Crop management tools for the french fry industry in the south east of South Australia

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MEDIA SUMMARY

This project has a focus on producing grower friendly crop management tools for the French Fry potato growers in South East of South Australia.

Key project components included;

- The collection and adaptation of crop management technologies and tools to improve the quality, yields and production efficiencies of Russet Burbank crops
- crop monitoring tools were produced that would take the take the format of Checklists and measurement-recording pages to be presented in a folder format
- project outcomes that would increase yields, improve the quality of product from the paddock that is in the optimum size and weight range with reduced numbers of 'smalls'

Many crop management tools have been produced in Australia and Internationally that reflect regional climate, soil types, variety and industry segment. This project evaluated some of these tools to assess their contents and methodology and referred positive concepts from them to the Project Management Team for consideration.

A large database of historical agronomic and crop management information that had been collected by the industry and growers over five years was analysed to detail trends and challenges that it may provide.

A key success to this project was that the potato growers and industry had a real enthusiasm and interest in exploring what outcomes maybe achieved by analysing the database and using this information to develop a crop management tool they could use to improve their crop management planning.

Most industries operate in the various phases of expansion, renewal, innovation and growth. The processing industry in the South East region of South Australia had an expansion phase during the 1990's that included the development and application in the field of a crop monitoring service to support this phase with up to date technical crop management information. This current project built on these experiences and the project output of a Checklist system for paddock recording provided the opportunity for the growers to actively record and mange their experiences.

The summary from the detailed database analysis indicated that in general the current crop management strategies were sound so this project outputs would focus on monitoring and improving *small incremental steps of management,* rather then wholesale changes to management systems. The analysis of the crop management database provided key concepts that the Project Management Team recognised as being priority issues and these are nitrogen application rate determination, budgeting and general management.

Growers and key industry personnel were contacted to identify their key concerns, knowledge and experiences regarding the application of crop monitoring tools. Several demonstration versions were produced and reviewed by the growers and industry mentioned above.

TECHNICAL SUMMARY

INTRODUCTION

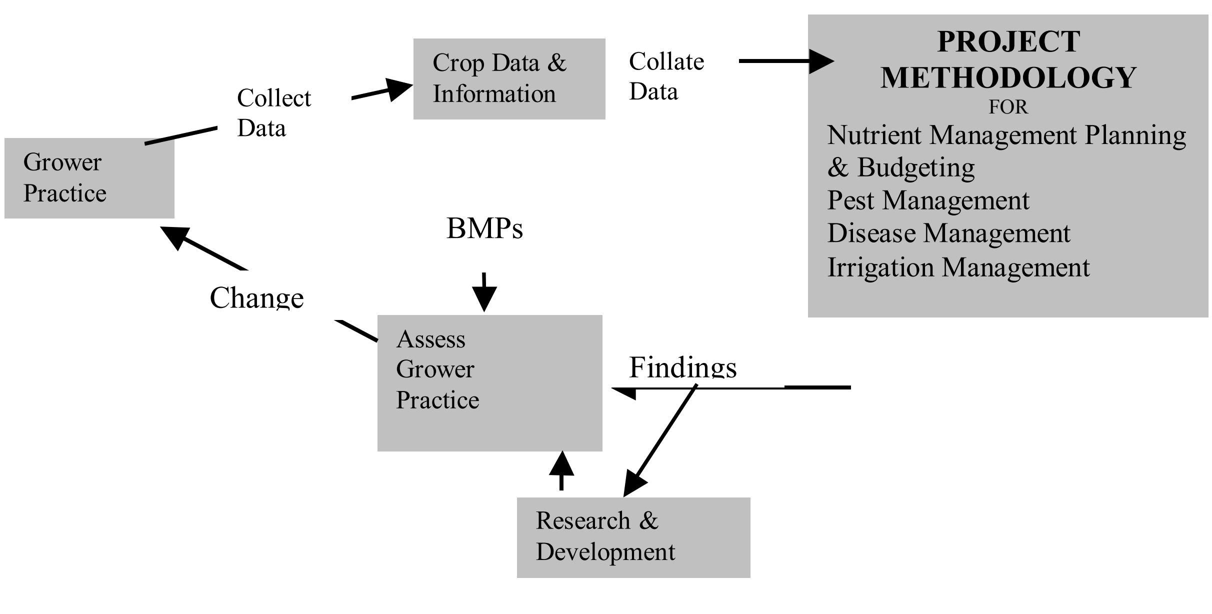
Most industries operate in the various phases of expansion, renewal, innovation and growth. The processing industry in the South East region of South Australia had an expansion phase during the 1990's that included the development and application in the field of a crop monitoring service to support this phase with up to date technical crop management information. The industry significance and key outcomes of this project are that the product developed has its origins in the database of information that the growers supplied and funded and they can continue to be actively involved in its continual improvement through the South East Potato Growers. The concepts derived from the analytical work demonstrated that the South East Potato Growers were in general, managing their systems on a comparable basis to others on a Global scale (page 19). This meant that management planning tools would focus on monitoring and improving *small incremental steps of management,* rather then wholesale changes to management systems. The analysis of the crop management database provided key concepts that the Project Management Team recognised as being priority issues. These issues mainly focussed on the issues of nitrogen application rate determination, budgeting and general management (Technology Transfer section). The key project components were to produce crop management tools that would assist the industry and growers to better manage the many increments in decision making processes that are the building blocks of the whole crop management system.

MATERIALS AND METHODS

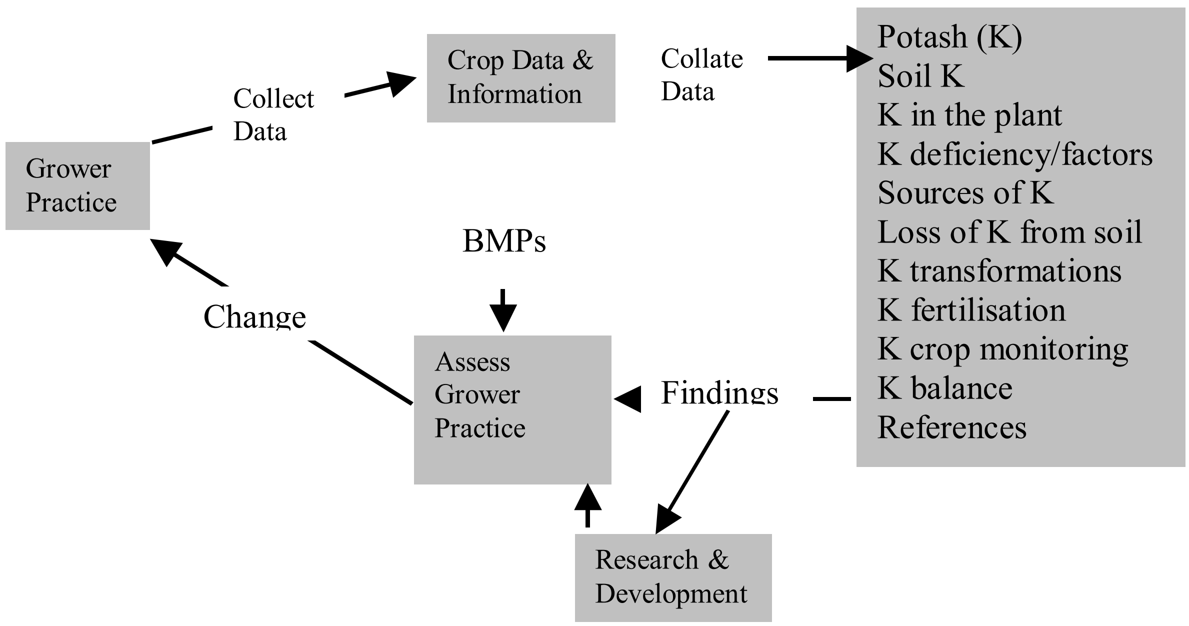
A Project Management Team was established that included growers with many years of practical and technical experience, industry staff with years of experience in crop monitoring and management as well as research and development. A Technical Support Team was established to provide support for the Project Management Team to manage and deliver this project.

The methodology followed the outline indicated by the following diagram;

- a large database of agronomic and crop management information was analysed for trends and challenges i.e. *grower practice*
- *data* was *collected* from external industry and technical sources related to *grower practice*
- this *crop data* and *information* was then *collated* and presented as *project methodology* to the project management team and growers for each of the sections. Appendix page 38.
- these *findings* were then compared to industry and technical *research and development* information
- *grower practices* were then reassessed and *Best Management Practises* developed for each of the sections. See page 29 of the Appendix.
- *change* will occur as a project output as the crop management tools are used by growers and industry



MATERIALS AND METHODS FOR NUTRIENT MANAGEMENT PLANNING AND BUDGETING:
Nitrogen, phosphorus, potash, calcium, magnesium, sodium, chloride, sulphur, copper, zinc and manganese were all analysed individually from the grower database in the manner described by the project methodology that follows. Potash is described in detail as an example of this methodology. Please see Appendix (page 9) for more detail as an example of the information that was presented to the project management team, growers and industry. The potash example discusses the amount of potash in the soil and plant, deficiency symptoms and factors influencing these symptoms, sources of potash to the whole crop system, loss of potash from the system by leaching, the transformations of potash in the soil and the effects of fertilisation, crop monitoring processes, potash in a nutrient balance and references that were used to support this information.



MATERIALS AND METHODS FOR PEST MANAGEMENT
The focus in this section is Risk Assessment and Action Points that need to be monitored to trigger actual action and the seasonality of these risks. There has been very little accurate field monitoring and research and development in pest management in the South East. It was agreed the best approach was to focus on crop monitoring in local conditions for the major potential pests in each season as outlined in *South East Potato Growing Pests.* This list was developed from the analysis of the database, these concepts were presented to industry and the growers for verification and a *Pest Rating* provided based on the individuals knowledge and experience. These were then collated in the Table on page 19 of Management Planning Tools. It was agreed that a section indicating *South East Potato Growing Beneficial Insects* was important so that the crop managers could consider the principles of IPM (Integrated Pest Management) in their crop management options.

MATERIALS AND METHODS FOR DISEASE MANAGEMENT
This section also has a focus on Risk Assessment and Action Points during constantly changing seasonal conditions. Once again it was agreed the best approach was to focus on crop monitoring in local conditions for the major potential diseases in each season as outlined in *South East Processing Industry Disease Management Strategy.* This list was developed from the analysis of the database and then these concepts were presented to industry and the growers for verification and a *Regional Severity* provided based on the individuals knowledge and experience. These were then collated in the Table on page 26 of Management Planning Tools.

The analysis of the database produced data sheets such as those that follow. These were assessed by specialists and general concepts were taken from them, discussed with the Project Management Team and then summarised and place into the Checklist. An example of the data sheets referred to are in the Appendix on page 35, 36 and 37; *SE Growers BMP Project, 2002-03, Fungicide Program; SE Growers BMP Project, 2002-03, Herbicide Program; SE Growers BMP Project, 2002-03, Insecticide Program.*

MATERIALS AND METHODS FOR IRRIGATION MANAGEMENT

The South East potato growers and industry were involved in a Natural Heritage Trust, South Australian Government and Primary Industries and Resources SA funded project (*Irrigation Benchmarking in the South East,* Technical report No.RB2001/023) to develop a module that could be used by groups of growers to assess irrigation management and to make comparisons across a group of sites. The project used a group of potato growers to test a process of benchmarking performance using quantitative indicators. This process developed project outputs as irrigation best management practises through case studies and group consultation with the objective of improving water use efficiency. The project outputs have been summarised on page 28 of Management Planning Tools as *Performance Indicators* and *Irrigation Best Management Practises.*

RESULTS

The contents of the *Management Planning Tools* are Confidential at this stage but will be available in the future through the appropriate industry mediums, available at that time.

Management Planning Tools was produced in a folder with the pages inserted in plastic envelopes. Master copies of the various section worksheets were supplied so that growers can photocopy them to provide working copies for each crop they wish to monitor and record for succeeding years. The focus was to produce a product that was grower and staff friendly, was portable, with worksheets that were suitable for field use and relatively time efficient to use and affordable.

Please refer to ***Management Planning Tools*** in the Appendix (page37) where copies of the front pages of each section and some section worksheets are included.

