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Nitrogen dynamics in commercial seed potato crops and its effect on seed yield, quality, storage and subsequent commercial crop performance

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Serve-Ag Pty Ltd

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PT99057

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Conducted for

HORTICULTURE AUSTRALIA LIMITED

By

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Contributors: Horticulture Australia Limited

Voluntary contributions were received from Simplot Australia Pty Ltd, Harvest Moon and McCain Foods (Australasia) Pty Ltd.

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Media Summary

As a result of the project 'Nitrogen dynamics in commercial seed potato crops and its effect on seed yield, quality, storage and subsequent commercial crop performance', seed potato growers will gain access to better guidelines on site-specific nitrogen management using 'real-time' monitoring tools.

Nitrogen (N) and other nutrients greatly influence yield and quality of seed potatoes. If seed users are to gain the seed's full potential, nutritional management is one input that has to be fine-tuned to keep the crop within optimum nutrient uptake levels throughout the growing season.

Nitrogen management includes taking into account N that becomes available from incorporated plant residues and organic matter during the growing season. N from mineralisation and possible N-fertiliser carryover from the previous season can significantly influence the crop by producing unexpected N excesses which may affect tuber set and seed performance. N flushes can lead to growth spurts resulting in other nutrient deficiencies as well as higher susceptibility to foliage diseases. On the other hand, N deficiency at any time will be detrimental to yield.

The test for monitoring available soil N levels, *N-check*, was adopted from Europe, where it is the recommended method for managing N inputs into crops to improve yield and quality, and avoid environmental problems through nitrate leaching into waterways. The test for monitoring N uptake into the plant, *NU-test*, analyses nitrate levels in petiole sap. Different from tissue testing, which provides information on nutrient accumulation, *NU-test* shows current nutrient uptake, and reflects on nutrient availability in the root zone and uptake conditions. Both tests have a 24-hour turnaround time for results.

The project focus was on nitrogen dynamics, as previous research had revealed alarmingly high soil nitrate levels in seed potato crops, especially in ex-pasture soils, during early to mid summer.

With the assistance of staff from Simplot Australia Pty Ltd, McCain Foods (Australasia) Pty Ltd and Harvest Moon, soil and plant N levels in seed potato crops were monitored over three seasons. Prior to harvest, crops were assessed for plant, stem and tuber numbers, yield, tuber size and quality. Crops to be monitored were selected by the participating seed producing companies to represent different paddock histories, i.e. previous crops with high or low amounts of N release from crop residues.

Data collected from seed potato crops following different previous crops showed that cropping history should be taken into account when determining N fertiliser inputs. The crop preceding potatoes influenced soil, plant and tuber nitrate levels. The effects of exposure of seed to different soil nitrate levels on performance of the following crop were investigated in a replicated field trial. Some results from the field trial could not be related to previous crop N management. Other agronomy factors and seed handling and storage also had an impact on the seed. The number of seed lines tested was not large enough to allow a statistical analysis of results.

Technical Summary

The aim of the three-year project 'Nitrogen dynamics in commercial seed potato crops and its effect on seed yield, quality, storage and subsequent commercial crop performance' was to develop guidelines for site-specific nitrogen management of seed potato crops using 'real-time' monitoring tools. This included the investigation of relationships between soil nitrate nitrogen, plant nutrient levels and seed quality/performance. Seed potato crops grown in soils with high and low organic residue levels were included to study nitrogen mineralisation patterns.

The project also investigated the effect of high nitrogen levels in mid summer due to N release from pasture residues on storage and subsequent performance of seed potato crops. N from mineralisation and possible N fertiliser carryover from the previous season can influence a potato seed crop by producing unexpected N flushes which may affect tuber set and seed performance. N extremes may lead to growth spurts resulting in deficiencies of other nutrients as well as higher susceptibility to foliage diseases. On the other hand, N deficiency at any time will be detrimental to yield.

The test for monitoring available soil N levels, *N-check*, was adopted from Europe, where it is the recommended method for managing N inputs into crops to improve yield and quality, and avoid environmental problems through nitrate leaching into waterways. The test for monitoring N uptake into the plant, *NU-test*, analyses nitrate levels in petiole sap. Different from tissue testing, which provides information on nutrient accumulation, *NU-test* shows current nutrient uptake, and reflects on nutrient availability in the root zone and uptake conditions.

Company staff from Simplot Australia Pty Ltd, McCain Foods (Australasia) Pty Ltd and Harvest Moon were involved in planning, sampling, data collection and discussion of results.

The project found that the crop preceding potatoes influenced soil, plant and tuber nitrate levels. The data set (small number of paddocks monitored per previous crop over three years) did not allow a statistical analysis of nitrogen and other factors in relation to stem or eye numbers and harvest assessments. Data showed that seed crops were, at times, under or oversupplied with nitrogen. Levels were between <50 and >500 kg N/ha, depending on paddock history and sampling time. It was concluded that monitoring of soil levels and adjustments to fertiliser applications according to a nitrogen budget would lead to a more balanced nitrogen supply during the season. The project report provides a method of calculating nitrogen fertiliser requirements (N-balance) based on a draft nitrogen budget for seed potatoes.

The N balance calculation takes into account soil test results, N that becomes available from incorporated plant residues and organic matter during the growing season, and fertiliser N. N input from irrigation water can also be included. These N inputs have to match the N target for a selected growing period. The N target is made up of nitrogen uptake over that growing period and a safety margin, which accounts for uptake efficiencies that may be low under some conditions.

The effects of exposure of seed to different soil nitrate levels on performance of the following crop were investigated in a replicated field trial. Some results from the field trial could not be related to previous crop N management. Again, this was partly due to the limited data set. Other agronomy factors and seed handling and storage, which also had an impact on the seed, were not recorded. The project showed that the overall nutrition of each crop has to be managed according to its own site-specific history, crop removal figures and monitoring results (soil and plant tests) rather than following production recipes, to optimise yield and quality.

The small project budget and the objective of technology transfer through company staff involvement in data collection led to some incomplete data sets. However, the project, designed to be a pilot study, contributed to the general industry focus on producing 'better seed'. The included information on nitrogen budgeting will assist this focus through offering improved N management procedures.

Introduction

Nutritional management of seed potatoes has to focus not only on yield but also on storage performance, yield and quality of the subsequent crop. Currently, most seed crops are treated like commercial crops, even though they have to meet very different performance criteria.

Nitrogen (N) is the nutrient with the greatest influence on yield and quality. It is also the most difficult to manage, mainly because relatively large amounts of N can become available from incorporated plant residues and organic matter. This, and possible nitrogen fertiliser carry-over from a previous crop can result in excessive N-levels, which may delay and/or reduce tuber set. Nitrogen flushes as a result of the breakdown of organic material or top dressing can lead to growth spurts and thus a relative reduction of other nutrients in the plant. High N-inputs may also increase the risk of bruising. Nitrogen deficiency at any time will have an adverse effect on yield and quality, if not discovered before symptoms become visible.

During the season preceding this project, a small number of seed potato crops were sporadically tested for soil nitrate nitrogen levels. Ex-pasture soils especially, which are frequently used for seed production, showed alarmingly high soil nitrate nitrogen levels of up to several hundred kilograms per hectare in mid summer. The effects of these levels on seed health and quality was not investigated.

At the commencement of the project, standard methods of determining nitrogen levels in potato soils and crops[1] were not used routinely by the seed potato industry as a tool to monitor and manage seed and subsequent commercial crop performance. One reason may be that nitrogen levels are 'dynamic', being influenced by many factors, and real time information is required to judge and manipulate the nutritional status of crops. Another reason may be that the benefits of regular crop monitoring for yield and quality were not recognised.

Developing and calibrating a dynamic, real time monitoring system, in cooperation with seed potato producers, was believed to have the potential to improve nutritional management of seed potato crops and thus their performance in storage and for subsequent commercial crops.

Aims

- To evaluate dynamic, real time methods to determine the nitrogen status of seed potato soils and crops.
- To investigate correlations between soil nitrate nitrogen, plant nutrient levels and seed quality/performance.
- To determine whether dynamic methods can be used to develop critical nitrogen levels and appropriate fertiliser applications for seed potato crops.
- To compare seed potato crops grown in soils with high and low organic residue levels and thus nitrogen release.
- To investigate the effects of high nitrogen levels due to N-release from pasture residues, on storage and subsequent performance of seed potato crops.
- To involve company staff in planning, sampling, data collection and discussion of results, to facilitate technology transfer.

