock	701		
	Top-5 Average #	*644*		

Adjusted for for your soil type using CEC = #

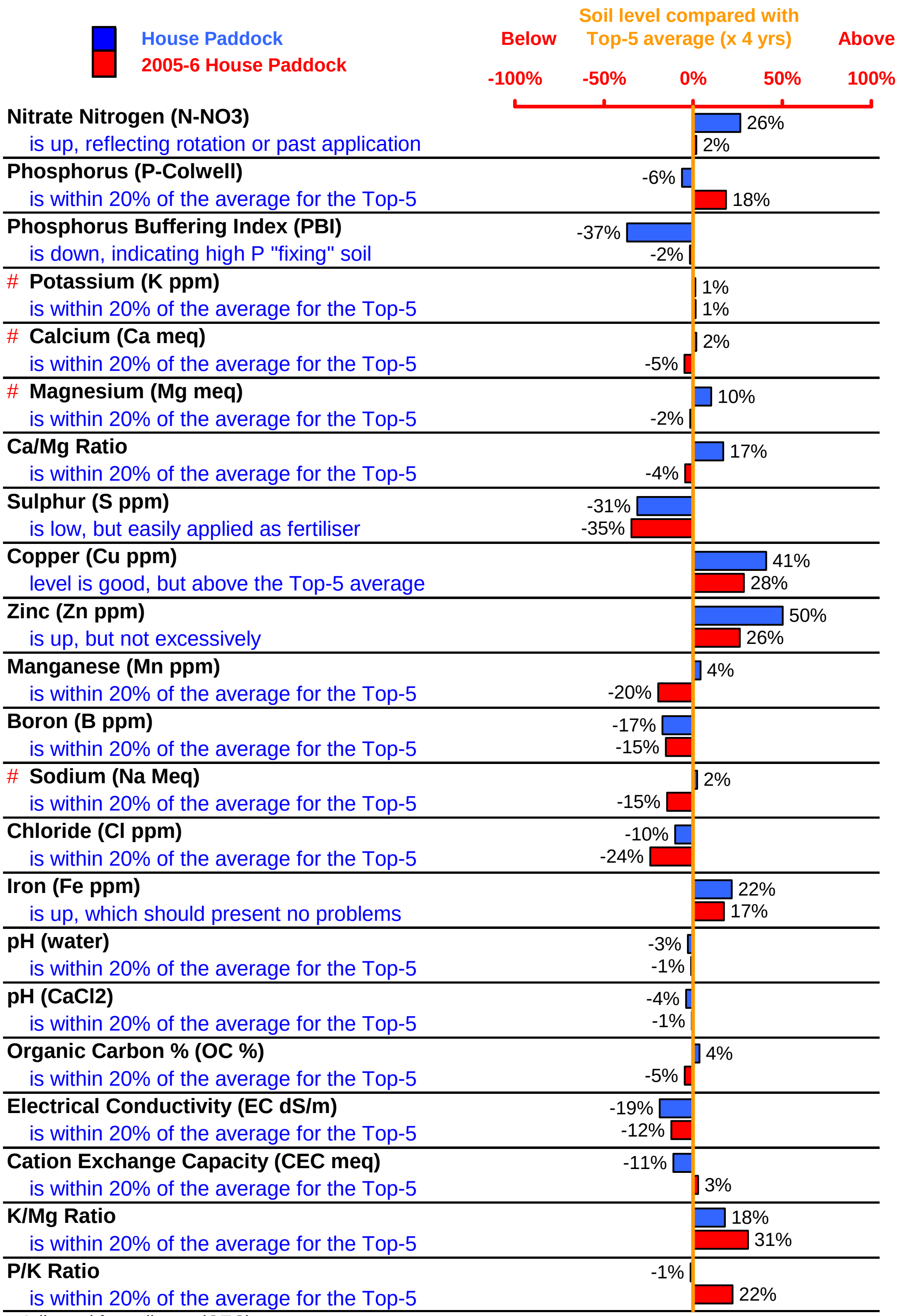
Trace elements :

	Paddock	Soil kg/ha
Boron (B)	House Paddock	2.8
	Top-5 Average	*2.5*
Copper (Cu)	House Paddock	5.2
	Top-5 Average	*4.3*
Zinc (Zn)	House Paddock	6.0
	Top-5 Average	*3.7*
Iron (Fe)	House Paddock	196
	Top-5 Average	*121*
Manganese (Mn)	House Paddock	95
	Top-5 Average	*76*

Soil Test

Figure 35 relates the soil test values to the average of the Top-5 yielding CMS paddocks over three seasons.