- Management Planning Tools
- Table of Contents
- Crop Nutrient Management (BMP)
- Best Management Practice (BMP's Worksheet)
- Nutrient Management Planning and Budgeting
- Pest Management
- Disease Management
- Irrigation Management
- Paddock Worksheet
- Paddock Recording Worksheet

DISCUSSION

This project has built on a previous project called *Improving International Competitiveness of the French Fry Potato Industry in South East South Australia* (PT340-1995). This project was an innovative technology transfer project that markedly improved the crop management skills particularly with plant nutrition, irrigation and crop monitoring within a structure that raised average yields, improved tuber quality and plant nutrition, crop establishment, irrigation practices, recording and reviewing overall crop performance, and their awareness of integrated approaches to disease control during the industry growth phase in the 1990's.

This current project has focussed on producing management planning tools that will assist both industry and growers to monitor the preparation of the paddocks and then the crops grown on these paddocks for the complete crop cycle. The narrowing of the potential profit margin as well as the need to manage the whole management system in a more sustainable manner increased the focus on producing a practical tool to deliver both these outcomes.

The project methodology included the collation and assessment of crop management practises and strategies from a database of information from grower's records of crop management. Data has been tabulated and graphed on both an individual grower and whole grower group basis. This methodology indicated trends within years and over the previous three to five years depending on the availability of complete data sets.

Information that was analysed and tabulated included individual elements i.e. nitrogen, phosphorus, potassium, calcium, magnesium, sodium, chloride, sulphur, boron, copper, zinc, manganese and iron; the effects of planting time; the influences of soil type; extractable nitrogen, phosphorus and potassium; phosphorus, nitrogen and potassium rates applied; plants per hectare and stems per plant; regional soil type selections and paddock preparation methods.

The major research findings demonstrated that the general crop management systems applied by these growers were comparable to those identified as being the most successful from the review of crop monitoring, extension tools and research information that was collated from national and global sources. This highlighted the need to focus on a crop management tool that provided opportunity to 'massage' and monitor each small increment in the crop management process, rather than modify large components of the process.

The final product focuses on improving the incremental steps in management planning that will, with time and experience, improve the quality, yields and production efficiencies. The final product was produced in a folder, grower friendly format with plastic filmed tear resistant paper so that it could be used in the paddock and be resistant to the elements. The growers did not support the concept of the Cd format as they considered it as not being practical and grower friendly. Crop management tools from National and International sources were collated to consider new concepts that they demonstrated and these concepts were then discussed with the growers for their consideration. Yield increases from reducing the numbers of *large* tubers and reducing the number of *smalls less than 100 grams* as well improving production efficiency particularly with the recent increases in fuel and nitrogenous fertilisers, will be the main outputs from this project. The final product has been developed with the assistance of information that the South East Potato Growers have provided from a commercial database that they have funded and so this product is specific to their needs and requirements.

TECHNOLOGY TRANSFER

Initial planning and delivery of the final draft of the project were carried out at industry and grower meetings. However, the geographical distance of the industry and growers from the Project Leader meant that review of the project progress, and review and assessment of draft versions of the *Management Planning Tools* was assisted by the use of e-mail, fax, phone and mobile phone to achieve the project outcomes and outputs. The Project Leader has delivered numerous concurrent projects in the South East region during this project life so, on many occasions, contact and discussion for this project occurred both on an informal and formal basis with Project Management Team members and growers during the course of specific project and general duties.

PROJECT DELIVERY

YEAR 2002	**DATE**	**YEAR 2005**	**DATE**
March	5/6	January	14/15/16
April	9/10/11	March	1/2
June	26	April	5/6
July	20/21/22	May	4/5
October	24/25	June	2/3 & 29/30
		July	13/14
YEAR 2003	**DATE**	August	15/16
February	19	September	6/7 & 29/30
March	24	October	18/19
May	20	November	8/9 & 21/22 & 29/30
June	24/25	December	13/14 & 19/20
July	22/23		
September	23/24	**YEAR 2006**	**DATE**
November	17/18	January	31
		February	1 & 20/21 & 27/28
YEAR 2004	**DATE**	April	10/11 & 18/19/20
February	23/24	May	3/4
April	21/22	June	5/6/7
May	19/20	August	1/2/3
June	28/29		
August	2/3 & 30/31		
September	21/22 & 28/29		
October	19/20		
November	16/17/18		
December	1/2		

The Project Management Team, the South East Potato Growers and a Technical Support Group all supported an application to the National Landcare Program (NLP) for a project to deliver objectives and outcomes for improved nitrogen management. This project titled *Evaluating Monitoring Tools for Sustainable Potato Production in South Australia* was successful in gaining funding for $118,000 per anum for 3 years, subject to project management criteria being met.

RECOMMENDATIONS

Management Planning Tools is maintained as a specific product for use by the South East Potato Growers and that liaison is continued with this group so that changes to this tool maybe arranged on an annual basis at their cost.

APPENDIX

Potassium (K)

1. Soil potassium

1.1. Forms

Potassium occurs in the soil as:

<u>K^+ ion in soil solution</u>: Optimum potassium concentrations in soil solution is in the range 10-60 mg/kg, depending on soil type, soil moisture and crop. Potassium in soil solution equilibrates rapidly with exchangeable-K. Potassium concentration in soil solution ranged from 0-5,000 μM (median 1,300), compared with 500-11,500 μM in the xylem and 20,000-85,000 μM in the phloem.

<u>Exchangeable-K (labile-K)</u>: Exchangeable-K is potassium adsorbed to negatively charged soil colloids or humus. Soil solution-K and exchangeable-K constitute only about 0.1-2% of the total potassium in soils. *Cation Exchange Capacity (CEC)* - indicates the capacity of a soil to retain cations, including potassium. Exchange sites are located principally on clay minerals and organic matter (humus). Therefore, the higher the clay and/or humus content of a soil the higher its CEC. Cation exchange capacity is also affected by clay type. For a given clay content, soils dominated by kaolinite (CEC < 15 meq/100g) have lower CEC compared with soils high in montmorillonite (CEC 80-150 meq/100g) or vermiculite (CEC 100-150 meq/100g). *Exchange sites* - the main exchangeable cations are calcium, sodium, potassium and magnesium. In acid soils H+, aluminium, iron and manganese may also contribute to CEC. Organic matter contains negatively charged phenolic, phosphate or carboxyl groups which can bind potassium. Organic matter has been reported to account for 30-80% of soil CEC. In clay minerals, exchange sites occur on outside surfaces (planar, p-position), in interlayer or inner positions (i-positions), and at edges (e-positions). Interlayer and edge positions have a high specificity for potassium. *Buffering capacity* - The relationship between exchangeable-K (Q, capacity) and activity of potassium in soil solution (I, intensity) is used to define potassium buffering capacity (Q/I; which indicates the capacity of the soil to resist changes in I when potassium is added or removed from the soil).

<u>Mineral and non-exchangeable-K (non-labile-K)</u>: This fraction is essentially non-exchangeable and is a constituent of micas, feldspars and illite. Its release requires weathering or destruction of the mineral.

Potassium ions removed from soil solution by plants or leaching are replaced by desorption from negatively charged soil colloids (exchangeable-K), weathering of K minerals (eg. micas or feldspars), or applied fertiliser.

1.2. Soil tests and soil testing procedures

Extractable-K levels
Pre-plant soil test data.

Range and frequency distribution of extractable-K (mg/kg)

Year	Range in levels	Soil test level (mg/kg)						
		…50	>50-100	>100-150	>150-200	>200-250	>250-300	>300
93/94	63-334	0	3	6	3	4	1	1
94/95	39-350	1	10	4	2	1	3	2
95/96	14-810	4	9	5	3	2	1	2
00/01	81-300	0	4	10	2	1	1	0
01/02	50-330	1	6	4	5	1	0	3
02/03	100-970	0	1	6	8	7	1	5

Extractable-K (kg/ha) in surface (0-15 cm) soil before planting

Year	Median	Range
93/94	270	113.4-601.2
94/95	198	70.2-630.0
95/96	189	25.2-1458.0
00/01	234	145.8-540.0
01/02	252	90.0-594.0
02/03	360	180.0-1746.0
Soil bulk density, 1.2 g/cm^3,		

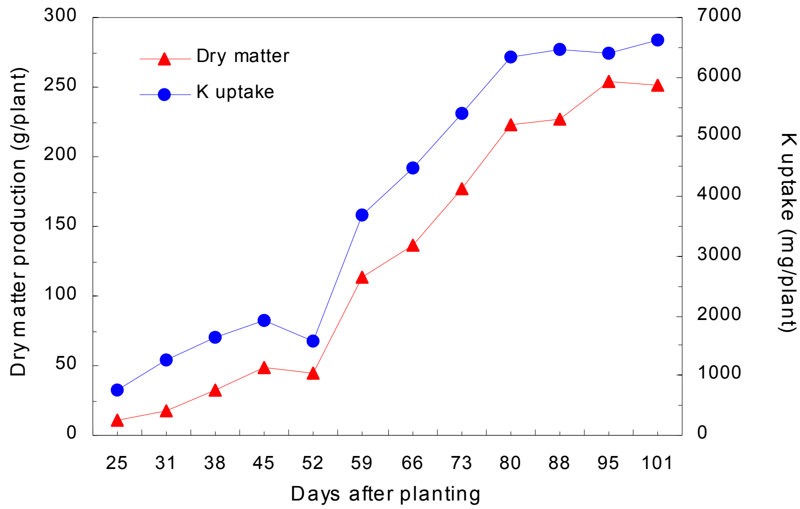
Extractable-K represents only a small fraction of the total-K in the soil.

2. Potassium in the plant

Uptake by roots: Uptake of potassium occurs as K^+ ions and is selective. Uptake is dependent on both plant (eg. transpiration rate, root growth rate and distribution) and soil (eg. temperature, moisture content, K in soil solution and K buffering capacity) factors. Diffusion and mass flow are the main processes for movement of potassium to the root surface.

Mobility within the plant: Mobility indicates the capacity for retranslocation in the plant. Potassium is highly mobile in plants and is transported via the xylem and phloem. It is the most abundant cation in the phloem sap.

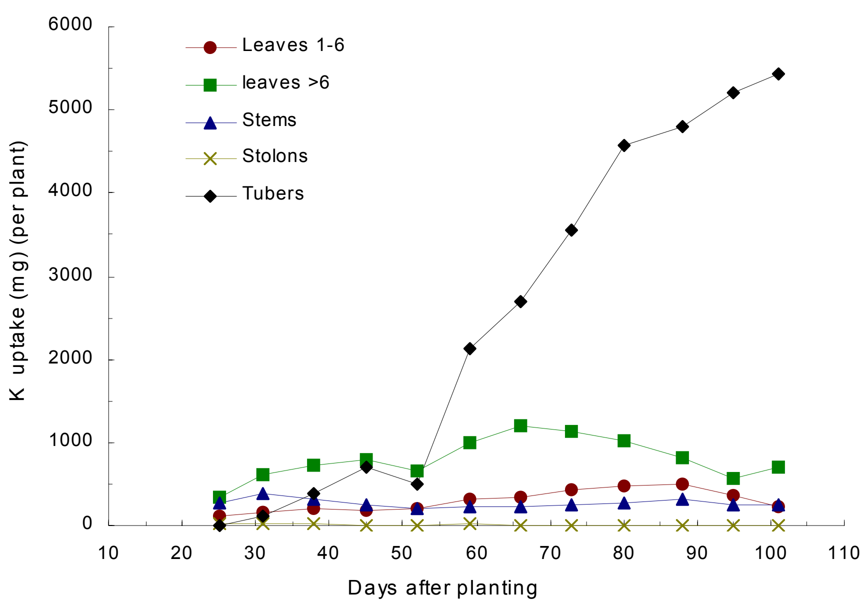
Accumulation of potassium in the plant:
Potassium accumulation was positive during the vegetative and tuber bulking periods, up to 80 days after planting.



Dry matter production and potassium uptake by tops+stolons+tubers. Plants were grown under an adequate potassium fertiliser regime. Data are for the cv. Pontiac grown in pots in a glasshouse

Potassium uptake by tops+stolons+tubers closely paralleled growth or dry matter production for tops+stolons+tubers. The steepest portion of both curves occurred between 52 and 80 days after planting

Accumulation of potassium by different plant parts:
The distribution of potassium among the different plant parts, varied during the growing season. Data for the cv. Pontiac, show that 40 days after planting potassium uptake was in the order, leaves >6 (older leaves) > tubers ≈ leaves 1-6 (young leaves) ≈ stems > stolons. In contrast at > 60 days after planting, the order was tubers >>> older leaves > young leaves > stems > stolons.