[1] Total Kejdahl N in soil, dry tissue analysis

Commercial seed potato crop details

In all three seasons covered by this project, crop selection criteria were decided in discussion with industry co-operators. They then selected seed crops to be monitored and were asked to supply crop details to the project leader. The project leader distributed a field book with forms for the entry of crop information, observations and detailed sampling instructions to collaborators. These were to be returned to the project leader after the end of the production season. The involvement of company representatives in decision-making, and field officers in sampling and information gathering, was designed to be the project's major technology transfer strategy.

In discussion with co-operators it was decided that they select seed potato crops from different production areas, as shown in Table 1, for monitoring during the 1999/2000 season. Table 2 lists actual monitored crops. Missing information in Table 2 is due to two collaborators not using field books or returning them at the end of the season.

Table 1 - Suggested seed production areas for selection of crops to be monitored

Simplot	McCain	Harvest Moon
Trowutta	Derwent	Riana
Scottsdale	East Coast	Wilmot
A third area was not selected	Ridgley	Mt Seymour

Table 2 - Actual crops selected for monitoring during the 1999/2000 season

Company	Site Name	Location	Previous Crop	Variety	Sampler's Comments
McCain	Dunbabbin	Cranbrook	Pasture	Russet Burbank	Good crop
	Greenhill				Poor crop
	Combes	Southern Tasmania			
Simplot	Malley 1	Trowutta	Pasture	Russet Burbank	
	Malley 2				Dry site
	Malley 3				Wet site
Harvest Moon	Clarke	Ridgely	Broccoli	Symfonia	
	Clarke Quarry		Clover rich pasture	Bintje	
	Jones	Wilmot	Pasture	Royal Blue	Low N input pasture
	Hayes	Wilmot	Pasture	Red Star	
	Langham	East Yolla	Pasture	Bintje	

The 1999/2000 season results were discussed with collaborators, and the decision was made to select crops for the following seasons based on the previous crop. Previous crops should either provide high or low amounts of crop residue for mineralisation. Each company chose two crops, one with a high and one with a low residue crop preceding seed potatoes (Table 3). The participating field officers for sampling changed for McCain and Harvest Moon. Two companies, in spite of frequent reminders, did not return the field books that were distributed prior to the season. These were designed to be a record of the season's crop development and growing conditions. Basic information was recorded during phone conversations and during project meetings.

Table 3 - Seed potato crops selected for monitoring during the 2000/01 season

Company	Site Name & Location	Previous Crop	Variety	Comments
McCain	Astell, Hampshire	Old pasture	Shepody	Clay soil 1400 kg/ha 9-14-15-3 at planting
	Dunbabbin, Cranbrook	Poppies		Sandy loam 1000 kg/ha 0-7-11-9 pre-plant, plus 1235 kg/ha 9-14-15-3 at planting, plus 125 kg/ha Urea, top dress
Simplot	1- Langham, Riana	Old pasture	Russet Burbank	Ferrosol
	2- Langham, Riana	Poppies		Ferrosol
Harvest Moon	Harrison, Henrietta	Pasture	Gold Star G3	Ferrosol
	Kelly, Beulah	Pasture/fallow		Clay soil

Crop selection criteria for the 2001/02 season remained the same as for the previous season.

Table 4 - Seed potato crops selected for monitoring during the 2001/02 season

Company	Site Name & Location	Previous Crop	Variety
McCain	Dunbabbin, Cranbrook	Poppies	Shepody
	Wisedale, Frankford	½ Pasture, ½ Lucerne	
Simplot	1- Carr	Pasture	Russet Burbank
	2- Carr	Poppies	
Harvest Moon	Jones	Pasture/Fallow	Red Star
	Harrison	Pasture	Gold Star G3

Assessments & Analyses - commercial seed crops 1999-2002

All assessment timings and changes from season to season were decided in annual discussions with industry co-operators.

1. AVAILABLE SOIL NITRATE ANALYSIS

SAMPLED BY -	Company Co-operators
TIMING 1999/00 -	0: unplanted 1: prior to tuber initiation 2-3: mid tuber initiation 4-5: early to mid tuber bulking 6: tubers fully sized 7: after harvest
TIMING 2000/02 -	Pre-planting (Nov/Dec) Every 14 days until mid March (or until tubers are fully sized) After harvest (April or May).
METHOD & SAMPLE SIZE -	12-20 sub-samples per crop from a representative 1 ha paddock area, combined to one sample and kept refrigerated until analysis. A second soil sample taken from an uncropped, non-grassed, non-compacted area in the same paddock.
ANALYSIS -	N-check analysis procedure

2. PLANT NUTRIENT UPTAKE ANALYSIS

SAMPLED BY -	Company Co-operators
TIMING 1999/00 -	1: prior to tuber initiation 2-3: mid tuber initiation 4-5: early to mid tuber bulking 6: tubers fully sized
TIMING 2000/02 -	Prior to tuber initiation and then every 14 days until mid March (or until tubers are fully sized)
METHOD & SAMPLE SIZE -	Petioles from the youngest fully expanded leaf of 30 plants per crop from a representative 1 ha paddock area, combined to one sample and kept refrigerated until analysis.
ANALYSIS -	NU-test analysis procedure

Assessments - commercial seed crops 1999-2002 [cont.]

3. PLANT DENSITIES, TUBER WEIGHTS AND NUMBERS

CONDUCTED BY -	Serve-Ag Pty Ltd
TIMING -	1 week pre-harvest
METHOD & SAMPLE SIZE -	Count plant, stem and tuber numbers, and tuber weights, from 3 x 2 m of row from representative areas per paddock.

4. EYE COUNT

CONDUCTED BY -	Serve-Ag Pty Ltd
2000/02 TIMING -	1 week pre-harvest
METHOD & SAMPLE SIZE -	Count number of eyes on 30 tubers (100-160 g ea) taken from each of the 3 x 2 m sampling areas per paddock.

5. TUBER SAP NUTRIENTS

CONDUCTED BY -	Serve-Ag Pty Ltd
2000/02 TIMING -	Tubers were collected at harvest
METHOD & SAMPLE SIZE -	1 kg of tubers, randomly picked from representative areas per paddock.
ANALYSIS -	NU-test analysis procedure

6. STORAGE DISEASES AND SPROUTING

STORAGE -	Co-operators
SAMPLING AND ASSESSMENT -	Serve-Ag Pty Ltd
2000/01 TIMING -	After storage, prior to planting
METHOD & SAMPLE SIZE -	100 kg of tubers per paddock were stored for approximately 6 months, from which 100 tubers were randomly selected and assessed for diseases and sprouting.

Commercial crop performance trial 2001/02 season

Seed used was from seed crops monitored during the 2000/01 season, which were stored in commercial seed stores.

Table 5 - Site details, commercial crop performance trial

Grower	Lyndon Butler
Location	Forthside Vegetable Research Station, Forth, Tasmania
Soil Type	Ferrosol (Krasnozem)
Varieties	Russet Burbank (Simplot) Shepody (McCain) Goldstar (Harvest Moon)
Trial Design	Complete randomised block
Replicates	4
Plot Size	2.4 m x 8 m
Pre-plant Fertiliser	500 kg/ha 13-14-13+ trace
Row Spacing	0.8 m
Plant Spacing	Russet Burbank: 33 cm Shepody: 20 cm Goldstar: 25 cm
Sowing Date	09/11/01 (sown by hand)
Harvest Date	April 2002

Table 6 - Seed Storage and Treatment Details

NO.	Variety	Spacing [cm]	Seed Origin		Crop preceding seed crop
			Company	Site Name	
1	Russet Burbank	33	Simplot	Langham 1	Old pasture
2	Russet Burbank			Langham 2	Poppies
3	Shepody	20	McCain	Astel	Old pasture, clay soil
4	Shepody			Dunbabbin	Poppies, sandy loam
5	Gold Star G3	25	Harvest Moon	Harrison	Pasture & 62.5 kg/ha N, 1250 kg/ha 5-6-9 to seed crop
6	Gold Star G3			Kelly	Pasture/fallow & 45 kg/ha N, 500 kg/ha 9-14-17 to seed crop

Trial plan

1	2	4	3	5	6	**Block 1**
4	5	1	6	3	2	**Block 2**
3	2	6	5	4	1	**Block 3**
2	6	3	4	1	5	**Block 4**

↑ (Planting direction)

Plot size: 8m long in planting direction x 3.2m (4 rows) wide

A buffer row of the variety Royal Blue was planted, in the same planting direction, between plots and on the outside of the trial area, and as a buffer plot at the beginning and end of rows. A tractor spray run was required between plots in planting direction, marked by a double line in the trial plan. Blocks ran at a right angle to planting direction as the trial side was gently sloping in the planting direction.