N.B. Whilst averaging the data for the Top-5 paddocks is a useful guide, it may not be the optimum. Comments relate to **BLUE** bars



Adjusted for soil type (CEC)

Figure 35

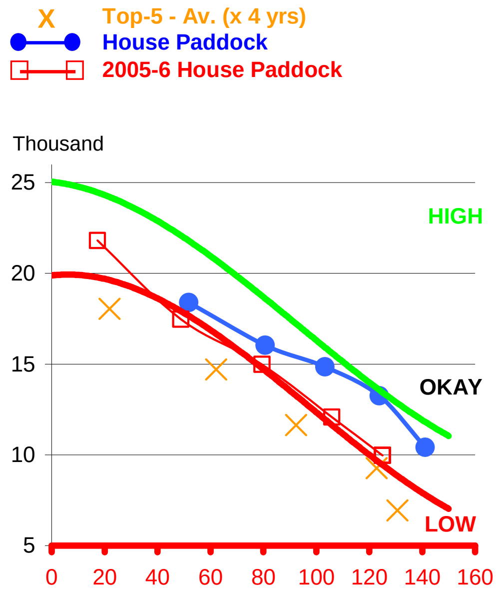
Tissue Nutrient Summary

Major elements :

	House Paddock						
Sample	1st	2nd	3rd	4th	5th	6th	7th
Date	16-Dec	30-Dec	12-Jan	25-Jan	8-Feb		
Days	52	81	103	124	141		
Date	18-Jun	2-Jul	16-Jul	30-Jul	13-Aug		
Days	22	62	92	123	131		
	Top-5 - Av.						

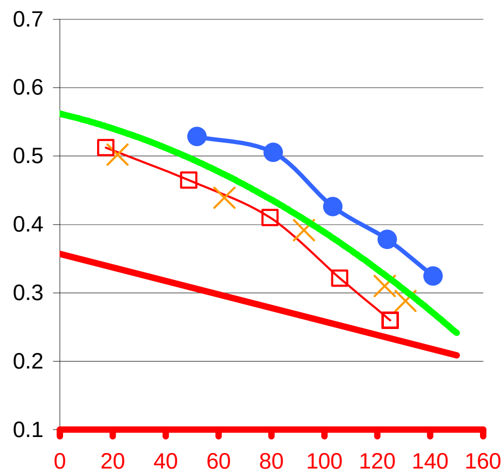
Nitrate-N (NO3-N)

Tissue levels were generally above the average for the Top-5 crops. The combined soil and fertiliser N was above the average for the Top-5 crops.



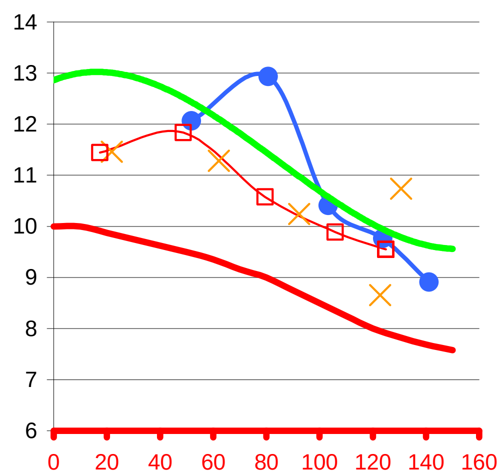
Phosphorus (P)

Tissue levels were generally above the average for the Top-5 crops. The combined soil and fertiliser P was below the average for the Top-5 crops.



Potassium (K)

Tissue levels were generally similar to the average for the Top-5 crops. The combined soil and fertiliser K was above the average for the Top-5 crops. The high soil iron level (compared with the average for the Top-5 crops) may restrict P uptake by the plant, but not in this case



Tissue Nutrient Summary cont'd

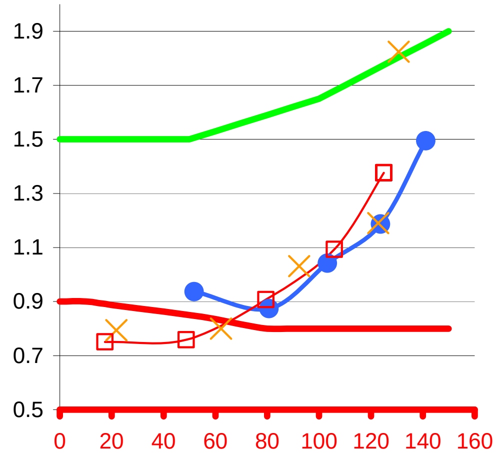
X Top-5 - Av. (x 4 yrs)
House Paddock
2005-6 House Paddock

Major elements cont'd :

	House Paddock						
Sample	1st	2nd	3rd	4th	5th	6th	7th
Date	16-Dec	30-Dec	12-Jan	25-Jan	8-Feb		
Days	52	81	103	124	141		
Date	18-Jun	2-Jul	16-Jul	30-Jul	13-Aug		
Days	22	62	92	123	131		
	Top-5 - Av.						