Potassium uptake by different plant fractions.

Data are for the cv. Pontiac, grown in pots in a glasshouse. Plants were grown under an adequate potassium fertiliser regime

At the final harvest, 82.1% of the total potassium accounted for was removed in tubers, compared with only 14.0% in leaves; 3.8% in stems and 0.1% in stolons. Jackson and Haddock (1959) found that at the end of the season, tubers of the cv. Russet Burbank accounted for approximately 89% of the potassium taken up by the plant.
Jackson and Haddock (1959) for the cv. Russet Burbank, and Ezeta and McCollum (1972) for Solanum andigena (cv. Renacimiento), reported similar trends for potassium accumulation in tops and tubers. Jackson and Haddock (1959) found that tops accumulated potassium until 95 days after planting. Thereafter (95-152 days after planting), tops lost 80% of the potassium contained at 95 days. In our study, during the period 66-95 days after planting, older leaves (leaves >6) lost 52.4% of the potassium contained at day 66.

Uptake rates:
Nutrient uptake rates by tubers depend on bulking rates and duration of the tuber bulking period. For the cv. Pontiac, developing tubers may accumulate potassium at a rate of 4.8 kg/ha/day when averaged over the tuber bulking period. Westermann (1993) presented uptake data for a range of cultivars grown in America, including: Russet Burbank, 3.1-4.0 kg/ha/day; Norchip 2.5-3.2 kg/ha/day; and Kennebec, 4.6-6.1 kg/ha/day. Ezeta and McCollum (1972) for Solanum andigena (cv. Renacimiento), reported that tubers accumulated potassium at approximately 5.6 kg/ha/day. The maximum rate was 6.6 kg K/ha/day.
Ezeta and McCollum (1972) and Harris (1992, p. 166) have tabulated potassium uptake rates for different cvv. and countries.

3. Predisposing factors and occurrence of potassium deficiency

A deficient level of exchangeable (available) potassium in the soil is not the only situation where potassium deficiency can be observed. Other factors, by affecting the rate of supply, uptake and translocation of potassium in the plant, can lead to potassium deficiency.

Coarse texture and/or low cation exchange capacity (CEC): Cation exchange capacity indicates the ability of a soil to hold exchangeable potassium. Loss of potassium due to leaching can be significant in soils with kaolinite (1:1 layer silicate), which is poor in specific interlayer (i-position) binding sites, as the main clay mineral. In coarse textured sands with low CEC, leaching of potassium beyond the root zone may occur after periods of heavy rain or excessive irrigation. Potassium supply may therefore be inadequate for optimum crop growth. The order of retention of applied potassium by soils for different sources was, $KCl < K_2SO_4 < K_3PO_4$. For phosphate sources, percolation losses of potassium increased in the order, $KPO_3 < K_2HPO_4 < KH_2PO_4 = KNO_3$.
Side-dressing applications of potassium should be considered to reduce loss and ensure adequate supply throughout the growth period. In potatoes, tubers are the dominant sink for potassium and peak demand is during the tuber bulking period. On coarse grain siliceous sands a total of 300-350 kg K/ha may be required. A calibrated soil test should be used to determine the level of exchangeable (extractable) potassium.

Low soil temperature: Root growth and the rate of release of potassium from clay bearing minerals are influenced by soil temperature. Low soil temperature reduces the rate of diffusion of potassium in soil solution to the root surface, plant growth and the rate of potassium uptake. The rate of applied potassium needed to optimise tuber yield may therefore vary with planting time (eg. winter vs summer). Soil temperature affects the rate of release of nutrients from soil minerals and fertiliser granules.

Low soil moisture content/dry growing conditions: Inadequate soil moisture reduces potassium uptake. At low soil moisture: i) Contact between the root surface and the soil is decreased. ii) Mechanical impedance increases. Tortuosity increases as soil moisture decreases. iii) Diffusivity of potassium ions in the soil is decreased. Diffusion is the main process whereby potassium is transported to roots. iv) Root elongation is reduced. v) The rate of release of potassium from clay minerals is reduced.
Low soil moisture and temperature slow diffusion of potassium in the soil and result in potassium deficiency (weather induced potassium deficiency) depending on extractable-K levels in the soil and extent of the root system.
Potassium deficiency may be much more severe in dry years compared with wet ones.

Soil has a high capacity to fix potassium: The capacity of soils to fix potassium depends on: i) The type of clay minerals present and charge density. ii) The degree of depletion of interlayer sites. iii) Extent of the wedge zone. iv) Soil pH, fixation is lower in more acid soils. Ammonium and hydrogen ions can compete with potassium ions for fixation sites. v) Moisture content. Micas, illites and vermiculites (2:1 clay minerals) fix potassium under dry and wet conditions whereas montmorillonites only fix potassium under dry conditions. Fixation may therefore be higher under dry conditions. Drying and heating significantly increase fixation. vi) Particle size, the smaller the particle the greater the edge. vii) Concentration of ions in soil solution.

Imbalance of exchangeable cations (Ca, K, Mg and Na): Potassium deficiency can occur as a result calcium and magnesium depressing the uptake of potassium (antagonistic effect), particularly in calcareous soils. Soils high in available calcium may require higher than standard recommended rates of potassium (and magnesium) to optimise plant nutrition. If soil applied potassium fertilisers are ineffective, potassium concentration in plants may be increased by foliar application of a water soluble potassium fertiliser (eg. potassium nitrate). The effectiveness of foliar sprays depends on the degree of deficiency and when it occurs during crop growth.

Other nutrients applied: Repeated and high application rates of calcium and magnesium or ammonium-N fertilisers or soil amendments (eg. lime, gypsum or dolomite) can reduce potassium uptake.

Waterlogging/flooding: This can reduce the uptake and translocation of potassium. Effects can occur after only 2-3 days. Excessive soil moisture can reduce aeration and phytotoxins may accumulate.
The extent of the effects on plant growth depend on i) the stage of growth at which waterlogging or flooding occurred; ii) the duration the soil was waterlogged and iii) temperature, survival may be longer if air temperatures are cool.

Compaction of the soil: Compaction affects aeration, potassium diffusion rates and increases the physical resistance to penetration of the soil by roots.

Tillage system: Work in the USA with other crops (eg. corn and cotton) reported that potassium deficiency can occur in no-till or ridge-till systems, even at high soil test levels. It was suggested that root development is restricted (eg. by soil compaction) under these systems compared with conventional tillage.

Cropping history: Soils, particularly those which have kaolinite as the dominant clay mineral, that have been frequently cropped and/or used for hay production, often have depleted extractable potassium reserves.

Soil type: Deficiencies have been reported in coarse textured (sandy) soils, eroded soils, organic (peat and muck) soils.

4. Sources of potassium

Sources of nutrients are either internal or external to the soil-plant system.

4.1. External to the soil-plant system

Fertilisers: Includes inorganic and organic sources, and manures. These vary in their potassium content and availability.

Potassium sulfate: (K_2SO_4; 38-45% K; 17-18% S); High concentration of nutrients (K and S), effective source of sulfur. Very low salt index. Very low tendency to absorb moisture from the atmosphere. More expensive than KCl due to higher production costs. Easy to handle.

Potassium chloride: (KCl; muriate of potash, 50-52% K; 47-50% Cl); Cheapest source of potassium. Pink or white in colour. Readily soluble in water. Higher salt index compared with KNO3 and K_2SO_4. Consider salinity effects, and effects of chloride on quality factors (eg. specific gravity) of tubers.

Potassium nitrate: (KNO_3; 37-38% K; 13% N); High concentration of nutrients (K and N), effective source of nitrogen. Readily soluble in water. Solubility increases rapidly with increasing temperature. Suitable for foliar sprays and fertigation. Low salt index.

Potassium-Magnesium sulfate: (K-Mag; Langbeinite; $K_2SO_4.2MgSO_4$; 18% K; 11% Mg; 22-23% S); Effective source of Mg and S.

Irrigation water/Rain: Potassium concentrations in irrigation water were generally low and therefore, not a major source of this nutrient for crop growth.

Concentrations of potassium in irrigation water applied to potato crops in different States

State	Range of concentrations (mg/L)	Amount applied (kg/ha)/300 mm of irrigation water
Victoria	0.2-30.3	0.6-90.9
New South Wales	0.7-7.6	2.1-22.8
South Australia	0.8-28.1	2.4-84.3
Tasmania	0-7	0-21

Maier (1986) concluded that potassium concentrations were generally low and irrigation waters in South Australia appear to supply little potassium (0.6-7.2 kg/ha assuming 300 mm total irrigation) for crop growth. This contrasts with results obtained in other areas, for example, Idaho irrigation waters have been calculated to supply about 80 Kg/ha K (McDole 1978).
Higher concentrations (25-30 mg/L) were associated with high salinity water.

Animal urine and faeces (manures). This is important where potatoes are grown in rotation with sheep or cattle grazing enterprises. Levels may be particularly high in holding paddocks for stock, for example, dairy “night’ paddocks. The nutrient content of animal manures is quite variable and depends on the specific source or kind of animal, the amount and kind of litter and bedding, the feed the animal consumed, and how the material has been handled and stored. The values presented should be only used as general guidelines and not for making important planning or management decisions. In South Australia, potassium in poultry manure from broiler, cage or litter sheds, ranges from 0.6-1.4% K, (on a dry weight basis) (Armstrong 1972). Potassium levels (dry weight basis) in liquid wastes range from 0.13-0.36% for pigs, 0.03-0.78% for cattle and 0.33-0.87% K for poultry.

Erosion/Runoff: Erosion or runoff may move soil and therefore nutrients, from one paddock to another.

4.2. Internal to the soil-plant system

K+ in soil solution:

Desorption from negatively charged soil colloids, and organic matter: This exchangeable (labile) potassium fraction is in equilibrium with potassium in soil solution.

Weathering of potassium-bearing minerals: For example, feldspars or micas.

5. Loss of potassium from the soil

Removal by tubers: The amount of potassium removed in tubers depends on tuber yield, dry matter content (% d wt) and concentration of potassium.

Potassium removed in tubers (kg/ha)
Data presented are for three tuber dry matter contents (15, 20 and 25%), two tuber calcium concentrations (0.02 and 0.075%) and total tuber yield in the range 20-100 t/ha.

Yield	**15% d wt**		**20% d wt**		**25% d wt**	
(t/ha)	**1.5%**	**2.5%**	**1.5%**	**2.5%**	**1.5%**	**2.5%**
20	45	75	60	100	75	125
40	90	150	120	200	150	250
60	135	225	180	300	300	450
80	180	300	240	400	300	500
100	225	375	300	500	375	625

For total tuber yields in the range 40-60 t/ha, 90-450 kg K/ha are removed. This amount is high compared with phosphorus and similar to nitrogen.
The amount of potassium removed in tubers is high, therefore, potassium management of potato crops is important for long term sustainable production. Depending on soil type, frequent cropping with potatoes can deplete soil potassium reserves.

Leaching: May be important in soils with low clay and organic matter contents.

6. Application of potassium

6.1. Soil

Placement and sources:

Topdressing - Assess if top dressing is an effective means of increasing potassium supply to the crop. Other than in coarse textured soils with low cation exchange capacity (CEC), potassium is relatively immobile in the soil. Potassium should be incorporated, for example at hilling or banking, or “watered in” by irrigating after application.