Assessments & Analyses - 2001/02 commercial crop performance trial

1. SPROUTING

TIMING - Pre-planting

SAMPLE SIZE - 40 medium sized tubers (about 150 g) per seed line

METHOD - Visual assessment

RATING SCALE -
1= NONE 0% of eyes sprouting
2= LITTLE 01- 25% of eyes sprouting
3= MODERATE 26- 50% of eyes sprouting
4= HEAVY 51- 75% of eyes sprouting
5= SEVERE 76-100% of eyes sprouting

Assessments & Analyses - 2001/02 commercial trial [cont.]

2. FIRMNESS

TIMING -	Pre-planting
SAMPLE SIZE -	40 medium sized tubers (about 150 g ea) per seed line
EQUIPMENT -	Penetrometer “Fruit Pressure Tester” 3-27 lbs
METHOD -	A 12-15 mm disk of skin was removed from the side of the tuber with the largest surface area. The plunger of the instrument was pushed slowly into the exposed flesh up to the depth marking. The pressure reading for each tuber was recorded.

3. SOFT BREAKDOWN

TIMING -	Pre-planting	
SAMPLE SIZE -	40 medium sized tubers (about 150 g ea) per seed line	
METHOD -	Visual assessment	
RATING SCALE -	1= NONE	0% of tuber affected
	2= LITTLE	01-25% of tuber affected
	3= MODERATE	26-50% of tuber affected
	4= HEAVY	51-75% of tuber affected
	5= SEVERE	76-100% of tuber affected

4. DRY ROT

TIMING -	Pre-planting	
SAMPLE SIZE -	40 medium sized tubers (about 150 g ea) per seed line	
METHOD -	Visual assessment	
RATING SCALE -	1=NONE	0% of tuber affected
	2=LITTLE	01-25% of tuber affected
	3=MODERATE	26-50% of tuber affected
	4=HEAVY	51-75% of tuber affected
	5=SEVERE	76-100% of tuber affected

Assessments & Analyses- 2001/02 commercial trial [cont.]

5. FREE TUBER NITRATE

TIMING -	Pre-planting
SAMPLE SIZE -	10 medium sized tubers (about 150 g ea) per seed line
METHOD -	Sap analysis

6. AVAILABLE SOIL-NITRATE

TIMING -	Pre-planting, then every 4-5 weeks until senescence/harvest
SAMPLE SIZE -	1 sample per seed line, combined sub samples from four replicated plots
METHOD -	Soil-N analysis

7. PLANT HEIGHT

TIMING -	End of flowering
SAMPLE SIZE -	20 plants per plot
METHOD -	Measure total main stem length [m]

8. INTERNODE NUMBERS

TIMING -	End of flowering
SAMPLE SIZE -	20 plants per plot
METHOD -	Count number of internodes per plant

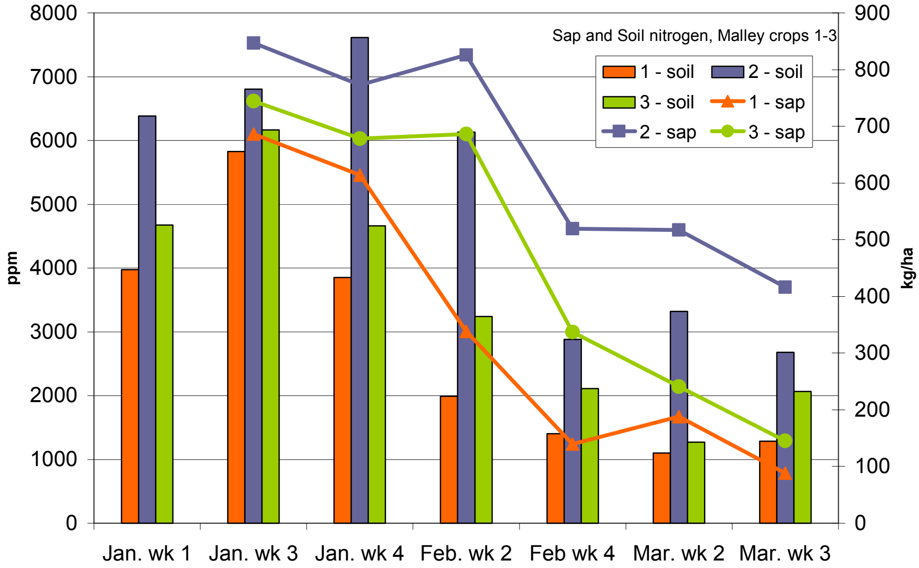
9. PLANT DENSITIES, TUBER WEIGHTS AND NUMBERS

TIMING -	1 week prior to harvest
METHOD & SAMPLE SIZE -	Count plant & stem numbers, tuber numbers and tuber weights from 3 x 2 m of row from representative areas per plot.

1999/00 Season crop monitoring results

Nitrogen monitoring methods

Graph 1 - Soil nitrate nitrogen levels (NO_3 – N [kg/ha]) in 0-30 cm soil depth in three seed potato crops (Simplot sites - Malley 1, 2 and 3), and nitrate uptake into petiole sap (NO_3 [ppm]) between 5/1/00 and 13/3/00



The test for monitoring available soil nitrogen levels, N-check, was adopted from Europe, where it is the recommended method for managing nitrogen inputs into crops to improve crop quality and avoid environmental problems through nitrate leaching into water resources. The test for monitoring nitrogen uptake into the plant, NU-test, analyses nitrate levels in undigested petiole sap. Different from tissue testing, which provides information on nutrient accumulation, NU-test shows current nutrient uptake, thus reflecting nutrient availability in the root zone and uptake conditions.

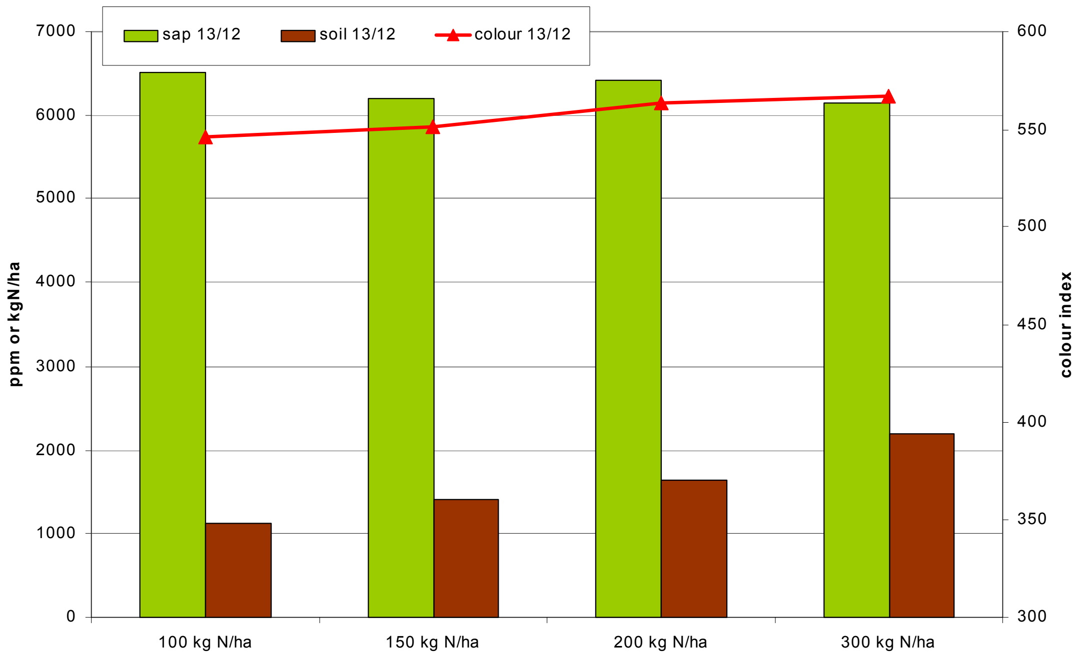
Graph 1 shows soil and sap nitrogen levels for the three Simplot Malley sites. It illustrates that the chosen analytical methods correlate well and reflect N-dynamics in plant and soil. The highest, medium and lowest soil nitrate nitrogen levels correspond with the highest, medium and lowest sap nitrate levels. The drop in soil nitrate nitrogen during the monitoring period was reflected in a drop in sap nitrate levels.

Similar results were obtained in a replicated potato trial which compared nitrogen monitoring methods such as soil nitrogen measurement (N-check), nutrient uptake monitoring (NU-test for petiole sap nitrate) and leaf colour index (Hydro N Minolta colour meter). Variation in nitrogen supply was achieved by four different nitrogen rates at planting (100, 150, 200 and 300 kg/ha). Graphs 2a and 2b show that all three tests produced data that correlated well. They also highlight that at the first date (13/12/99, Graph 2a) soil nitrate nitrogen levels and leaf colour reflect the differences in base fertiliser application, while petiole sap levels are the same for all four rates. Six weeks later (Graph 2b), sap petiole levels show deficiencies for the two lowest base fertiliser rates. Leaf colour index and soil nitrate nitrogen levels now correlate well with petiole sap nitrate content.