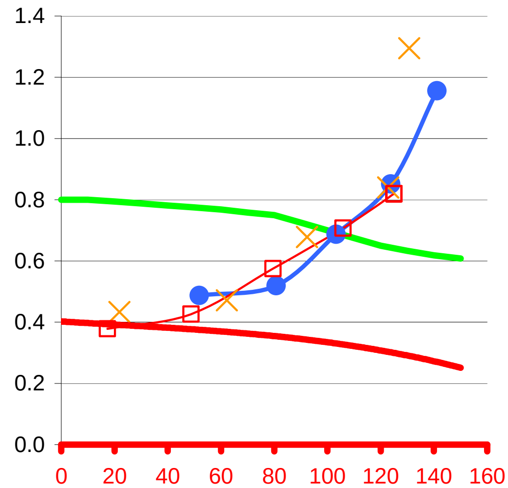
Calcium (Ca)

Tissue levels were generally similar to the average for the Top-5 crops. The combined soil and fertiliser Ca was within 10% of the average for the Top-5 crops. The high soil P level (compared with the average for the Top-5 crops) may restrict Ca uptake by the plant, but not in this case



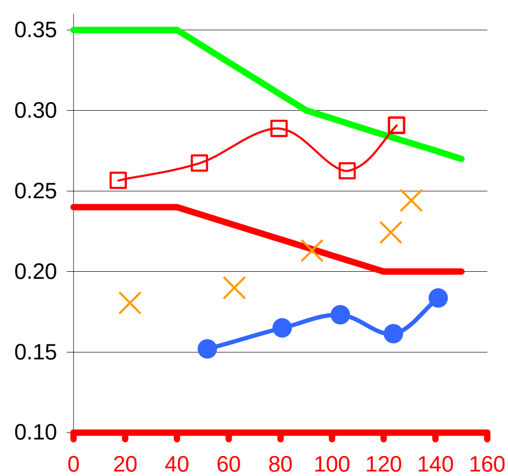
Magnesium (Mg)

Tissue levels were generally similar to the average for the Top-5 crops. The combined soil and fertiliser Mg was within 10% of the average for the Top-5 crops. The high soil P level (compared with the average for the Top-5 crops) may restrict Mg uptake by the plant, but not in this case



Sulphur (S)

Tissue levels were generally lower than the average for the Top-5 crops. The combined soil and fertiliser S was above the average for the Top-5 crops.



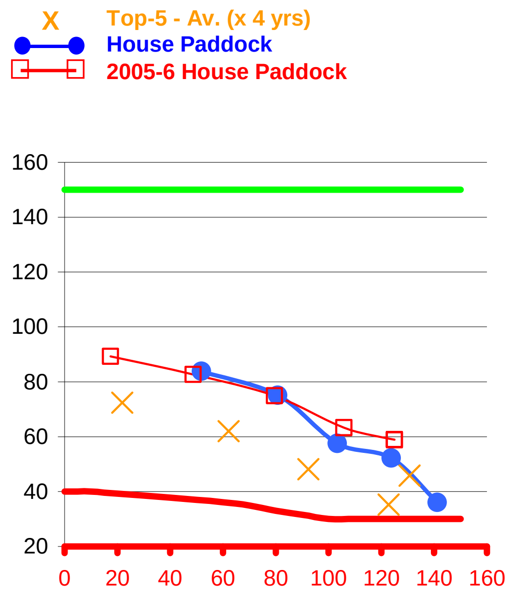
Tissue Nutrient Summary cont'd

Trace elements :

Sample	1st	2nd	3rd	4th	5th	6th	7th
	House Paddock						
Date	16-Dec	30-Dec	12-Jan	25-Jan	8-Feb		
Days	52	81	103	124	141		
Date	18-Jun	2-Jul	16-Jul	30-Jul	13-Aug		
Days	22	62	92	123	131		
	Top-5 - Av.						

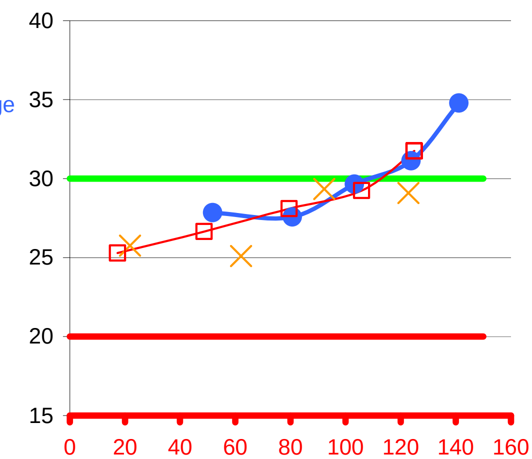
Zinc (Zn)

Tissue levels were generally above the average for the Top-5 crops. The combined soil and fertiliser Zn was above the average for the Top-5 crops. The high soil P level (compared with the average for the Top-5 crops) may restrict Zn uptake by the plant, but not in this case