Rates:

2000/01 and 2001/02 growing seasons

Total potassium applied

Frequency distribution of total potassium applied, tuber yield (t/ha) and early and late season petiolar potassium concentration (%)

Total K applied (kg/ha)	**Number (%) of crops**			**Tuber yield (t/ha) - mean (range)**		
	2000/01	**2001/02**	**2002/03**	**2000/01**	**2001/02**	**2002/03**
…250	0 (0%)	0 (0%)	2 (7.1%)	-	-	50.7 (50.4-51.0)
>250-300	1 (5.6%)	3 (21.4%)	16 (57.1%)	45.5 (-)	58.3 (39.7-60.9)	55.2 (44.9-82.6)
>300-350	12 (66.7%)	10 (71.4%)	2 (7.1%)	46.3 (41.0-68.3)	51.8 (33.7-68.6)	60.5 (60.1-60.9)
>350-400	3 (16.7%)	1 (7.1%)	7 (25.0%)	66.6 (61.3-73.3)	54.8 (-)	61.6 (32.9-71.4)
>400	2 (11.1%)	0 (0%)	1 (3.6%)	44.9 (41.0-48.8)	-	60.0 (-)
	Petiolar K (%) - mean (range)					
	Early season			**Late season**		
…250	-	-	14.2 (13.1-15.3)	-	-	13.4 (11.5-15.2)
>250-300	12.3 (-)	15.9 (13.2-18.5)	14.1 (12.5-17.2)	11.9 (-)	12.8 (11.7-13.9)	11.8 (8.6-14.1)
>300-350	12.0 (11.1-14.3)	16.0 (12.8-17.6)	13.6 (12.7-14.5)	9.8 (7.5-12.4)	13.4 (10.6-14.8)	11.7 (11.1-12.3)
>350-400	11.6 (11.5-12.2)	14.2 (-)	13.5 (12.6-14.6)	9.3 (7.6-9.8)	13.3 (-)	11.7 (9.6-13.2)
>400	12.3 (11.2-13.4)	-	16.6 (-)	9.9 (9.5-10.3)	-	14.0 (-)

Extractable-K, basal K rates and early season petiolar K concentrations for the 1993/94 – 1995/96 growing seasons

Year	Extractable-K and K rate (kg/ha)			Petiolar K (%, 10 mm)
	Extractable K	K rate	Mean (range)	Mean (range)
		1993/94		
	…50			
	51-100	200->225	220.8 (212.5->225)	11.2 (8.9-13.5)
	101-150	200-225	210.4 (200-225)	11.1 (7.6-13.6)
	151-200	150-200	183.3 (150-200)	9.4 (9.1-9.8)
	201-250	150	150 (150-150)	11.9 (9.1-13.2)
	251-300	150	150	9.4
	>300	80	80	7.6
		Mean	*165.8 kg/ha*	
1994/95				
	…50	240	240	12.0
	51-100	200-280	234.25 (210-270)	12.0 (10.3-13.3)
	101-150	200-225	215 (210-225)	12.8 (12.0-13.6)
	151-200	175-220	180 (150-210)	11.7
	201-250	150	150	11.5
	251-300	125-200	167.5 (175-190)	11.6 (11.2-11.9)
	>300	75	75 (75-75)	12.2 (12.1-12.3)
		Mean	*180.3 kg/ha*	
1995/96				
	…50	250	250 250-250)	12.4 (11.4-14.7)
	51-100	225-275	243.2 (225-262.5)	12.9 (9.5-15.2)
	101-150	210-250	234.2 (215-250)	13.3 (12.0-14.8)
	151-200	175-250	208.3 (175-237.5)	13.1 (11.7-13.1)
	201-250	200-225	206.25 (200-212.5)	13.7 (12.8-14.5)
	251-300	175	175	15.4
	>300	75-100	93.8 (87.5-100)	12.4(12.0-12.7)
		Mean	*201.5 kg/ha*	

6.2. Potassium fertigation

Irrigation water is the carrier and means of distributing the potassium. Assess if fertigation is an effective means of increasing potassium supply to the crop. Check soil type and assess potassium mobility. Depending on the soil type, potassium applied through normal fertigation may not be effective because it accumulates in the surface soil (eg. 5-15 cm) where little root development can occur due to the soil drying between irrigations or rainfall.

6.3. Foliar sprays

Although potassium is mobile in the plant, depending on the degree and occurrence of the deficiency, foliar sprays may not be adequate on their own because of the high rates required and the danger of leaf scorch (burn).
Tubers alone, may accumulate potassium at rates of 5-6 kg/ha/day.

Foliar uptake: The rate of absorption and translocation determine the effectiveness of foliar applied nutrients and the number of sprays required. Time for 50% absorption of potassium applied to foliage of bean, squash and grape is 1-4 days.

Mobility within the plant: Mobility indicates the capacity for retranslocation in the plant. Potassium is highly mobile in plants and is transported via the xylem and phloem. It is the most abundant cation in the phloem sap.

Sources and rates: Laughlin (1962) applied nine weekly sprays of solutions containing 0, 1, 2, 3 and 4 % K as KCl and K_2SO_4, during the season to foliage of the cv. Artic Seedling. Detergent was added to ensure uniform wetting, and the first spray was applied when the plants were approximately 5 cm high. Leaf margins and tips burned when sprays of KCl exceeding 1 % K were used. No leaf injury resulted from any spray concentration of K_2SO_4. Prummel (1959) reported that spraying and late season applications of potassium ameliorated potassium deficiency aggravated by dry conditions. In this study, 50-75 kg K/ha were sprayed in the form of 7% or 10% K_2SO_4 solution, or 5.9% or 8.4% KCl solution. Spraying was done four times with high pressure equipment. The KCl spray produced slight scorching in nearly all treatments, and in one experiment, K_2SO_4 also produced some scorching. When applied to severely deficient plants response to the treatments occurred after a week.

Frequency and timing:

6.4 Potassium strategy

Lower South East:

Potassium strategy: rate, timing, placement and source

Days	*Stage*	1993/94 – 1995/96	Current
	Pre-planting (Broadcast)	0-100 kg/ha	
0	*Planting*	75-200 kg/ha	
	Emergence		
	Tuber set		
	Tuber bulking	Check petiole data	
	Maturation		

Australia/Overseas

Potassium strategy: rate, timing, placement and source

Country	Strategy
USA – Nebraska	Soil test value: 0-40 ppm – 120 lbs/ac K. 41-74 ppm – 80 lbs/ac K. 125-150 ppm – 0 lbs/ac K Note: rates may be higher for fry-stock market. Excessive P will not injure potatoes No differences between superphosphate, DAP and MAP.
USA - Florida	Mehlich 1 extractant: < very low – very high – 140 lb/ac K_2O. inconsistent yield response to applied K regardless of soil K concentrations (mobility of K in sandy soils). Reduction in SG or chipping quality frequently resulted from higher rates of applied K Total K application should be split into 2 applications with some applied at planting. Yield did not respond to K source (medium soil test level) – yields were similar for KNO_3, KCl, K_2SO_4, controlled release KNO_3.
USA – Western Oregon	0-200 ppm – 170-225 kg/ha K_2O 200-300 ppm – 110-170 kg/ha >400 ppm – 0 kg/ha K is most effective if banded at planting. K in excess of 110 kg/ha should be ploughed down
USA - Minnesota	0-500 lb/ac K_2O - depending on soil test value and yield goal.
Netherlands	40-250 kg/ha K_2O, potatoes for human consumption.

Colorado – San Luis Valley	Most soils are relatively high in extractable K/few crop responses to K. 0-160 lb/ac K_2O, depending on soil test value (expected yield 400 cwt/ac). Usual method is broadcast application tilled into the soil prior to planting. Main K fertiliser is KCl.
USA – Michigan	Mineral soils: LS/SL - 0-380 lb/ac K_2O; L/CL/Clays - 0-410 lb/ac K_2O, depending on soil test level and yield goal. K may be applied broadcast before planting or banded at planting. Do not apply > 100 lb/ac K_2O banded at planting. Topdress applications of K after planting are not recommended. KCl is the cheapest and most common source of K. Under good irrigation management and at moderate rates there is little difference in effects on tuber quality between KCl and K_2SO_4 and KNO_3.
USA - Idaho	K is relatively immobile in the soil – for best results it should be applied preplant and mixed into the seedbed. 0-240 lb/ac K_2O depending on soil test value.

7. Assessment of potassium management of crops

7.1. Petiolar potassium concentration

7.1.1. Early season (tuber set-early tuber bulking period)

Range

Range and frequency distribution of potassium concentration (%) in petioles sampled from Russet Burbank crops at tuber set-early tuber bulking stages

Year	Range in concentration	Concentration (%) in petiole					
		..8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-16.0	>16.0
93/94	7.6-13.6	2	6	5	4	0	0
94/95	10.3-13.6	0	0	11	11	0	0
95/96	9.5-15.4	0	1	7	10	10	0
00/01	11.1-14.3	0	0	10	7	1	0
01/02	12.8-18.5	0	0	0	7	6	7
02/03	12.5-17.2	0	0	0	17	8	3

Crop status

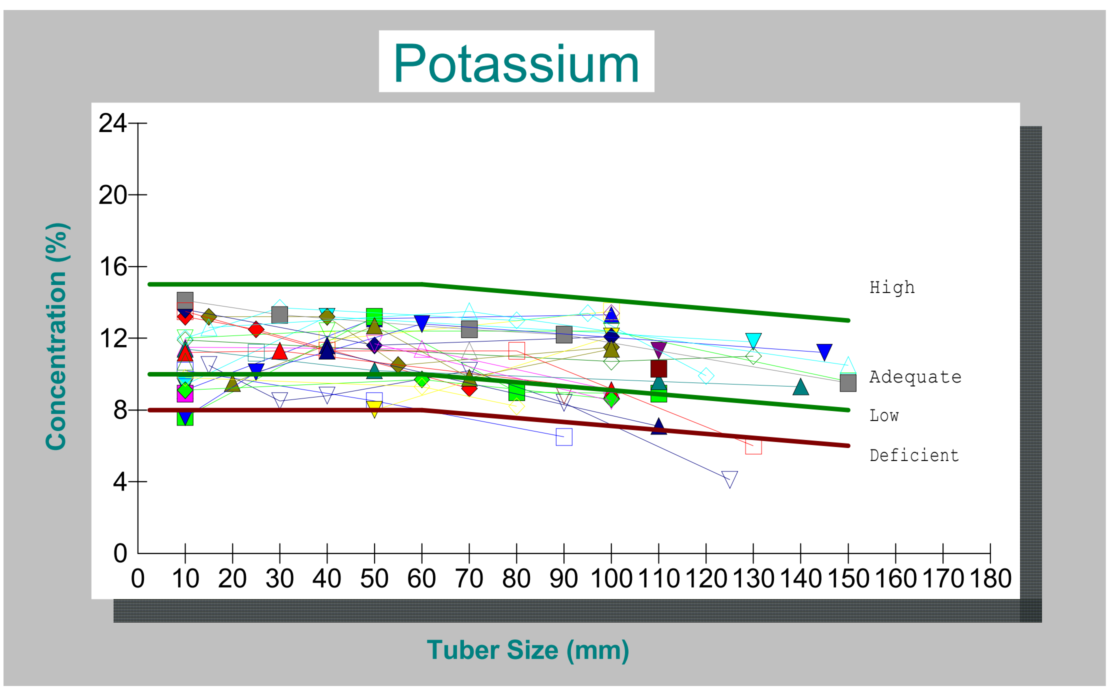
Potassium status of Russet Burbank crops at tuber initiation - early tuber bulking stages

Year	Deficient	Low	Adequate	High
93/94	2	6	9	0
94/95	0	0	22	0
95/96	0	1	24	3
00/01	0	0	18	0
01/02	0	0	10	10
02/03	0	0	22	6

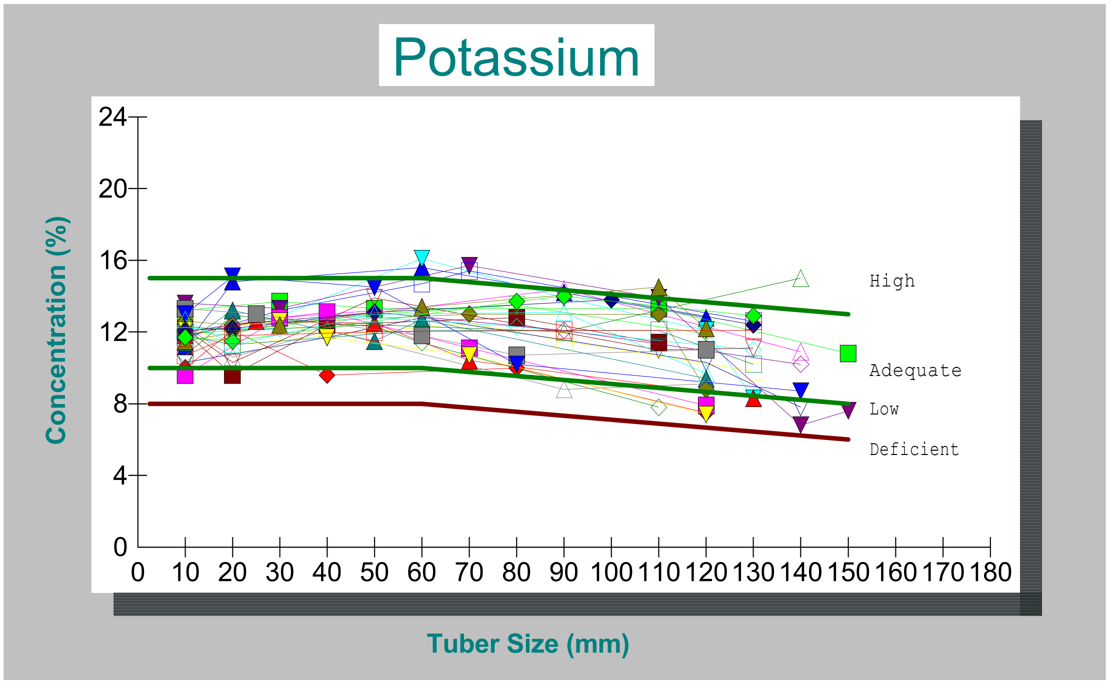
7.1.2. Nutrient tracking during crop growth

<u>CropTest printouts</u>: Petiolar potassium concentrations for commercial crops during the 1993/94, 1994/95, 1995/96, 2000/01, 2001/02 and 2002/03 growing seasons.