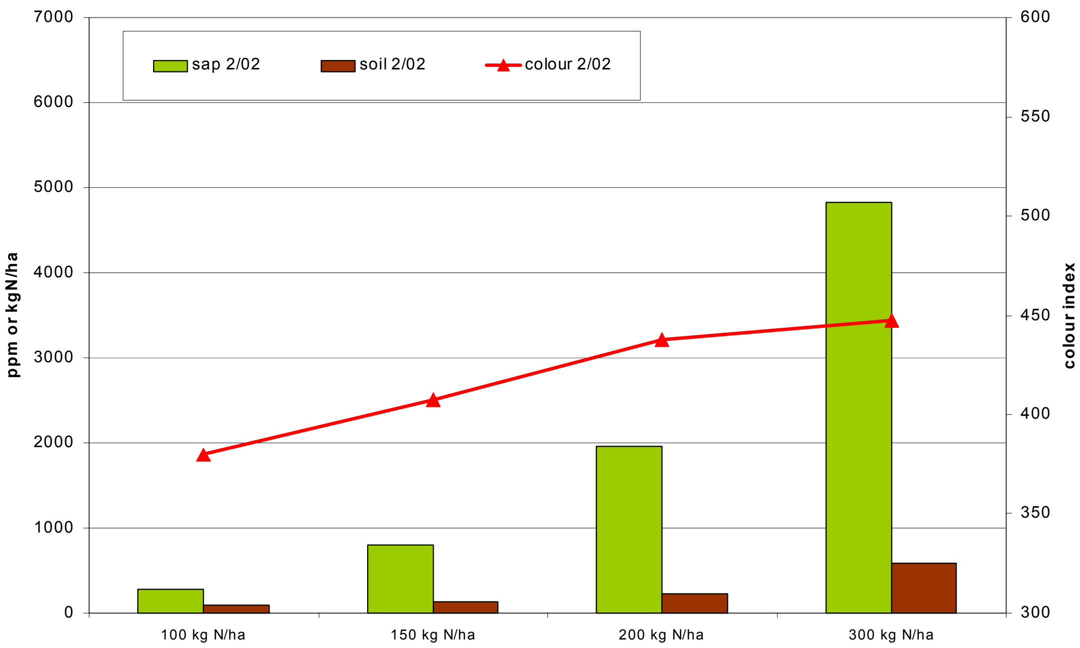
Results presented in Graphs 1 and 2 confirm that the real-time monitoring methods, N-check and NU-test, can provide reliable information on the nitrogen status of potato crops. N-check shows nitrogen depletion in the soil before it can be diagnosed in plant sap (Graphs 2a and 2b). This may be partly due to the plants' ability to relocate nitrogen from older to younger tissue.

Graphs 2a & 2b - Soil nitrate nitrogen levels (NO_3 – N [kg/ha]) in 0-30 cm soil depth, nitrate uptake into petiole sap (NO_3 [ppm]) and leaf colour index (Hydro-N Minolta colour meter) measured in a replicated trial (Russet Burbank, 1999/00)

2a)

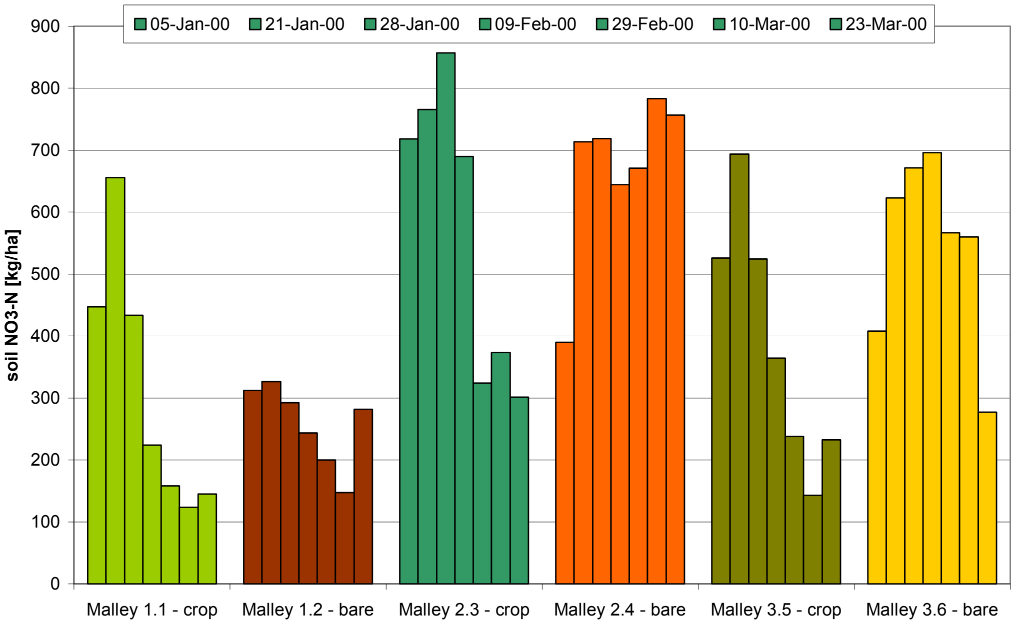


2b)



Soil nitrate nitrogen - Simplot sites

Graph 3 - Soil nitrate nitrogen levels [kg/ha] in 0-30 cm soil depth between 5/1/00 and 13/3/00 in three seed potato crops (Malley 1, 2 and 3 = green bars), and non-cropped soil adjacent to the crop ('bare' = brown, orange and yellow bars), Simplot sites, 1999/2000



Graph 3 shows differences in soil nitrate nitrogen levels between sites, and within sites, between crops and non-cropped (bare) areas. All crops were planted near Trowutta following pasture on light Krasnozem, in mid-December 1999. The variety was Russet Burbank and all crops had the same fertiliser applications during the season.

Nitrate levels in cropped soil declined over the monitoring period by about 450-500 kg/ha. At Site 1, which had the lowest overall N-levels, the bare soil did not reach the peak value of the cropped area, nor did it become as depleted. The peaks in cropped areas are due to mineralisation of organic matter and crop residues, which is usually increased by fertiliser input. Site 3 had similar results to Site 1. At Site 3, however, the bare ground maintained higher nitrogen levels until 10/3/00. Site 2 also showed a drop in soil nitrate nitrogen commencing in February. N levels started and remained at a higher level than for Sites 1 and 3. N levels in the bare ground stayed consistently high at Site 2, after an early January level that was similar to that of the other bare ground samples. Pre-harvest (March) N levels still reflected the season's nitrogen history for each site. It has been observed in other crops here and in Germany that the soil nitrate nitrogen level at harvest reflects the overall seasonal level [1].

Graph 3 highlights that soils of the same type (light Krasnozem) and history (ex-pasture) can have quite different nitrogen dynamics. It also confirms the preliminary findings of high N-mineralisation from pasture, with peak values in summer (January) in this study. The difference in mineralisation at the three sites must be related to pasture quality and/or timing and type of incorporation. The decline in soil nitrate nitrogen levels mentioned above is far above plant uptake for the time period from January to March, which would not exceed 200 kg N/ha.

[1] Serve-Ag Pty Ltd, unpublished data, Bolap Pty Ltd Germany, personal communication

Nitrogen sinks, besides being a result of plant uptake, would have been due to:

- denitrification during times of temporary water logging,
- nitrogen immobilisation into organic matter and soil micro-organisms,
- leaching past the sampling depth.

Nutrient uptake - Simplot sites

NU-test results (NO_3, K, P, Mg, Ca and Zn) for the three Simplot crops (Malley 1, 2 & 3) are shown in Graphs 4a, 4b and 4c. The elements are the ones usually analysed for potato crop monitoring unless deficiencies in other nutrients are expected.

At Malley 1, the low soil nitrate nitrogen levels were reflected in low sap nitrate values (Graph 4a). Ca levels were low as well, especially towards the end of the season, which may be due to soil conditions or a poor root system, as Ca is mainly taken up by root interception. Mg, K and Zn levels were in the optimum range for Russet Burbank potatoes.