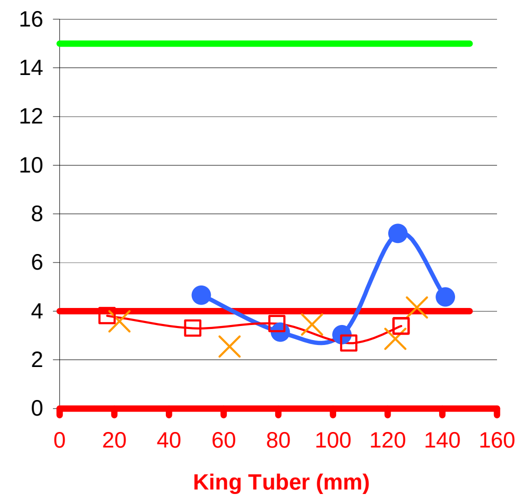
Boron (B)

Tissue levels were generally similar to the average for the Top-5 crops. The combined soil and fertiliser B was above the average for the Top-5 crops.



Copper (Cu)

Tissue levels were generally above the average for the Top-5 crops. The combined soil and fertiliser Cu was above the average for the Top-5 crops. The high soil Fe level (compared with the average for the Top-5 crops) may restrict Cu uptake by the plant, but not in this case

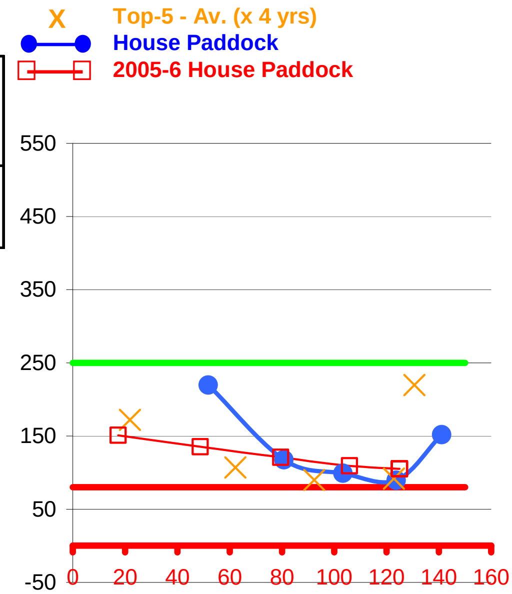


Tissue Nutrient Summary cont'd

Trace elements cont'd :

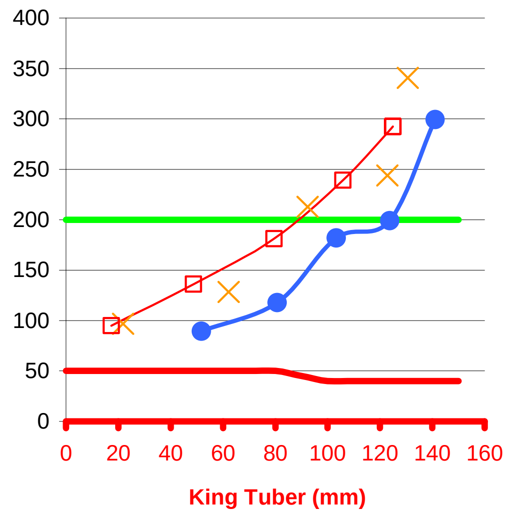
	House Paddock						
Sample	1st	2nd	3rd	4th	5th	6th	7th
Date	16-Dec	30-Dec	12-Jan	25-Jan	8-Feb		
Days	52	81	103	124	141		
Date	18-Jun	2-Jul	16-Jul	30-Jul	13-Aug		
Days	22	62	92	123	131		
	Top-5 - Av.						

Iron (Fe)



Tissue levels were generally similar to the average for the Top-5 crops. The soil Fe level was above the average for the Top-5 crops.

Manganese (Mn)



Tissue levels were generally lower than the average for the Top-5 crops. The soil Mn level was above the average for the Top-5 crops. The high soil K level (compared with the average for the Top-5 crops) may restrict Mn uptake by the plant, but not in this case

Tissue or sap results give an indication of plant nutrient content, but may not reflect the soil nutrient level. Diseases, fungicide application, weather conditions, soil compaction and nutrient interactions in the soil all influence plant nutrient uptake.

An in-depth understanding of your "normal" levels and trends is needed to determine the most cost effective corrective actions, considering your infrastructure and intended approach. Using an experienced agronomist makes understanding tissue and soil test results considerably easier.
Molybdenum, Sodium and Chloride levels were also assessed, but proved of little value eg. minimal variation from very low levels generally.