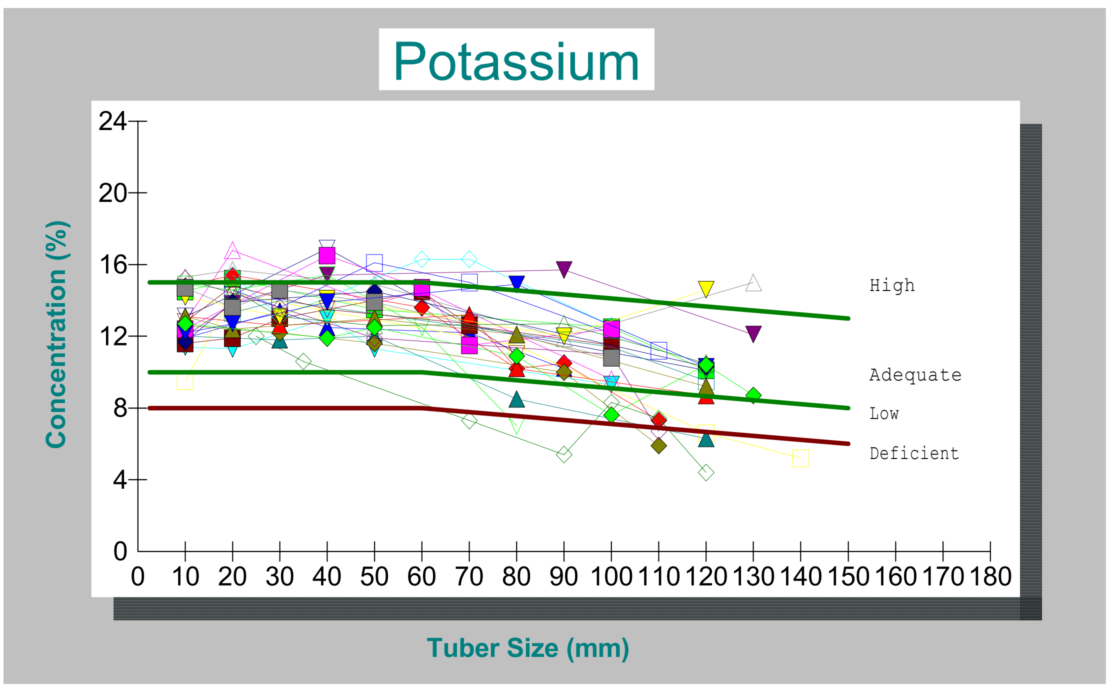
1993/94



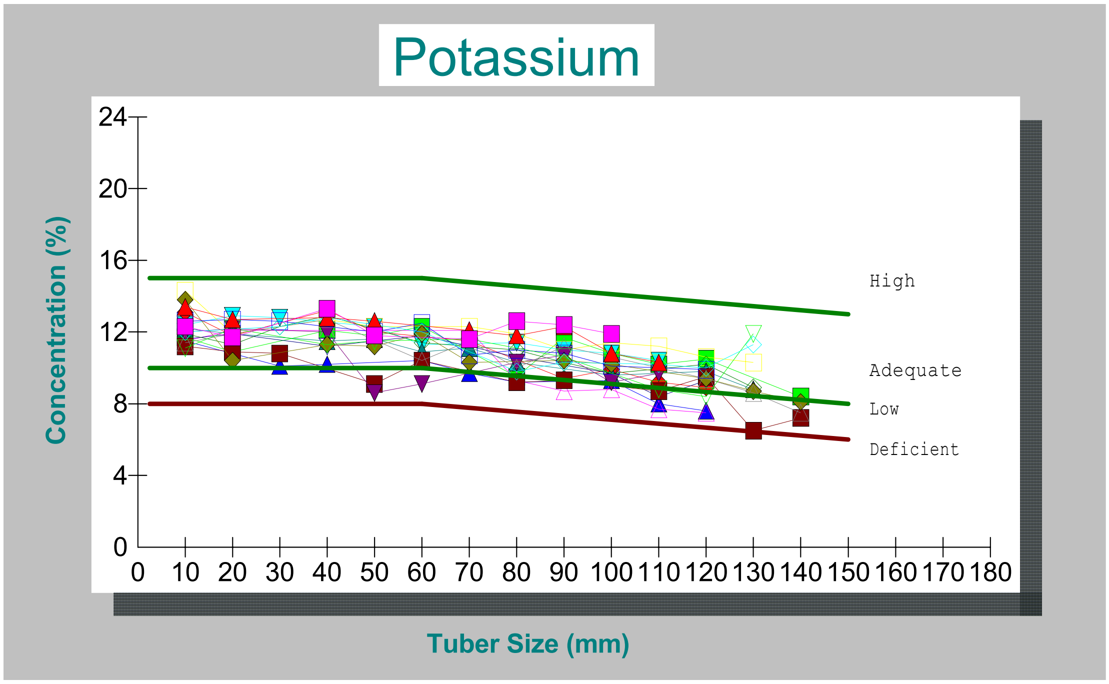
1994/95



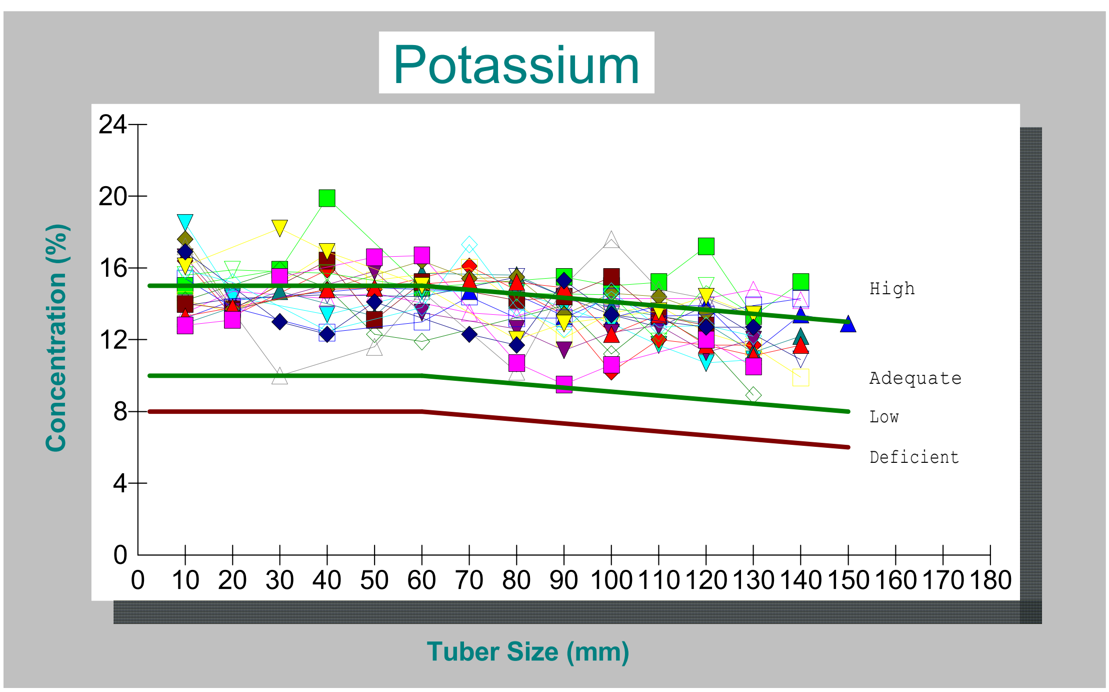
1995/96

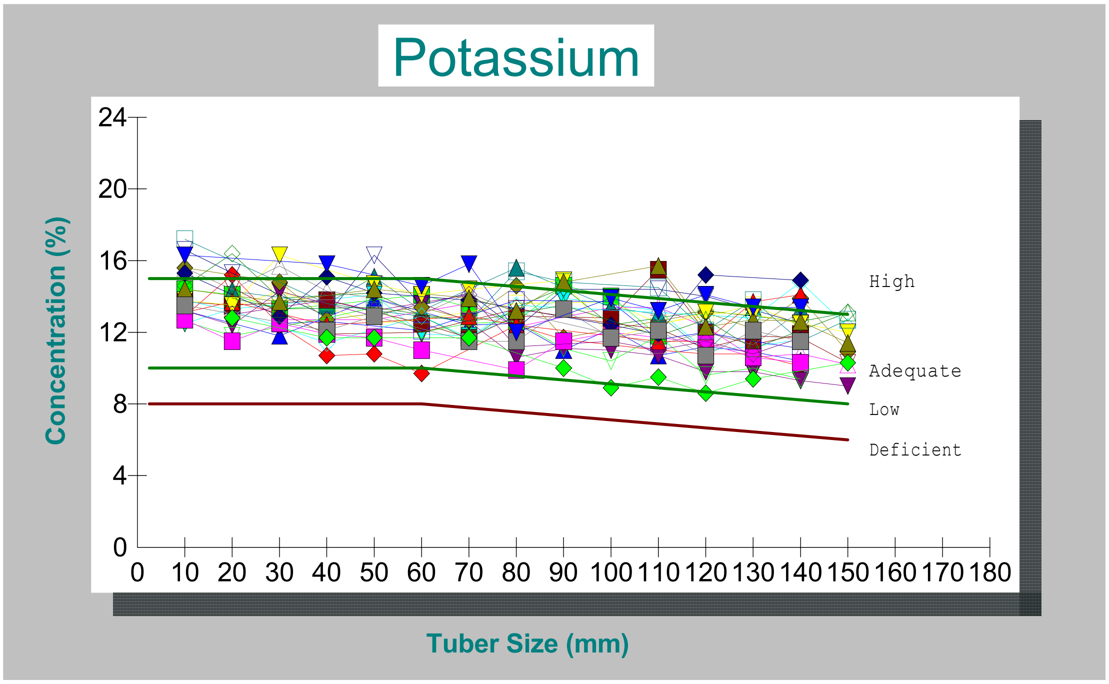


2000/01



2001/02




Potassium
Concentration (%)
24
20
16
12
8
4
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
High
Adequate
Low
Deficient
Tuber Size (mm)

7.2. Nutrient budget

Potassium loss and accumulation

Losses and sources	Amount	Example
Losses		
Removal by tubers (40-60 t/ha)	90-450 kg/ha	300kg/ha
Leaching	?	
Total (A)		***300kg/ha***
Sources		
(1) External to the soil-plant system		
Fertiliser (applied to soil; LSE 2000/01, 2001/02)	250-400 kg/ha	325 kg/ha
Foliar sprays	?	
Irrigation water (depends on potassium concentration and amount of water applied)	2-85 kg/ha	10 kg/ha
Rainfall/Dry deposition (rainfall: 1.0-4.0 g/mm K; Oct-April 150 mm)	0.15-0.6 kg/ha	0.35 kg/ha (negligible)
Total (B)		***335 kg/ha***
*Net gain/loss **(B-A)***		*+35 kg/ha*
Sources		
(2) Internal to the soil-plant system		
Extractable-potassium (kg/ha for layer 15 cm deep)	25-1500 kg/ha	200 kg/ha
Total (C)		***200 kg/ha***
*Residual amount **(Net gain/loss+C)***		*235 kg/ha*