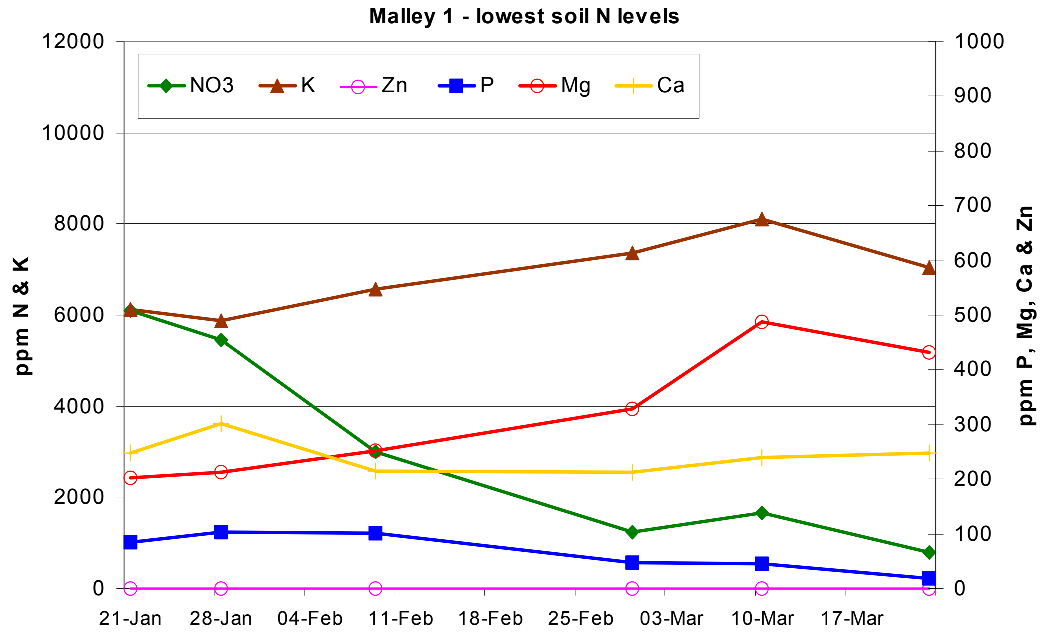
Malley 2 (Graph 4b) had adequate levels for all tested elements apart from Ca and Mg. This site was quite dry, which may have had an impact on Ca uptake.

Malley 3 (Graph 4c), which was a wet site, showed a drop in K levels in March, associated with an increase in Mg and Ca levels. Usually cations should not drop sharply towards the end of the season but rather show a steady increase over the production period. The reason for the sharp increase in Mg and Ca, and whether the drop in K was due to ion competition cannot be explained from available data. Crop three had a slightly lower P uptake than the other crops.

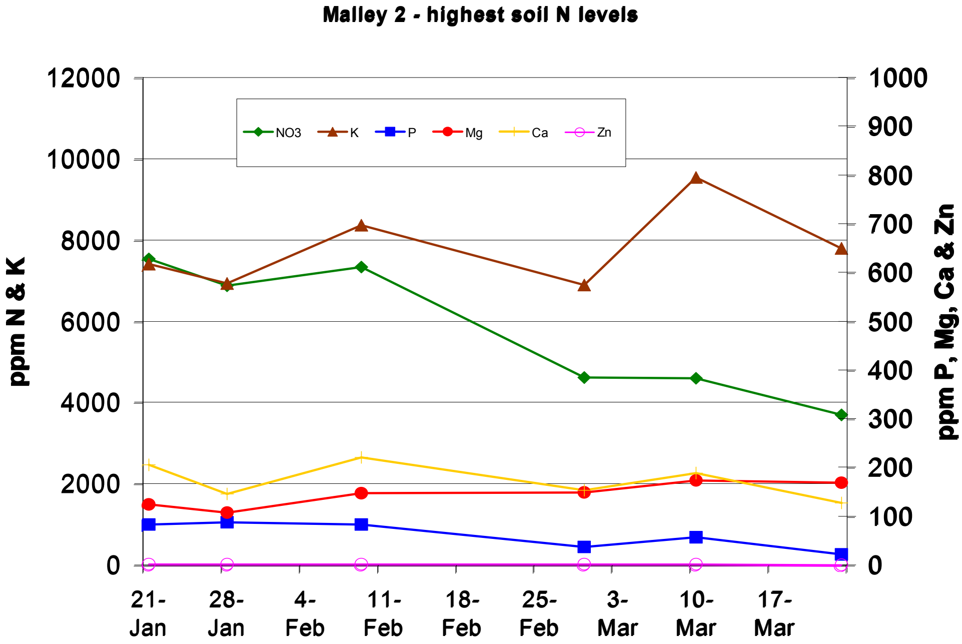
As also shown in Graph 1, the soil and plant nitrogen status correlated well at the Malley sites.

Graph 4a, b and c - Nutrient uptake shown as petiole sap concentration [ppm]) in three seed potato crops (Simplot sites, Malley 1, 2 and 3), between 5/1/00 and 13/3/00

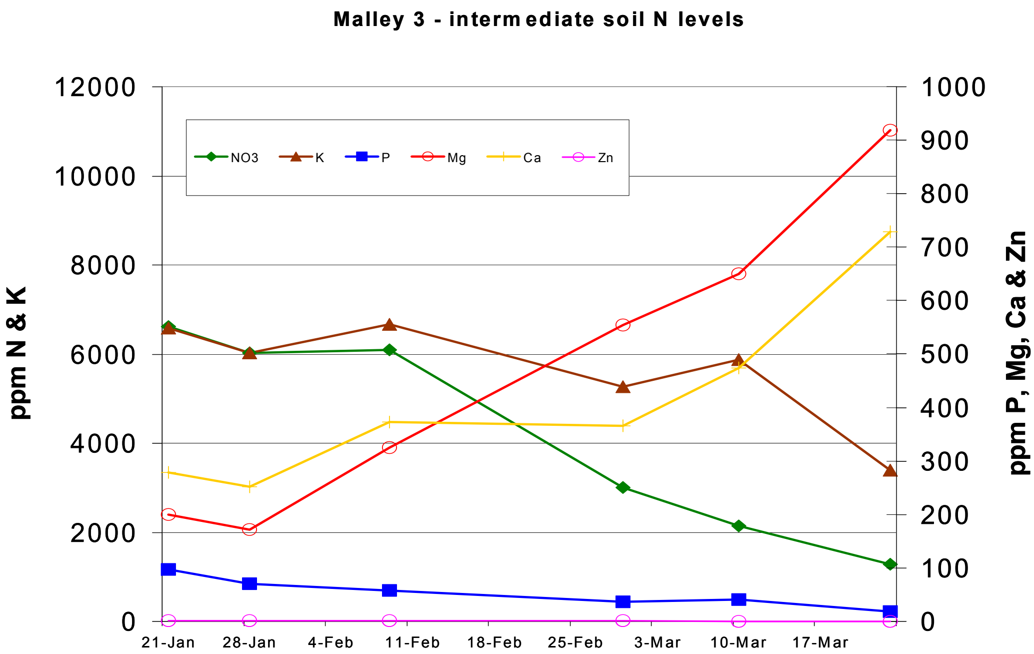
4a)



4b)

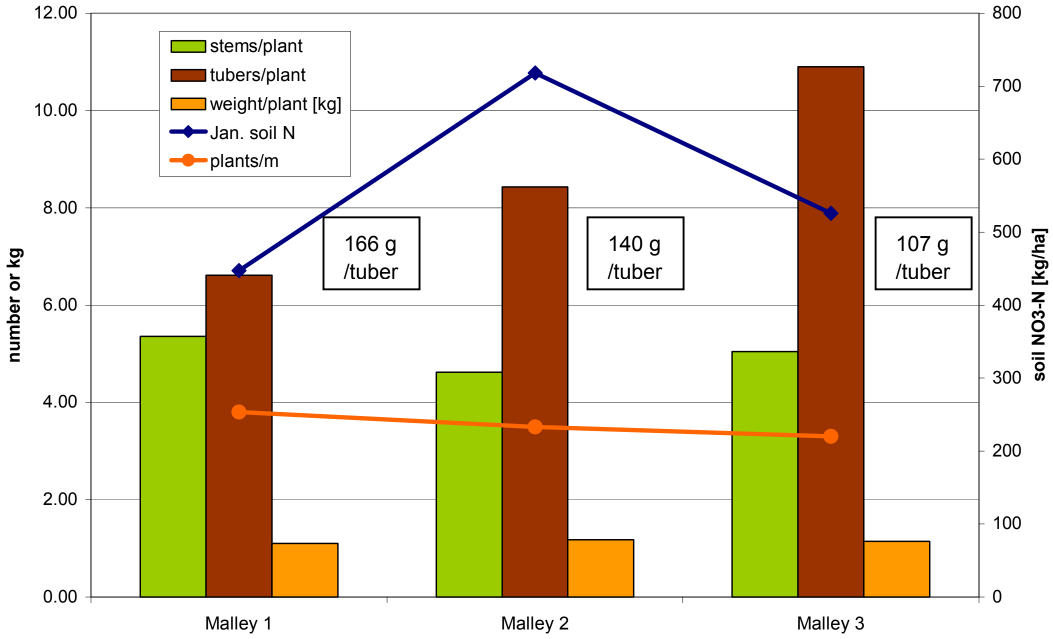

Malley 2 - highest soil N levels
NO3
K
P
Mg
Ca
Zn
ppm N & K
ppm P, Mg, Ca & Zn
12000
10000
8000
6000
4000
2000
0
1000
900
800
700
600
500
400
300
200
100
0
21-Jan
28-Jan
4-Feb
11-Feb
18-Feb
25-Feb
3-Mar
10-Mar
17-Mar