Crop Fertiliser Summary

	Total kg/ha N	P	K	S
2004-5 House Paddock	306	281	400	74
2005-6 House Paddock	297	272	224	45
House Paddock	348	295	412	63

Pre-Planting Fertiliser

Product - Traces	**kg/ha**	**N**	**P**	**K**	**S**
Single Super Phosphate	275		24		30
Sulphate of Potash	360			149	61

The high soil Phosphorus level (compared with the average for the Top-5) removed the need for a pre-spread application.

Planting Fertiliser

Product - Traces	**kg/ha**	**N**	**P**	**K**	**S**
10-15-13	1750	175	263	228	

The fertiliser applied should be sufficient considering the soil test.

Top-Dressed Fertiliser

Product - Traces	**kg/ha**	**N**	**P**	**K**	**S**
Sulphate of potash	100			42	17
Urea	60	28			
MAP (Mono-Ammonium Phosphate)	50	5	11		1
Urea	60	28			
Urea	60	28			
Urea	60	28			
Urea	60	28			
Urea	60	28			

The total Nitrogen application rate was similar to the average for the Top-5 crops.

Foliar Fertiliser

Not Applied (according to our records)

Your use of foliar fertiliser this season did not assist sufficiently to raise your yield above this seasons CMS average, suggesting other more substantial problems exist or occurred.

Scouting Inspection Summary

House Paddock

Top-5 Average

Dry	Fair	Good	Wet	+

P = Planting E = Emergence H = Hooking

Date	Week	Growth Stage/ King Tuber mm	Soil Moisture 0-20cm	Soil Moisture 20-40cm	Comments
	3				
22-Nov-06	5	Hook	Good	Good	(None made)
	5				
15-Dec-06	8	20	Fair	Good	Foliage not as vigourous as expected for stage of growth. One seedline broken down / 80% emergence. Soil structure has improved, lupin & ryegrass has broken down - soil should be wetter for tuber gully
	7	27			
15-Dec-06	8	44	Good	Good	Plants look healthy about to flower, some windblown good rich colour.
	8	37			
27-Dec-06	10	53	Good	Good	Plants very healthy. Flowering. Some wind damage & fertiliser burn, low weed density
	11	82			
11-Jan-07	12	100	Fair	Good	Good top growth, small percentage of rot in canopy. Tuber growth ok. - moisture varies according to irrigation & soil conditions
	12	99			
11-Jan-07	12	97	Good	Good	Plants very healthy, good even tuber size. Some black leg noticed as well as odd target spot. Fertilser burn & wind burn. Some insect damage
	13	108			
26-Jan-07	14	108	Good	Good	Plants healthy although insect damge noticable on leaves & some target spot. Some sclerotinia on stems. Tuber size relatively even. - moisture on south side is fair/good. Moisture on north side is good
	16	126			
8-Feb-07	16	200	Fair	Good	Different seedlng showing degrees of senescing. Variation in soil showing degree of senescing. - Dry for stage of growth
	18	146			
22-Feb-07	18	134	Good	Good	Crop 1/4 senesced. Tuber size ok, good numbers. Some rhizo & sclero on stems. Some target spot. No scab found - soil structure ok
	19	146			
10-Mar-07	20	126	Good	Good	Plants dead in most of paddock. Tubers mostly even size. Some minor scab, no rot found. - 54mm dpiwe rainguage. 53mm - sag.
	20	138			
15-Mar-07	21	190	Good	Good	Different seedlines dying earlier, strong growth in better soils - Could be wetter for stage of growth
	20	130			
15-Mar-07	21	129	Fair	Fair	Tubers fair to good size. Fairly even. Little scab found.
	21	163			

Scouting Inspection Summary Cont'd

Top-5 Average
House Paddock

Rating : 0 = Nil - 1 - 2 - 3 = High

Date	Week	Common scab	Powdery scab	Rhizo	Blackleg	Pink Rot	Black Dot	Target Spot	Weeds	Fusarium	Sclero	Late Blight
4-Dec-05	3	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0.2	0	0	0
22-Nov-06	5	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0.2	0	0	0.8	0	0	0
15-Dec-06	8	0	0	0	0	0	0	0	1	0	0	1
	8	0	0.2	0	0	0	0.4	0	0.2	0	0	0
15-Dec-06	8	0	0	0	0	0	0	0	0	0	0	0
	11	0.4	0.2	0	0	0	0.2	0	0	0	0	0
27-Dec-06	10	0	0	1	0	0	1	0	1	0	0	0
	12	0.2	0.2	0.4	0	0	0.2	0.2	0.4	0	0	0
11-Jan-07	12	0	1	1	0	0	0	0	1	0	0	0
	13	0.2	0.2	0.8	0	0	0.4	0	0.6	0	0	0
11-Jan-07	12	0	0	1	0	0	1	0	1	0	0	0
	16	0.4	0.2	1	0	0	0.4	0	0.8	0	0	0
26-Jan-07	14	0	0	1.5	0	0	0	0	1	0	0	0
	18	0.6	0.6	1.2	0	0	0.4	0.2	1	0	0	0
8-Feb-07	16	1	0	1	0	0	0	1	1	0	0	0
	19	0.5	0.8	0.8	0	0	0.3	0.3	1	0	0	0
22-Feb-07	18	0	1	1	0	0	0	0	1	0	0	0
	20	0.5	0.5	1.3	0	0	0.3	0	0.8	0	0	0
10-Mar-07	20	0	0	0	0	0	1	0	1	0	0	0
	20	0.5	0.5	1	0	0	0	0	1	0	0	0
15-Mar-07	21	1	0	1	0	0	0	0	0	0	0	0
	21	0.8	0	1.3	0	0	0	0	0	0	0	0
15-Mar-07	21	0	1	1	0	0	0	0	1	0	0	0