8. Potassium and crop yield

8.1. Petiolar potassium concentration and tuber Yield

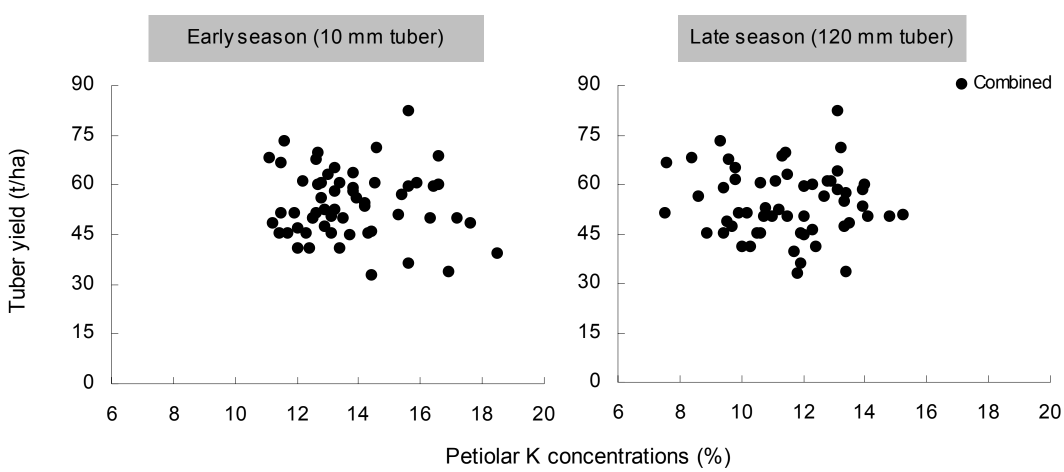
<u>Early/Late season petiolar potassium concentration and tuber yield</u>

Data for 1994/95, 2000/01, 2001/02 and 2002/03

Yield (t/ha) range	No. of crops	Tuber yield (t/ha)		Petiolar K concentration (%)			
				Early[A]		Late[B]	
		Median	Range	Median	Range	Median	Range
—65	9	68.6	65.1-82.6	12.7	11.1-16.6	9.8	7.6-13.2
>55-65	21	59.7	56.3-63.9	13.4	11.2-16.6	12.3	8.6-14.0
>45-55	29	50.1	45.5-54.8	12.9	10.7-17.6	11.2	7.5-15.2
>35-45	16	40.4	36.3-44.9	12.3	10.0-18.5	11.8	7.5-13.3
…35	14	32.1	29.7-34.6	12.1	9.6-16.9	10.4	7.4-14.4

[A] Sampled at tuber initiation – early tuber bulking stages (10 – 20 mm tubers).
[B] Sample at mid – late tuber bulking stage (100 – 130 mm tubers).

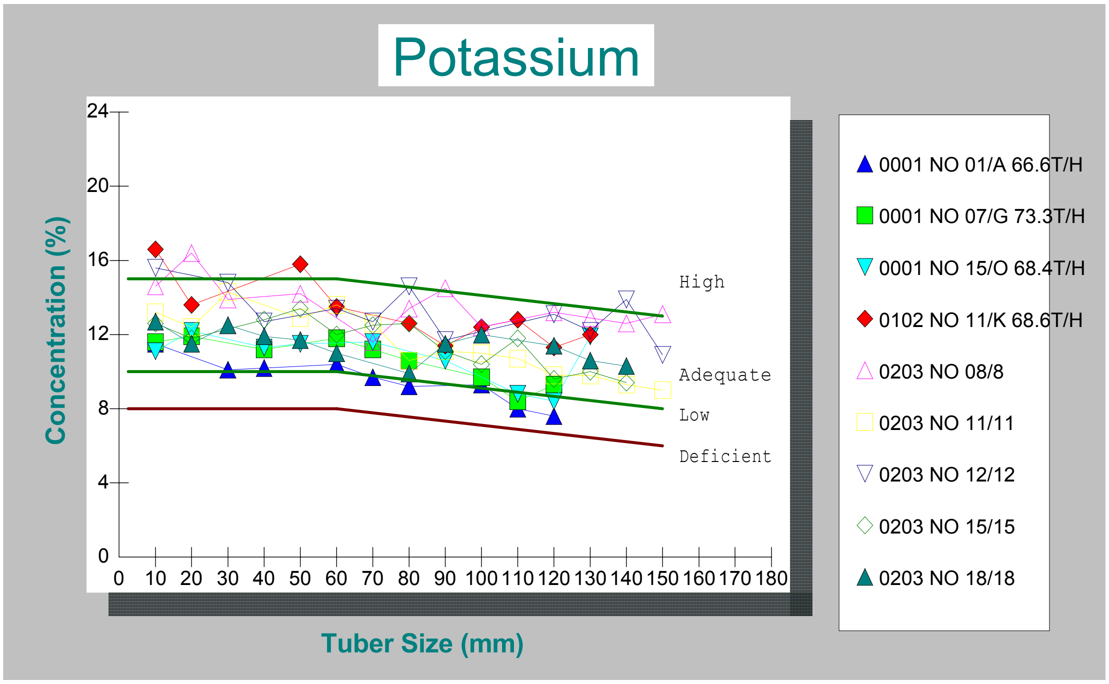
<u>Relationships between tuber yield and petiolar K concentration</u>



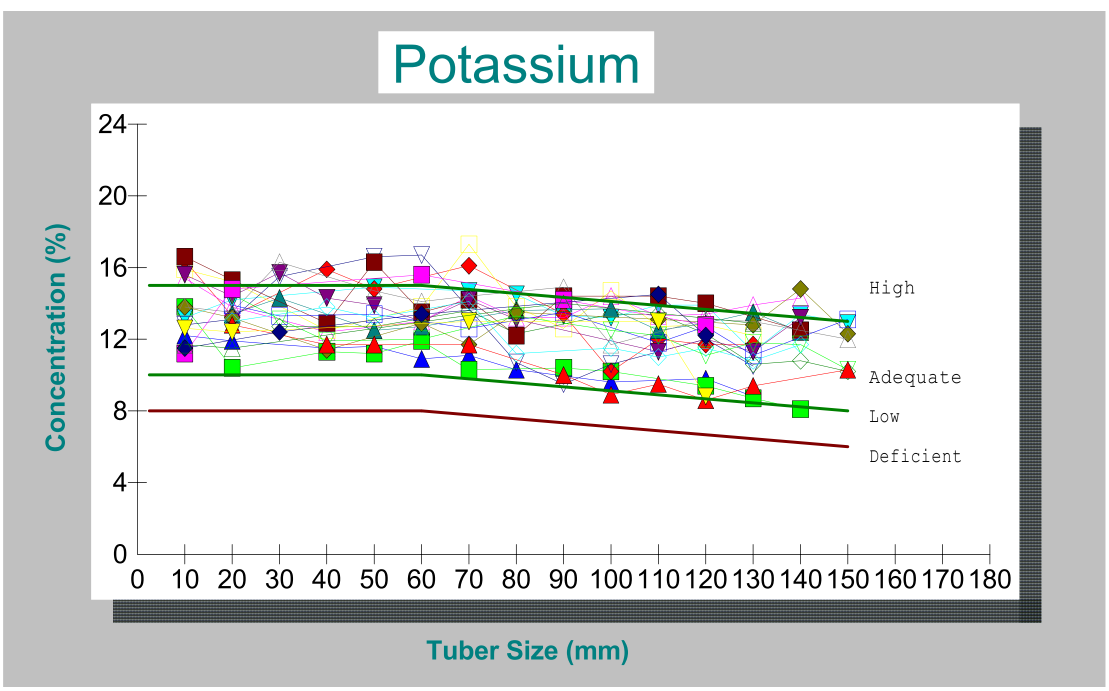
Relationships between petiolar potassium concentration and tuber yield for the 2000/01, 2001/02 and 2002/03 growing seasons

Nutrient tracking
Data for 1994/95, 2000/01, 2001/02 and 2002/03.

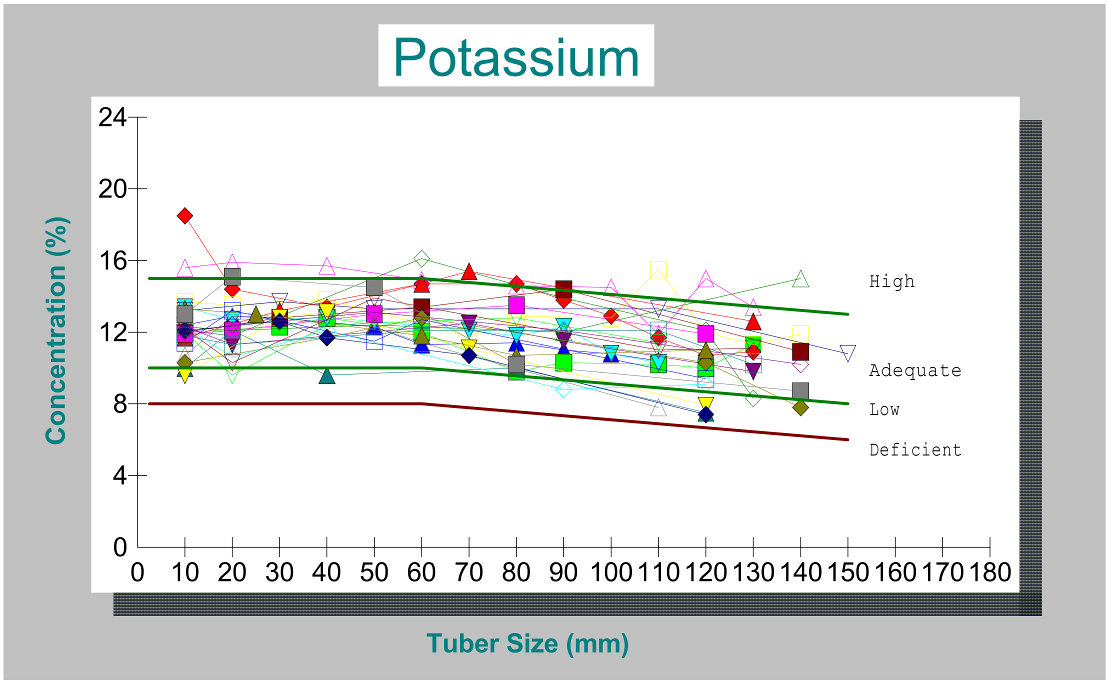
Yield > 65 t/ha (66.6-82.6 t/ha)



Yield >55-65 t/ha (56.3-63.9 t/ha)



Yield < 45 t/ha (29.7-44.9 t/ha)



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The following product was produced to demonstrate the type of tools that could be produced and the supporting information for the Checklist. Nitrogen, Phosphorus and Potash are provided as examples for nutrient budgets. This process provided an introduction to the concept of Best Management Practices.

Nutrient Management Planning and Budgeting
– tools to improve crop nutrient management

Potatoes are a high value crop grown under intensive management. Because of the high value, growers may apply excess fertiliser and water to ensure maximum yield. However, leaching of nutrients, especially nitrogen, into groundwater is considered to be at greatest risk under irrigation, especially with high nutrient inputs and poor management.
In this section we will discuss the use of nutrient management plans and nutrient budget (balance) as monitoring tools by growers to assess/improve the nutrient management of their potato crops.

Crop Nutrient Management Plan
A Crop Nutrient Management Plan is a tool to increase nutrient use efficiency and reduce off-site effects (eg. ground and surface water pollution).