4c)


Malley 3 - intermediate soil N levels
NO3
K
P
Mg
Ca
Zn
ppm N & K
ppm P, Mg, Ca & Zn
12000
10000
8000
6000
4000
2000
0
1000
900
800
700
600
500
400
300
200
100
0
21-Jan
28-Jan
4-Feb
11-Feb
18-Feb
25-Feb
3-Mar
10-Mar
17-Mar

Pre-harvest assessments - Simplot sites

Graph 5 - Harvest assessment of three seed potato crops (Simplot, Malley 1, 2 and 3) and pre-harvest soil nitrate nitrogen level, January 2000



The yield, illustrated through weight/plant and plants per meter, of the three Malley sites was identical. Graph 5 shows that the nitrogen levels during the season had no influence on yield.

There was no difference in the number of stems per plant at the three sites, but the number of tubers per plant varied, resulting in smaller tubers at Malley 3. This site had the 'medium' soil nitrate nitrogen history, whereas Malley 1 had the lowest, and Malley 2 the highest overall levels. In seed crops, a higher number of smaller tubers is desirable. All three sites produced tubers within the required range of 100-225 g.

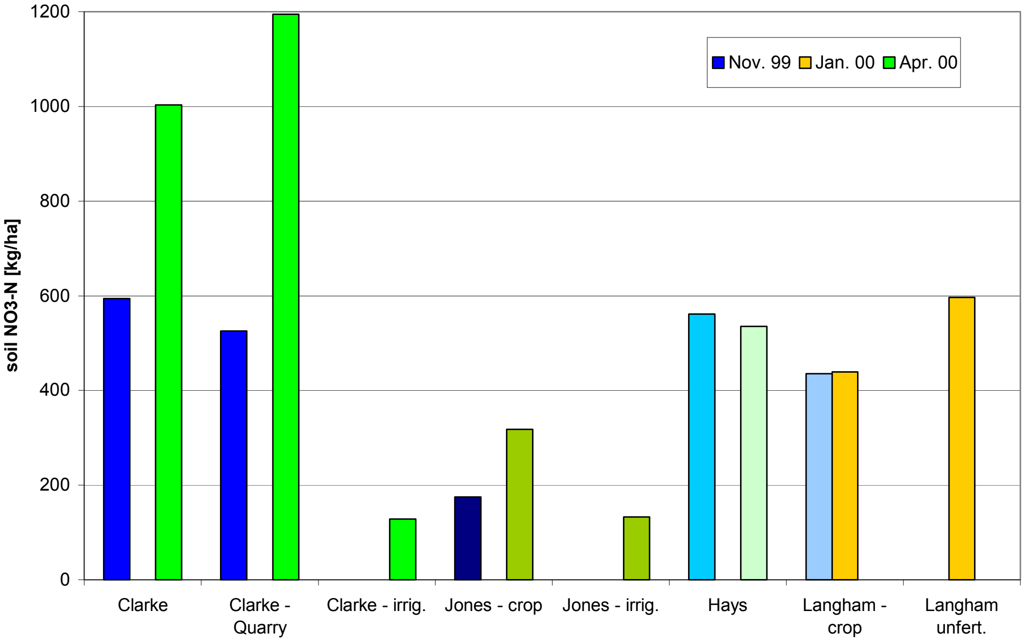
Both very high and very low soil nitrate nitrogen levels are said to influence tuber set. However, the data produced during this applied study cannot prove whether nitrogen was the major influencing factor at the Malley sites. Replicated trials would be needed to confirm the observation.

Phosphorus is another element important for tuber initiation. However, NU-test information does not show enough of a difference between early P levels to justify considering an influence of P on tuber numbers in this instance (Graphs 4a, 4b & 4c).

Soil nitrate nitrogen - Harvest Moon sites

Harvest Moon sites were not monitored at the same dates for all sites. Samples were mainly taken in November, prior to planting, and in April, before harvest. Some sites were also sampled in January (Graphs 6 and 7). Sampling times per site were reduced to get information on more sites. Harvest Moon also sampled a range of commercial seed crops that were not part of the project, but were happy for the data to be included in this report.

Graph 6 - Soil nitrate nitrogen levels [kg/ha] in 0-30 cm soil depth between November 1999 and April 2000 in six seed potato crops (Harvest Moon), and three non-cropped areas adjacent to the crop



'irrig.'= irrigation run, 'unfert.' = buffer between seed lines

Graph 6 illustrates soil nitrate nitrogen information from several seed potato crops. All blue bars, irrespective of the shade, show the November sampling time, all green bars the April time, and yellow bars give results from January samples. The Clarke crops had very high nitrogen levels prior to planting. This would be mainly due to mineralisation of a previous broccoli crop for 'Clarke' and clover rich pasture for 'Clarke Quarry'.

Mineralisation increases rapidly as soil temperatures rise above 12^{o}C in spring. Fresh organic matter such as crop residues is broken down rapidly and then soil mineral nitrogen levels increase, often above the levels these crop residues contain. The high levels usually drop within 6-8 weeks. This has been found over several seasons and in a range of crops grown after green crops, pasture, peas or *brassica* crops[1]. An example from a green crop trial is shown in Graphs 7a and b. There was a slight difference in nitrate release between cover crops and fallow, but the major difference was due to the incorporation methods. Ploughing and using the rotary hoe afterwards to create fine residues resulted in a nearly one third higher N surge compared to mulching, followed by ploughing.

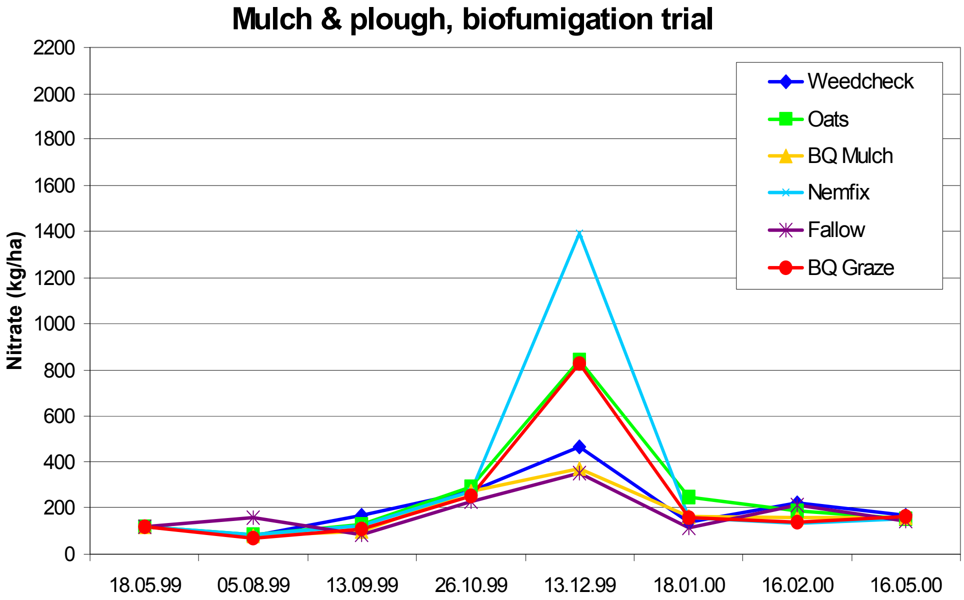
[1] Serve-Ag Pty Ltd, unpublished data

Wyland et al (1996)[1] who investigated the effect of winter cover crops on nitrate leaching, soil water, crop yield and pest management cost reported similar findings: "Incorporation (of cover crops) caused sudden large surges in inorganic N pools, net mineralisable N, and microbial biomass N and C in the surface soil, which subsided within six weeks." The surge was found to be due to rapid residue decomposition, combined with soil mixing and aeration. Rising soil temperatures may have been supporting the rapid increase in microbial activity following incorporation and tillage, which took place in April (Northern Hemisphere spring).

A similar study on ^{15}N labelled cover crops in lettuce revealed that most of the added ^{15}N remained in the organic N pool (60.7%) at harvest of the 4-month crop. Only 40% of the N contained in the cover crop's biomass had been released by harvest[2].