Scouting Inspection Summary Cont'd

Top-5 Average
House Paddock

Date	Week	Tuber Count per Plant mm 0-50	mm 50-100	mm 100+	Total Tubers	Hollow Heart	Brown Centre	Second Growth	Stems /Plant 4.4 Av.
4-Dec-05	3	3.6	0	0.1	0	0	0	0	3.6
16-Dec-05	5	4.4	21	0	0	4.7	0	0	4.4
22-Nov-06	5	5.5	0	0	0	0	0	0	5.5
2-Jan-06	7	3.8	13	0.3	0	3.3	0	0	3.8
15-Dec-06	8	3.3	15	0	0	4.7	0	0	3.3
10-Jan-06	8	4.2	14	1.3	0	3.6	0	0	4.2
15-Dec-06	8	4.5	16	0.3	0	3.6	0	0	4.5
25-Jan-06	11	3.7	5.7	5.6	0	3.1	0	0	3.7
27-Dec-06	10	5	10	7	0	3.5	0	0	5
6-Feb-06	12	4.2	4.3	8.1	0	3	0	0	4.2
11-Jan-07	12	3	4.5	2	0	2.2	0	0	3
15-Feb-06	13	3.8	3.5	7.6	0	3.3	0	0	3.8
11-Jan-07	12	4.8	4	13	0	3.6	0	0	4.8
1-Mar-06	16	3.5	2.2	7	0	3.6	0	0	3.5
26-Jan-07	14	4.8	2.8	9	0	3	0	0	4.8
18-Mar-06	18	3.7	1.4	5.3	0	3.2	0	0	3.7
8-Feb-07	16	2.8	1	3.3	0.3	3.3	0	0	2.8
25-Mar-06	19	3.3	2	4.1	0	3.5	0	0	3.3
22-Feb-07	18	4.5	2.5	7.5	0	3.4	0	0	4.5
31-Mar-06	20	3.4	1.3	5.2	0	3.2	0	0	3.4
10-Mar-07	20	5.5	1.8	11	0	2.7	0	0	5.5
5-Apr-06	20	4.3	0.9	4	0	2.5	0	0	4.3
15-Mar-07	21	3.3	2.3	3.5	0	2.8	0	0	3.3
12-Apr-06	21	4.4	0.3	3.1	0	2.2	0	0	4.4
15-Mar-07	21	6	3	9.5	0	2.6	0	0	6

Irrigation Summary

The rate of irrigation can influence crop growth and development. Very high rates can damage soil structure, causing problems with emergence, water infiltration, runoff and erosion. Irrigating more often improves access to the higher nutrient levels near the soil surface, potentially increasing yield.

From planting on 19-Oct-06 till 8-Dec-06 (around the first third of the crop) the root system is small and rapidly developing. During this time the soil moisture level needs to be sufficient in the mound for the root system to form properly. Restricting root growth at this early stage through water stress or tight soil reduces the crop potential significantly during the later stages of growth.

Irrigation "thoughts"

Following irrigation and the peak/spike in soil moisture the plant should begin reducing the moisture almost immediately - especially for the shallow sensor. If soil moisture remains high/saturated for a number days the crop is most likely stressed and at right of developing pink rot or water rot.

The rate of water uptake is related to the slope of the line, and once the slope begins to flatten out water uptake has slowed and the plant may be struggling to access enough water for optimal growth - just prior to this point would have been the ideal time to irrigate.

If the soil moisture at depth (60cm) continually declines mid season, this may not be a problem provided the applied water is having some influence upon the the sensor readings at that depth. Once the crop water requirements decline (towards the end of tuber bulking) the deep sensors should be watched closely to ensure excess moisture is not applied ie. the deep sensor should not record an increase in soil moisture.