Components of a crop nutrient management plan

Overall plan objectives	*Consider production goals and potential environmental impacts. What information/technology is required to achieve goals. Review previous crop information.*
Site evaluation	*Identify information to be collected. Develop field map, including reference points (eg. dams, buildings, trees, water courses, etc), adjacent land use, soil types, paddock size and general wind direction. Are there any special conditions which need to be considered?*
Nutrient requirements	*Determine crop requirements (amount and timing of nutrients) and sources of nutrients to be used (solubility, cost of nutrients, transport and storage). Set realistic yield goals. Decisions should be based on research findings and grower experience.*
Nutrient application	For each nutrient, decide on the optimum time and method of application. Rates applied will depend on the number of applications (timing) and the method of application (eg. broadcast vs band or solid vs fertigation). Application strategies may vary between paddocks depending on factors such as soil type, slope, planting time, irrigation water quality and rainfall.
Monitoring	*Set objectives, what will be monitored. Decide on appropriate sampling strategies for soil, plant and water testing. Ensure samples are handled correctly prior to analysis. Interpretation of results. Record keeping.*
Risk management	*Minimize the risk of impacts on the environment (eg. surface or ground water and soil), crop and marketability of the product (eg. tubers). User Best Management Planning.*
Health and safety	*Consider how nutrients and practices can impact on human health. Use Best Management Planning.*
Annual review	*Were production goals (eg. yield, quality, no off site effects, etc) achieved? Use nutrient balance sheets to do a crop nutrient audit.*

Crop Nutrient Budget/Balance
Growers and consumers are becoming increasingly concerned with the sustainability of crop production systems. Nutrient budgets allow one to determine the balance between nutrient inputs and outputs (nutrient balance). A nutrient balance can be positive – inputs > outputs (nutrient accumulation), negative –inputs > outputs (nutrient depletion) and neutral – inputs = outputs (balanced). The difference between inputs and outputs of nutrients can be used as a measure to evaluate the efficiency of the nutrient management of the crop.
Balance sheets can be done on an individual crop, farm or regional basis. Over time, temporal trends for the balance can be established.
The tool can be used to 1) assess the sustainability of nutrient management practices – prevent soil mining and reduce off-site effects (eg. ground and surface water pollution), and 2) identify areas of nutrient management which need to be improved.

Nutrient Balance Sheets
This section is designed to help growers develop nutrient balances for individual crops. It will focus on nitrogen (N), phosphorus (P) and potassium (K). Crop requirements for these nutrients can be high, therefore they represent the highest cost to growers and greatest risk to the environment if not managed properly.

Inputs
Only those inputs external to the soil plant system will be considered.

1. Fertiliser
   Average N, P and K fertiliser rates are presented in Table 1.

Table 1. Rate applied (kg/ha) for 2001/02 and 2002/03 growing seasons

	Nitrogen		**Phosphorus**		**Potassium**	
	2001/02	**2002/03**	**2001/02**	**2002/03**	**2001/02**	**2002/03**
Mean	483.0	503.1	122	144	314	300
Range	281-718	274-754	54-177	100-210	263-357	222-403
Median	457.4	525.0	120	136	314	280
N[A]	20	28	20	28	20	28

[A] Number of crops.

2. Other
   Seed **–** Calculations are based on a seeding rate of 2.4 t/ha, 20% dry matter and nutrient concentrations of 2% N, 0.2% P and 2% K.

   Irrigation water **–** The amount of a nutrient supplied in irrigation water depends on its concentration in the water and the amount of water applied. Inputs from irrigation water were variable, ranging from 15-150 kg N/ha, 0.05-1.0 kg P/ha and 2-85 kg K/ha.

   Rainfall/Dry deposition **–** The amount of a nutrient supplied in rainfall depends on the nutrient concentration and the amount. Calculations are based on a rainfall of 150 mm during October-April and concentrations of 5-10 g/mm nitrate, 0.5-2 g/mm P and 1.0-4.0 g/mm K. Inputs from rainfall ranged from 1-2 kg N/ha, 0.075-0.3 kg P/ha and 0.15-0.6 kg K/ha.

Exports

1. Tubers
   Removal by tubers is dependent on yield, dry matter content and nutrient concentration. For yields of 40-60 t/ha removal by tubers can range from 90-375 kg N/ha, 12-45 kg P/ha and 90-450 kg K/ha.

NPK balances

Estimated major N, P and K inputs (external to the soil-plant system) and exports for an "average" French fry crop in 2002/03 growing season are presented in Table 2. By subtracting exports from inputs, nutrient balances can be determined.

Table 2. Partial NPK balances for an "average" French fry crop for 2002/03

Variable		Nitrogen	Phosphorus	Potassium
		kg/ha		
Inputs				
	Seed	5	1	5
	Fertiliser	503	144	300
	Irrigation water	50	0.5	10
	Rainfall/Dry deposition	1	0.1	0.5
	Total inputs	**559**	**145.6**	**315.5**
Exports				
	Removal by tubers	300	30	300
Balance				
	Inputs - Exports	**+259**	**+115.6**	**+15.5**

Crop Nutrient Audit

Crop details – yield - 60 t/ha; tubers - 20% dry matter and 300 mm irrigation water.

Table 3. Nutrient balance sheet for an "average" French fry crop in 2002/03

Variable	N	P	K	Ca	Mg	Na	Cl	S	Cu	Zn	Mn
	kg/ha										
Inputs[A]											
Fertiliser	503	144	300	-[B]	-[B]	0	100	163	5	3	5
Other	56	1.6	15.4	202	32	302	760	30.5	0.1	0.51	0.5
Total	559	145.6	315.4	202	32	302	860	193.5	5.1	3.51	5.5
Exports											
Tuber	300	30	300	5	10	10	100	20	0.05	0.15	0.1
Balance	+ 259	+115.6	+15.4	+197	+22	+292	+760	+173.5	+5.05	+3.36	+5.4

[A] External to the soil-plant system.

[B] Inadequate data.

The balance sheet shows:

- All nutrients were in positive balance (inputs > exports), with large positive balances for nitrogen, phosphorus, calcium, sulfur, chloride and sodium.
- Nitrogen, phosphorus and sulfur inputs are high compared to the exports in tubers.
- Potassium inputs and exports are almost balanced.
- Irrigation water supplies significant amounts of chloride, calcium, magnesium and sodium.

Action

Nutrient balance	Impact	Action
Positive Inputs > Outputs	▪ Nutrient accumulation. ▪ Increased nutrient flow in agro-ecosystem.	Review nutrient management strategy: ▪ Review/Develop nutrient management plan. ▪ Adopt Best Nutrient Management Practices.
Neutral Inputs = Outputs		
Negative Input < Outputs	▪ Nutrient depletion. ▪ Decline in soil fertility.	Review nutrient management strategy: ▪ Review/Develop nutrient management plan. ▪ Adopt Best Nutrient Management Practices.

Best Management Practices (BMPs)

Growers should adopt best management practices when making nutrient management decisions.

BMPs: Are practices which combine information from scientific research with practical knowledge to optimise crop productivity and product quality while maintaining environmental integrity.

Plant Nutrients and the Environment

Environmental and Health Concerns

- Nitrate – Drinking water
- Nitrogen & Phosphorus – Pollute surface and ground waters (eutrophication)
- Heavy metals
- Soil acidification

Environmental and Health Benefits

- Productivity – Land use efficiency

Crop Nutrient Management BMPs:

- Develop a nutrient management plan for each paddock.
- Credit all nutrient sources (eg, irrigation water, manures and previous crops). Use soil tests to assess/monitor the nutrient status of the soil.
- Set realistic yield and quality goals. Use actual yield records for the specific paddock. Corrective approach or maintenance approach to nutrient management can be used.
- Select the appropriate source of nutrients (fertiliser) to apply. (See checklist).
- Apply nutrients when they are needed (timing) and where they can be most efficiently taken up by the crop (placement).
- Use most efficient nutrient placement method (band vs broadcast, solid vs fertigation, soil vs foliar (spray) application).
- Use application equipment which has been properly calibrated.
- Use plant analysis for crop monitoring.
- Base irrigation on BMP's to minimise leaching, runoff and erosion.

SE Growers BMP Project
2002-03
Fungicide Program

Code	Cultivar	Planting Date	Date Applied	DAP	Disease Target	Chemical Applied	Method Applied	Rate applied/ha	Grower or Contractor	Yield	Days Lived
1	RB	08/11/2002	03/01/2003	56	Target spot	Pennncozeb & Blueshield	Air	2 Kg ; 1 Kg	Contractor	52.6	140
			14/01/2003	67	Target spot	Penncozeb	Air	2 kg			
			27/01/2003	80	Target spot	Penncozeb & Blueshield	Air	2 Kg ; 1 Kg			
			07/01/2003	60	Target spot	Amistar	Air	2 L			
			18/02/2003	102	Target spot	Bravo & Alto	Air	2 L, 200 ml			
			23/02/2003	107	Target spot	Rovral	Air	2 L			
			03/03/2003	115	Target spot	Bravo & Alto	Air	2 L, 200ml			
2	RB	06/11/2002	08/01/2003	63	Target spot	Mancozeb	Ground	2 Kg	Grower	32.85	120
			22/01/2003	77	Target spot	Bravo	Air	2 L	Contractor		
			05/02/2003	91	Target spot	Amistar	Air		Contractor		
			19/02/2003	105	Target spot	Rovral	Air		Contractor		
			05/03/2003	119	Target spot	Wack	Air		Contractor		
3	RB	16/10/2002	09/12/2002	54	Pink Rot	Ridomil	Ground	2.5 Kg	Contractor	50.11	130
			28/12/2002	73	Pink Rot	Ridomil	Ground	2.5 Kg			
			07/01/2003	83	Target spot	Amistar	Ground	200 g			
			15/01/2003	91	Target spot	Mancozeb & Blueshield	Ground	2.5 Kg, 2 Kg			
			22/01/2003	98	Target spot	Walabi & Copper	Ground	2 L; 2 L			
			29/01/2003	105	Target spot	Rovral	Ground	2 L			
			07/02/2003	114	Target spot	Mancozeb & Blueshield	Ground	2.5 Kg, 2 Kg			

SE Growers BMP Project 2002-03
Herbicide Program

Code	Cultivar	Planting Date	Date Applied	DAP	Target	Chemical Applied	Method Applied	Rate applied/ha	Grower or Contractor	Yield T/ha	Day
1	RB	08/11/2002			Weeds	Glyphostae	Ground	2 L	Contractor	52.6	140
			13/12/2002	35	Couch	Fusilade	Ground	1.5 L			
2	RB	06/11/2002	10/12/2002	34	Couch	Fusilade	Ground	2 L	Grower		
3	RB	16/10/2002	13/11/2002	28	Weeds	Spray Seed	Ground	1.5 L	Contractor	50.11	130
4	RB	04/11/2002	28/11/2002	24	Weeds	Sencor	Ground(East half)	600 ml	Grower	52.67	140
			06/12/2002	32	Weeds	Sencor	Ground(West half)	600 ml			
5	RB	17/11/2002	?		Weeds	Sencor	Ground	?	Contractor	60.14	130-
6	RB	11/11/2002	06/12/2002	25	Weeds	Sencor	Ground	1.1 L	Contractor	60.87	140-
			28/03/2003	137	Dessicant	Reglone	Helicopter	4 L			
7	RB	20/11/2002	?		Weeds	Glyphostae	Ground	?	Contractor	60.0	140-
			?		Weeds	Spary Seed	Ground	?			
			14/04/2003	145	Dessicant	Reglone	Helicopter	4 L			
8	RB	31/10/2002	18/11/2002	18	Weeds	Spray Seed	Ground	1.2 L	Grower	71.36	140-
			07/12/2002	37	Weeds	Sencor	Ground	859ml			
10	RB	10/10/2002			Weeds	Glyphosate	Ground	2 L	Contractor	44.86	130-
			06/11/2002	27	Weeds	Spray Seed & Sencor	Ground	1.5 & 750 mL			
11	RB	08/10/2002	07/11/2002	30	Weeds	Sencor	Ground	900 mls	Contractor	65.11	140-
			25/02/2003	140	Ryegrass	Sertin	Ground	1.8 L			

SE Growers BMP Project 2002-03 Insecticide Program

Code	Cultivar	Planting Date	Date Applied	DAP	InsectTargeted	Chemical Applied	Method Applied	Rate applied/ha	Grower or Contractor	Yield T/Ha	Da
1	RB	08/11/2002								52.6	
2	RB	06/11/2002								32.85	
3	RB	16/10/2002								50.11	
4	RB	04/11/2002	########	32	Potato Moth	Nitofol	Ground	1 L	Grower	52.67	
			########	77	Aphids	Nitofol	Ground	1 L			
5	RB									60.14	
6	RB	11/11/2002								60.87	
7	RB	20/11/2002	########	112		Ambush	Helicopter	200 ml	Contractor	60.0	
8	RB	31/10/2002	########	117	Aphids	Confidor	Ground	300 ml	Grower	71.36	
			########	130	Jassids	Karate Zeon	Ground	20 ml			
			########	144	Aphids	Dimethoate	Ground	100 ml			
10	RB	10/10/2002								44.86	
11	RB	08/10/2002								65.11	
12	RB	26/10/2002								82.58	
13	RB	21/10/2002								59.57	