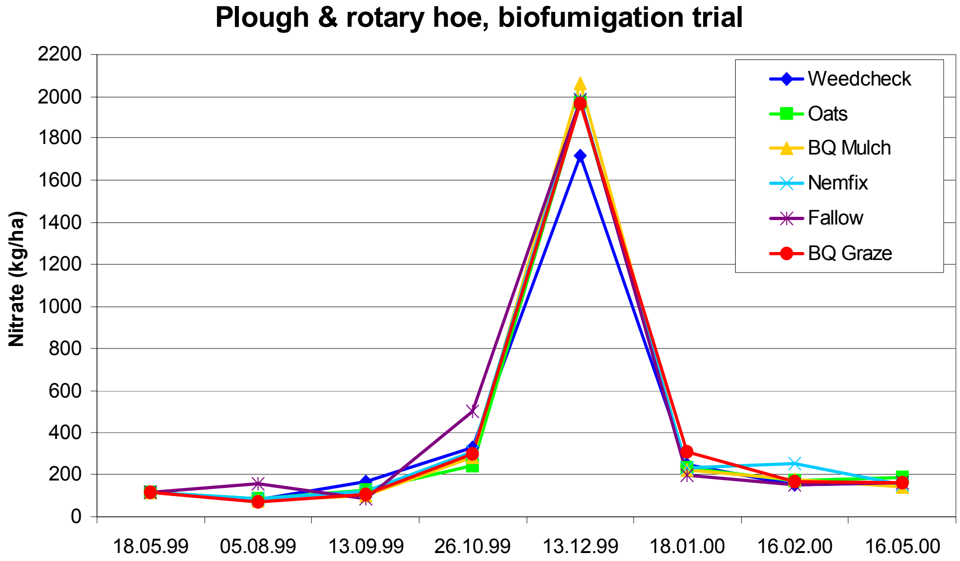
Graphs 7a & b - Soil nitrate nitrogen levels [kg/ha] in 0-30 cm soil depth in a cover crop (biofumigation) and potato system with different cover crop incorporation methods

7a)



1 Wyland L.J. et al, 1996: Winter cover crops in a vegetable cropping system: Impacts on nitrate leaching, soil water, crop yield, pests and management costs. Agriculture Ecosystems & Environment, 59: 1-17
2 Jackson L.E., 2000: Fates and losses of nitrogen from a nitrogen-15-labelled cover crop in an intensively managed vegetable system. Soil Sci.Soc.Am.J. 64: 1404-1412

7b)


Plough & rotary hoe, biofumigation trial
Nitrate (kg/ha)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
18.05.99
05.08.99
13.09.99
26.10.99
13.12.99
18.01.00
16.02.00
16.05.00
Weedcheck
Oats
BQ Mulch
Nemfix
Fallow
BQ Graze

The Clarke soils under potatoes had even higher nitrate levels at crop maturity (April 2000, Graph 6) than at planting. The project did not involve giving fertiliser recommendation to growers. The aim was to monitor the soil nitrate nitrogen developments under current practices. The N increases at Clarke sites would have been due to a combination of standard top-dressing practices and ongoing mineralisation of crop residues. It is interesting that the uncropped irrigation run showed very low nitrate levels at harvest time. The irrigation run was not grassed and may have become compacted and water logged for some time after each irrigation (no crop removal, poor drainage). Under these conditions, nitrogen may have been lost through leaching in non-compacted areas and denitrification during water logging. The irrigation run would not have been top-dressed.

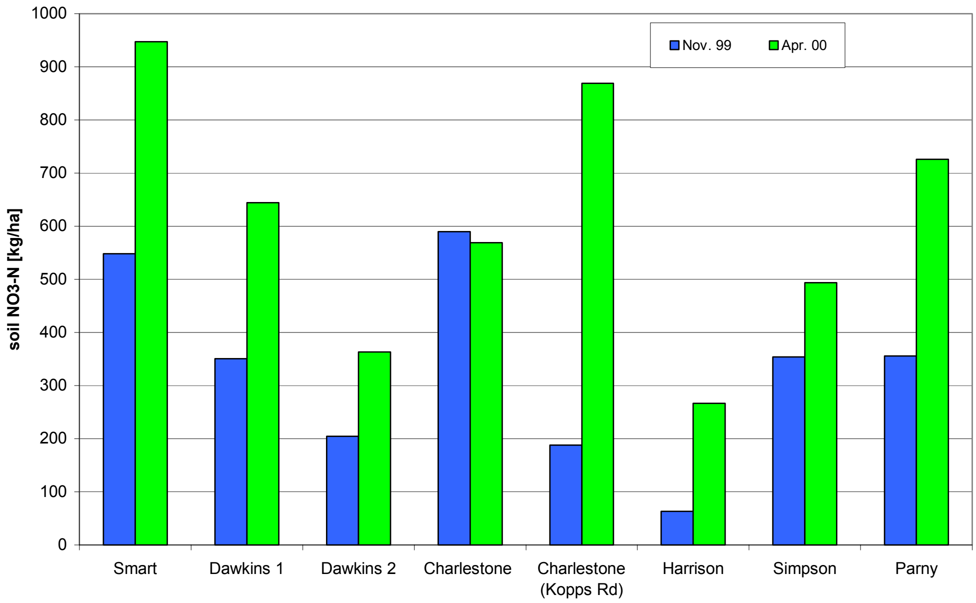
The Jones crop (Graph 6) was grown after low N input pasture. That explains the comparatively low, but entirely sufficient November soil nitrate nitrogen level. Here, soil nitrate nitrogen had also increased by harvest time to around 300 kg/ha, even though N fertiliser applications were below commercial practice. If no winter crops were grown on this paddock, the residual nitrogen would have been prone to leaching. Residual N in the Jones irrigation run was the same as in the Clarke irrigation run, probably for the same reasons.

The Hays crop, grown after good pasture, was sampled twice in November, with similar results. Levels were close to 600 kg/ha as a result of mineralisation. This crop would not have needed a base N application and should have been monitored again prior to intended top-dressing to avoid unnecessary fertilisation. Comparison of the Hays and Jones data at the same sampling time illustrates the difference that pasture management, quality and timing and method of incorporation may have on mineralisation.

The Langham site (Graph 6), also after pasture, shows a comparison between the crop and the unfertilised, uncropped area between seed lines, rather than the irrigation run. The differences in soil nitrate nitrogen here are due to crop uptake. The uncropped area was not fertilised but the high values from both areas suggest that mineralisation supplied ample nitrogen. This crop may have grown well without N fertiliser input as the January levels are far in excess of requirements. Data on N uptake of potato seed crops of different varieties could not be found. However, uptake figures for Russet Burbank processing crops are 300-320 kg N/ha. Considering the much shorter growing period of seed crops, an uptake figure of 200-250 kg N/ha may be realistic. Peak uptake time would be during tuber bulking. Soil nitrate nitrogen levels greater than 300 kg/ha at planting and greater than 250 kg/ha at early bulking should support a seed crop through the season without top dressing, especially if the previous crop (e.g. good pasture, *brassica* vegetable or cover crop) supplies ample residue for mineralisation. This assumption is based on the fact the nitrogen supply to a crop should cover its uptake needs plus a ‘safety margin’ or ‘buffer’ of 25-40% of uptake, depending on crop and conditions, as uptake efficiency will always be below 100%. The safety margin also allows for a certain amount of loss through leaching, immobilisation and/or denitrification (see Conclusions and Recommendations).