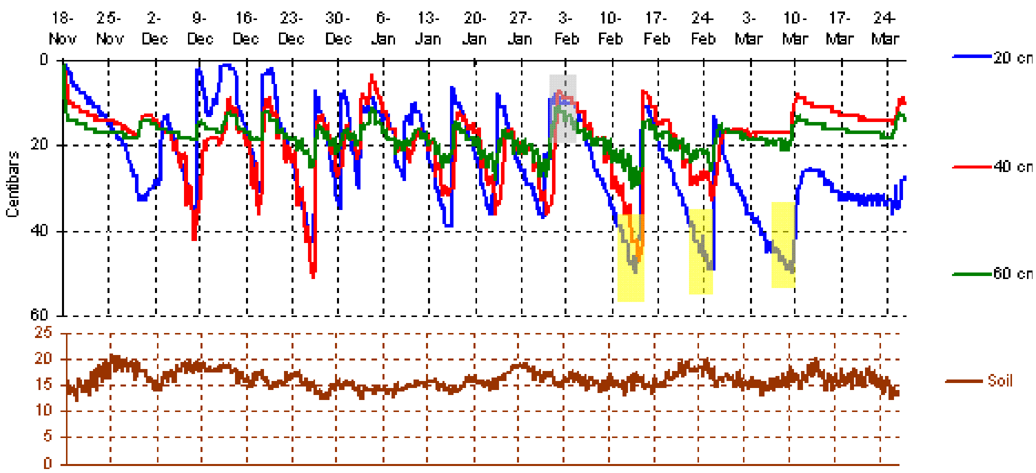


Figure 36

Figure 36 shows the soil moisture levels present in the root zone during the season - where data is available. As the root system develops the amount of water accessible by the crop increases - assuming no compaction issues. Nearing maturity the amount of moisture required by the crop decreases, and maintaining high levels promotes tuber rots.

Understanding soil moisture data is often complicated. If clarification is required on any aspect of the presented data please do not hesitate to contact Chris Russell.

Plant Population Summary

The plant population required to produce the maximum yield is difficult to determine on a yearly basis when other seasonal factors are involved. International data suggests higher plant populations produce higher yields - assuming the tubers produced are suitable for processing.

All paddocks are shown below, but a trend line has not been drawn as the return per ha has not been standardised in this figure. Please refer to the first section of this report for additional discussion on the influence of plant population on return per hectare.

The plant population for House Paddock (if recorded) is highlighted by the solid blue point in Figure 37. The plant population for 2005-6 House Paddock (if recorded) is highlighted by the solid red point. The plant population for 2004-5 House Paddock (if recorded) is highlighted by the solid black point.

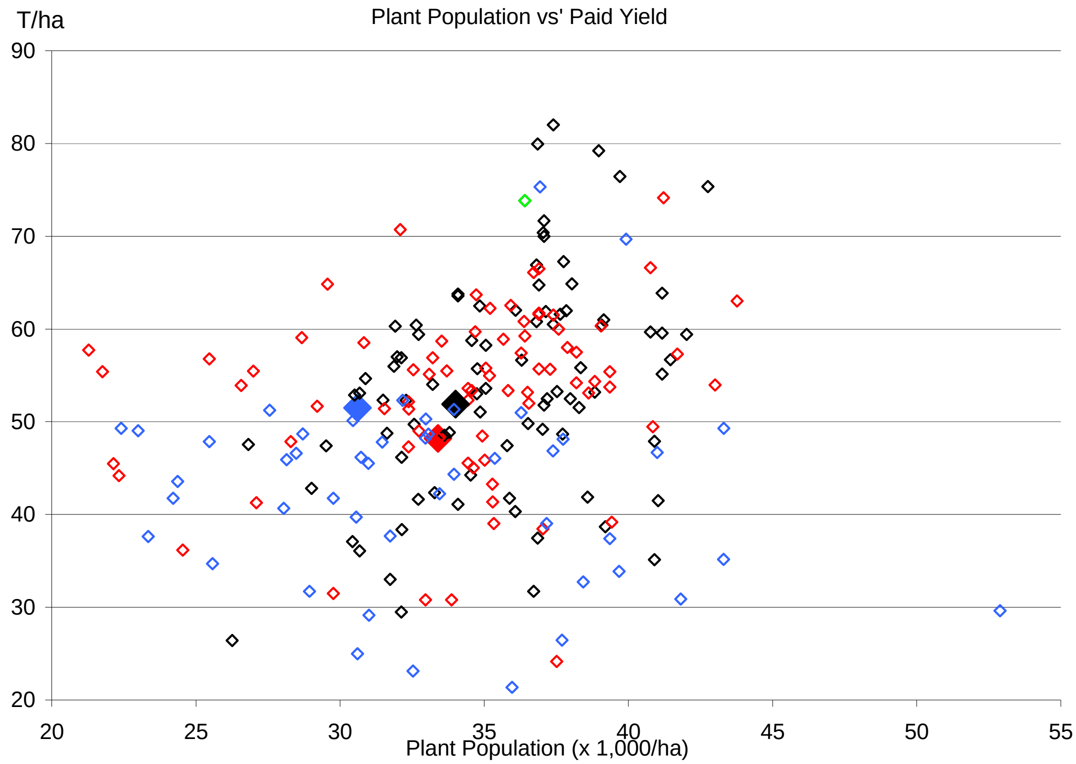


Figure 37

The blue points mark population data from 2006-07, the red points represent data from 2005-06, the black points are from 2004-05, and the green points are for 2003-04.