Management Planning Tools

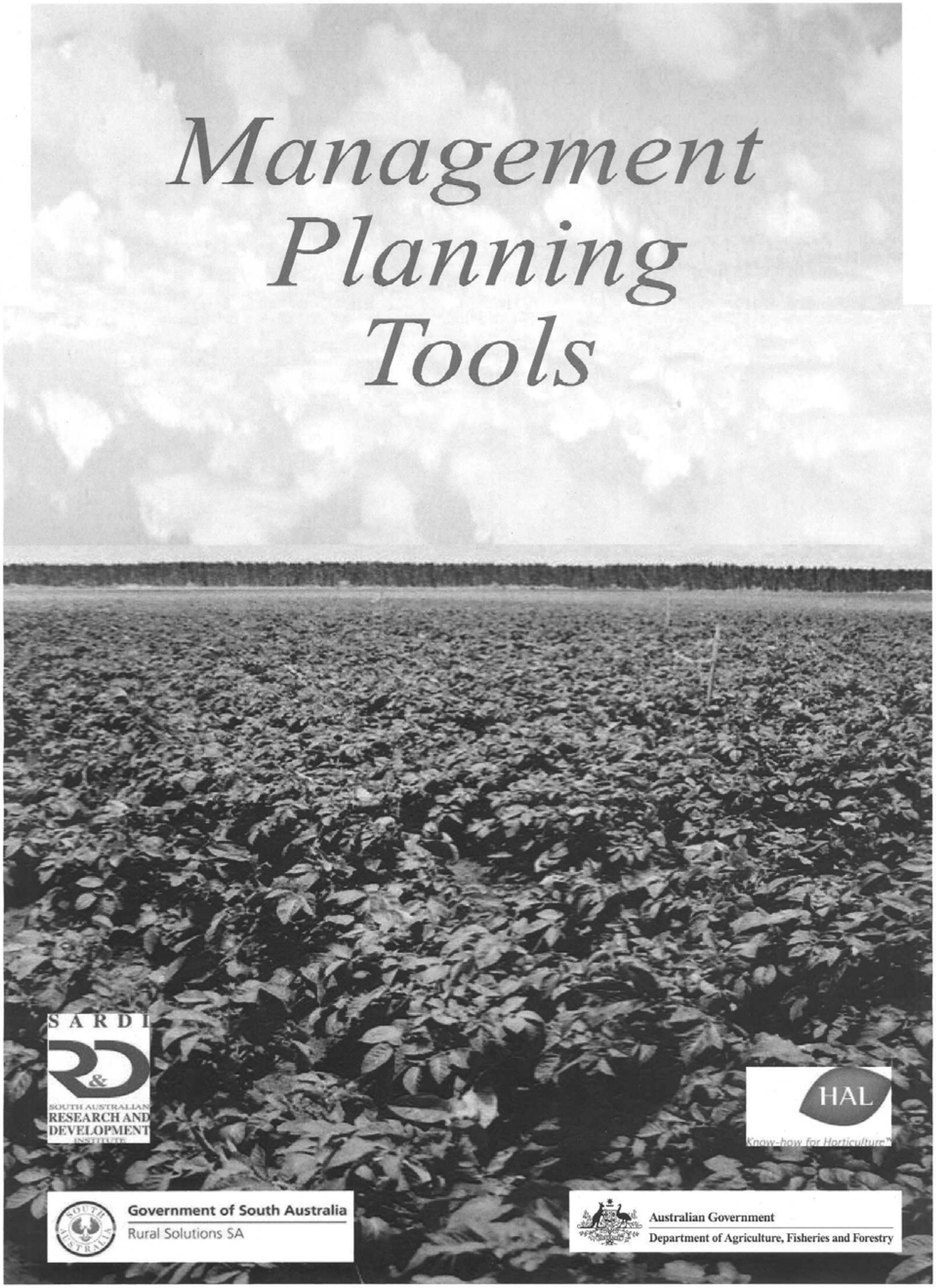

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TABLE OF CONTENTS

Crop Nutrient Management (BMP)

crop management

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Best Management Practice (BMP)	BMP Achieved ✗ or ✓
Develop a nutrient management plan for each paddock	
Credit all nutrient sources (eg irrigation water manures and previous crops)	
Use soil tests to assess/monitor the nutrient status of the soil	
Set realistic yield and quality goals. Use actual yield records for the specific paddock	
Corrective or maintenance approach to nutrient management can be used	

Nutrient Management Planning and Budgeting

...... tools to improve crop nutrient management.

Potatoes are a high value crop grown under intensive management and growers may apply excess fertiliser and water to ensure maximum yield. However, leaching of nutrients, especially nitrogen, into groundwater is considered to be at greatest risk under irrigation, especially with high nutrient inputs and poor management.

In this section we will analyse the use of *nutrient management plans* and *nutrient budget or nutrient balance* as monitoring tools by growers to assess and improve the nutrient management of their potato crops.

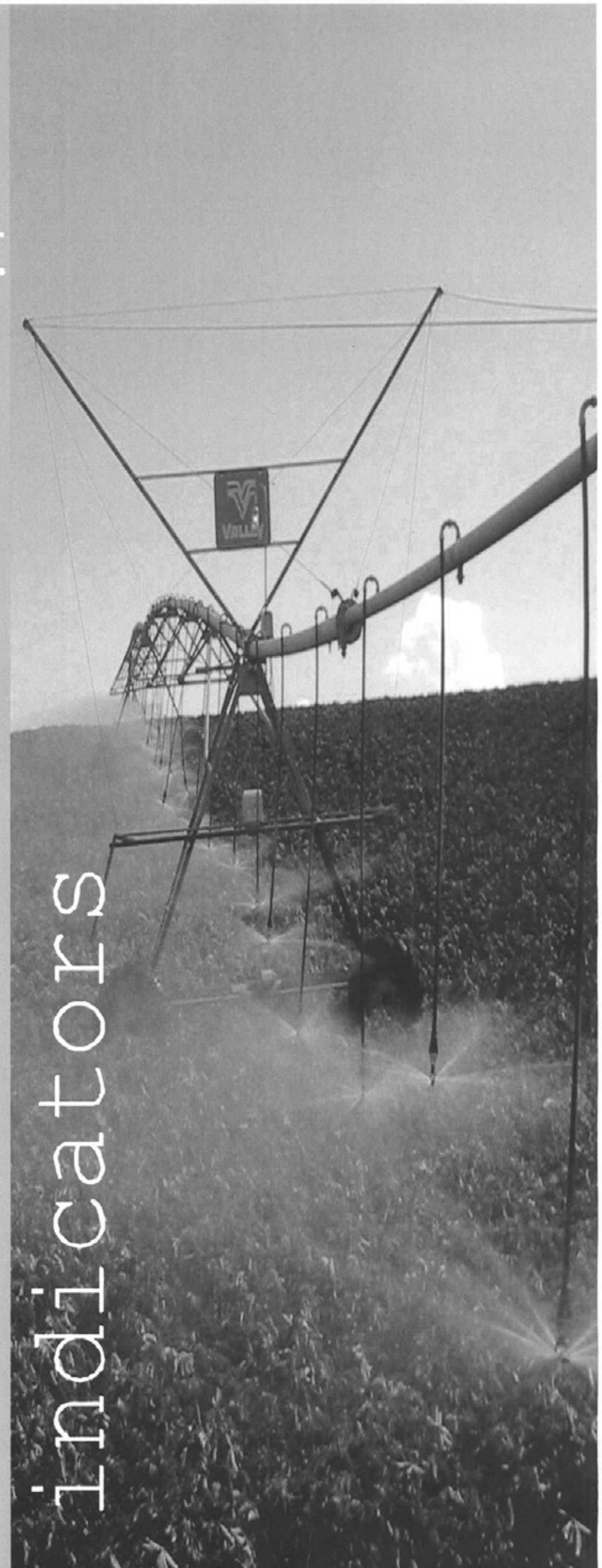
nutrient management

Pest Management

....tools to improve Integrated Pest Management (IPM) with South East Potato Growers.

integrated

Irrigation Management



performance indicators

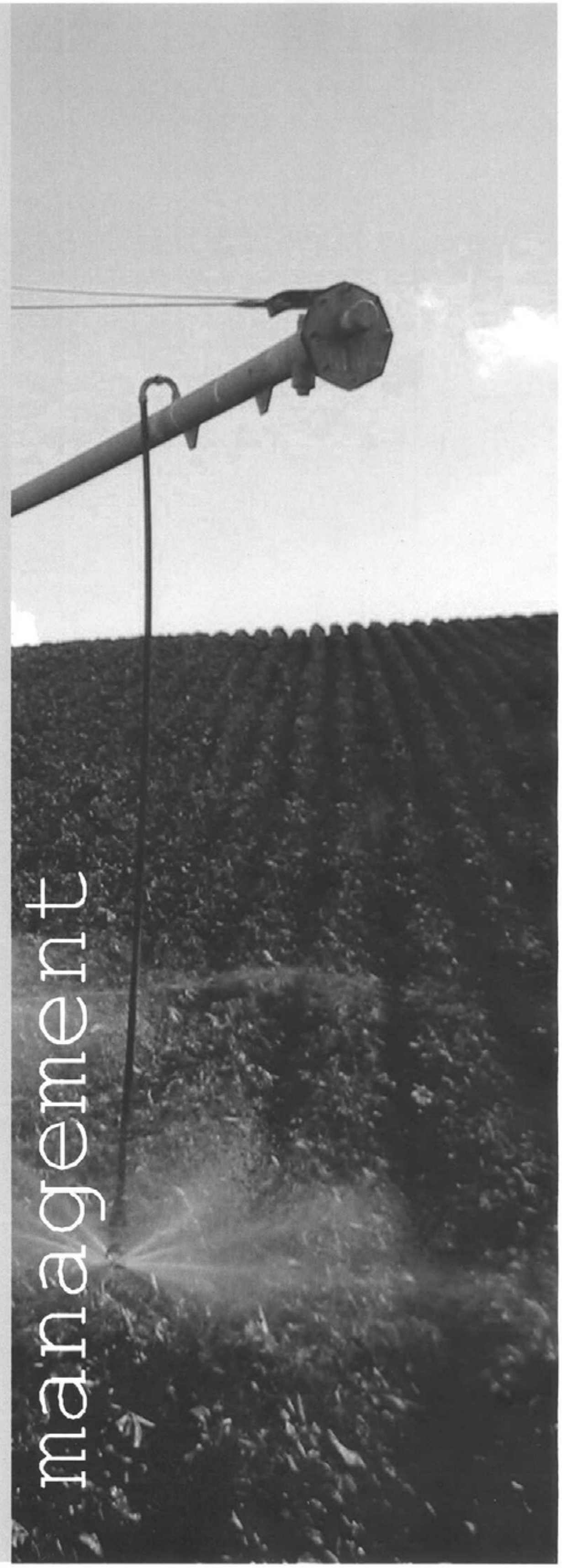
Disease Management

In order for a disease to occur there must be a susceptible host, a pathogen must be present and these two factors must come together under the right environmental conditions favourable for disease development

Most control strategies involve attempts to modify one or more of these factors and it is critical to understand how a pathogen gains entrance and infects the host plant to design and implement a risk management program. (Ref 2)

The focus for Disease Management is to consider **RISK ASSESSMENT** on a ongoing basis that leads to **ACTION POINTS** during the constantly changing circumstances during the crop cycle.

disease management



PADDOCK WORKSHEET

	Soil	Comments	×	✓
	Soil Texture **Sand, Loam, Black Clay and Duplex soils** (in the Lower South East this may include **Sand over Clay** or **Sandy Loam over Clay** or **Loam over Clay.** **Measure and record depths** of the different layers in the soil profile with a soil auger to a depth of 75cms **Measure and record depth** to any 'different' layers; • compacted layers • hard pans • potential drainage problems i.e. clay NOTE VARIABILITY WITHIN PADDOCK WITH THESE DIFFERENT LAYERS. **Collect soil** for soil analysis from each soil layer as per instructions. **Collect soil** for 'special' soil analysis from 'different' layers. **Note & Record** the extent 'different' layers on paddock map			

PADDOCK RECORDING SHEET

No	Comments	✕	✓
1			
2			
3			
4			
5			
6			
7			
8			
9			