Before changing your plant population, consider the effect on tuber size and yield, and whether your results are caused by factors other than plant population. If increasing the population, the fertiliser and water requirements increase accordingly.

The plant population for House Paddock was within 20% of the 2006-7 average.

Climatic Data Summary

Temperatures were recorded every two hours using electronic logging devices. Logging every two hours means some short periods of extreme temperature could be missed. All paddocks should have had a soil and air temperature logger, but some problems with equipment were encountered. Where temperature data from your paddock is not available, data from close by is shown.

Air Temperature

The air temperature data from your paddock, or one nearby are expressed as the daily maximum, average and minimum in Figure 38.

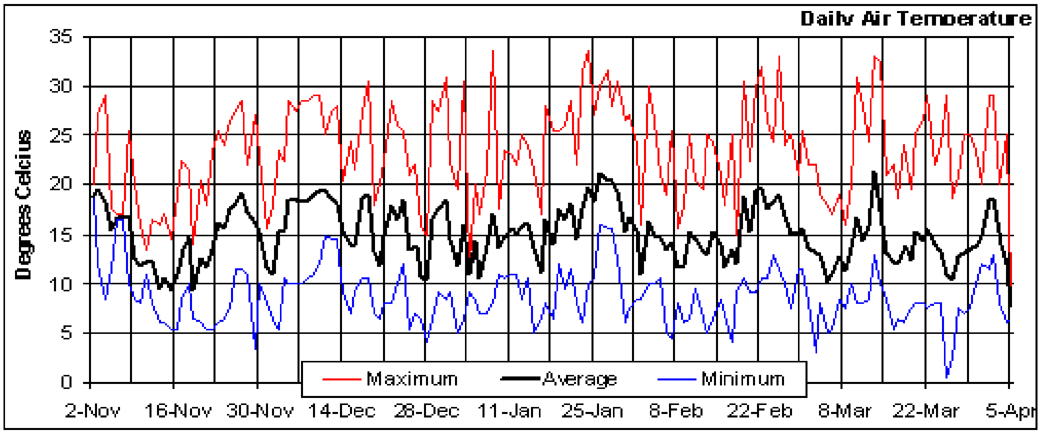


Figure 38

Any extremely high temperatures shown are not a true reading of the air temperature, but they do indicate when spikes occur. If these spikes correspond with low soil moisture conditions, the effects upon the crop maybe substantial.

Soil Temperature

Soil temperatures follow air temperatures, although there is a lag time of several hours. The logger was around 15cm below the top of the mould. The soil above the temperature logger, and later the plant, buffer the soil and tubers against the rate and amount of fluctuation seen in air temperatures.

Figure 39 shows the maximum, average and minimum soil temperatures logged in your paddock or a paddock nearby. N.B. Surface soil temperatures can be significantly different (above and below) from those recorded and shown below.

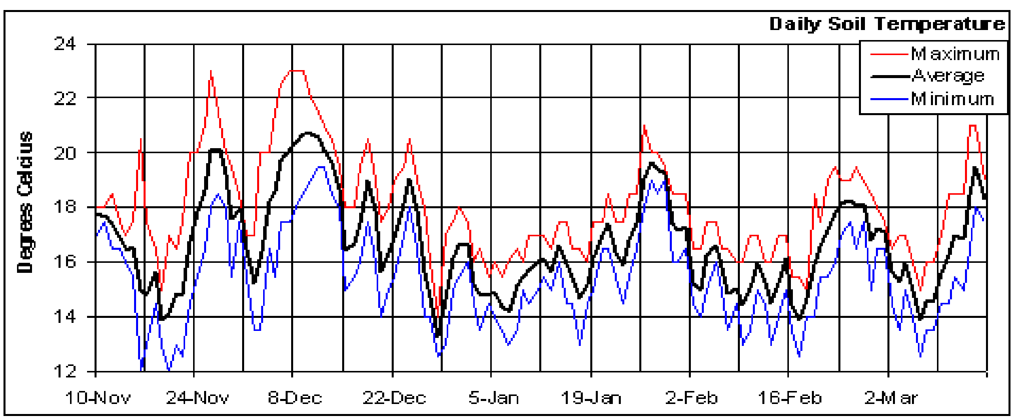


Figure 39

It is hoped that with the collection and analysis of additional soil temperature data in conjunction with other recorded data a correlation may be found with the onset of particular potato disorders.