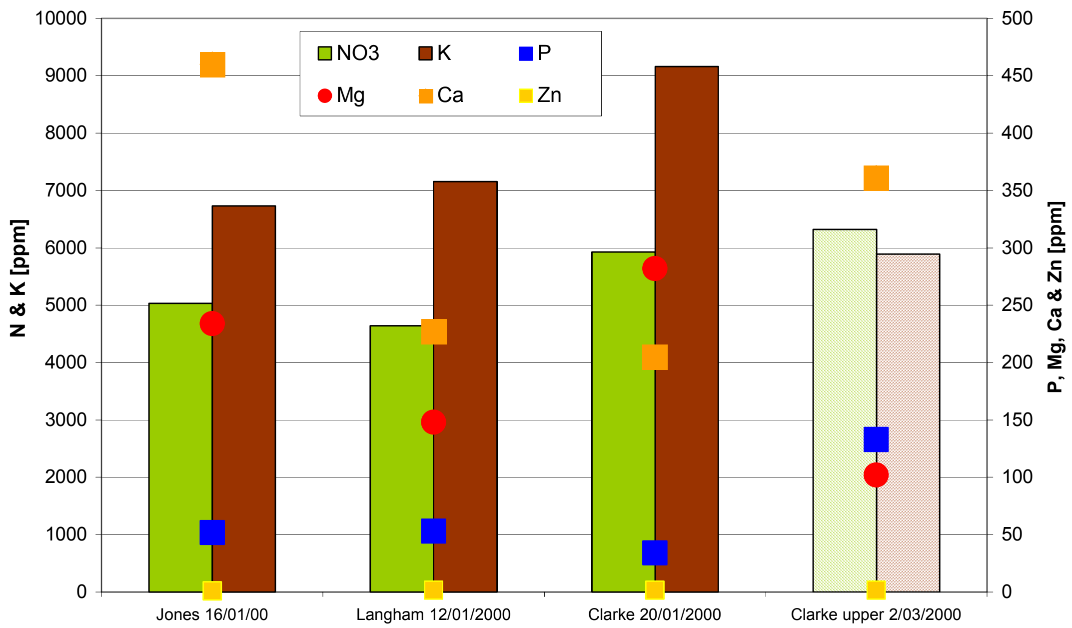
Graph 8 shows soil nitrate nitrogen levels for eight seed potato crops from Harvest Moon’s commercial monitoring program. Samples were taken prior to planting and at crop maturity. Crop details are not known, apart from the fact that most crops were planted after pasture. Still, the data shows that five crops had excessive N levels at planting and all had large amounts of residual N after crop uptake had ceased. The data includes two growers with two crops each. It is interesting to note the variation in soil nitrate nitrogen levels even though growers applied standard amounts of nitrogen. The information discussed above emphasises that recipe applications of nitrogen to seed potato crops can be wasteful and may lead to unwanted leaching of excess N.

Graph 8 - Soil nitrate nitrogen levels [kg/ha] in 0-30 cm soil depth between November 1999 and April 2000 in eight commercial Harvest Moon seed potato crops that were routinely monitored



Nutrient uptake - Harvest Moon sites

Graph 9 - Nutrient uptake analysis results, 2000, Harvest Moon sites



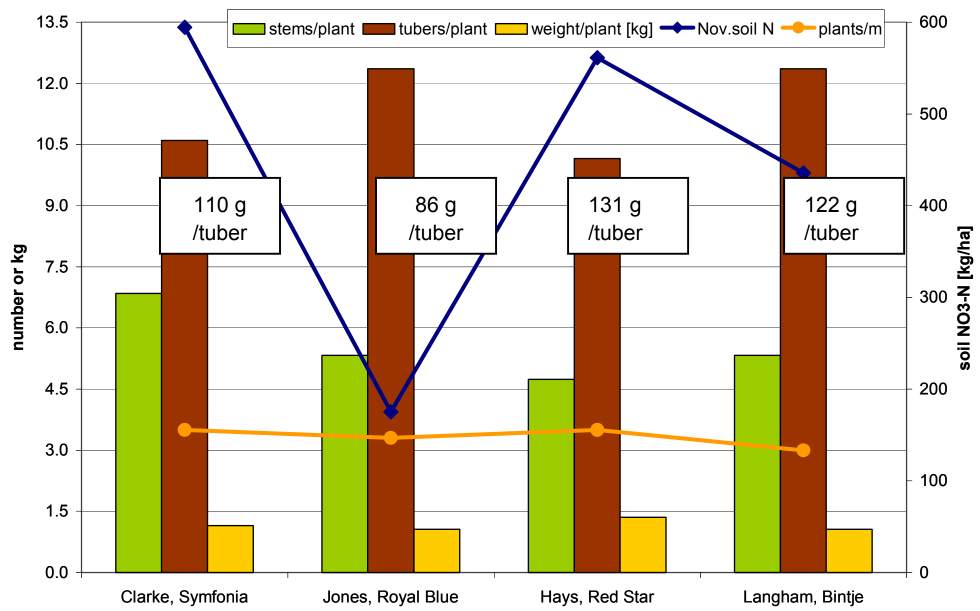
Nutrient uptake samples were only taken for some of the Harvest Moon crops: Jones, Langham and Clarke in January and Clarke Quarry (upper) in March. Sap nitrate levels reflect soil levels at Clarke, which show the highest nitrate amounts. Sap nitrate in Jones and Langham crops do not correlate well with the soil information at first sight. Unfortunately Jones soil samples are from an April sampling and Langham's from January, the same time petiole samples were taken. Jones soil levels may have been as high as Langham's in January. Even though soil levels were excessive in some crops, this is not reflected in plant levels, as plants do not take up greatly excessive amounts. Plants that are well supplied with nitrogen grow big, but their sap and tissue N levels stay in a similar range for a well-supplied plant. This shows that while plant analysis is a good tool to detect undersupply, nitrogen oversupply is better analysed in soil extracts.

All January sampled crops had low P levels. They should be close to 100pm. This is often difficult to achieve in Ferrosol soils. The Clarke March sample had a very high P level. The Jones Ca and the Clarke K levels were quite high. Unfortunately it is not possible to say much about the nutrient status of a crop when only one sample per season is available. Well-monitored crops are sampled fortnightly here and in the USA to be able to follow nutrient trends and correct them as required. Nutrient trends also give information about growing conditions that affect nutrient uptake, which assists in fine-tuning of crop management.

Pre-harvest assessments - Harvest Moon sites

Graph 10 shows results from pre-harvest assessments of the four main Harvest Moon crops. Comparisons between crops are made difficult by the fact that each site was planted with a different variety. Tuber size was small for Jones, which, if not variety specific, may have been due to lower nitrogen levels, if a comparison to Langham is possible. Royal Blue certainly grows tubers in the same size range as Bintje. Clarke and Hays have similar results apart from a higher stem number and lower tuber weight for Clarke. Again, it is difficult to say whether these are variety differences, or due to difference in physiological age of seed at planting, or other factors.

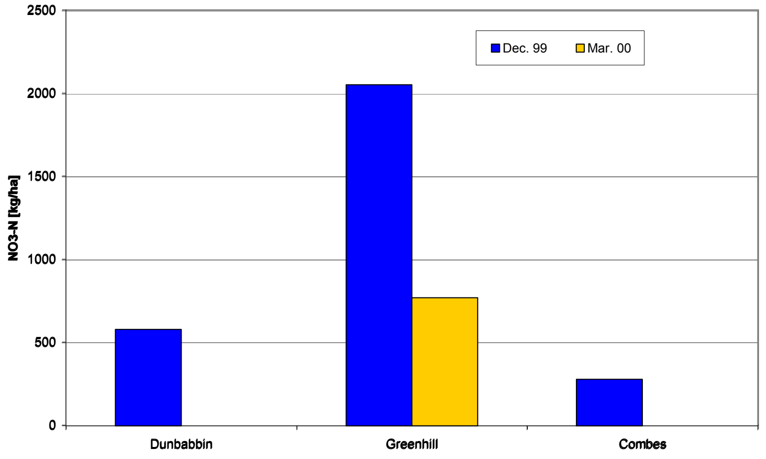
Graph 10 - Pre-harvest assessments, 2000, Harvest Moon sites



Soil nitrate nitrogen – McCain sites

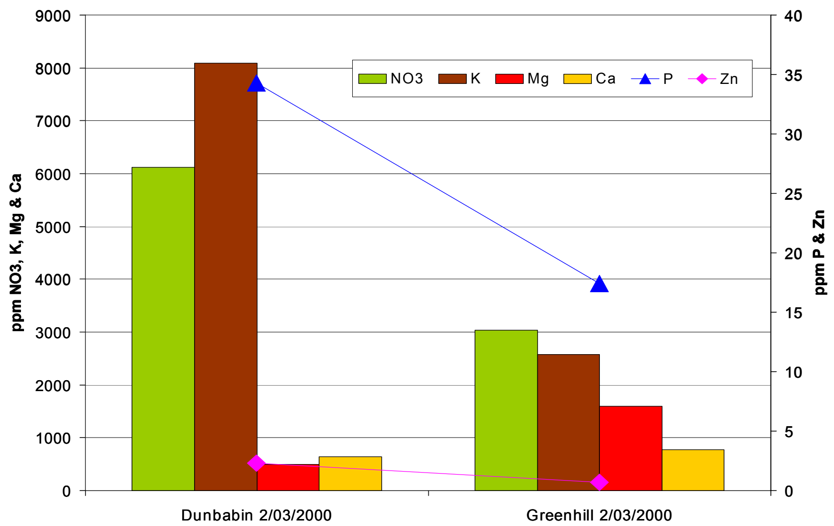
Graph 11 shows the nitrogen monitoring results for three sites after pasture. All were sampled in December, shortly after planting, and only one was sampled again in March, prior to harvest. Dunbabbin and especially Greenhill sites had excessive nitrate levels in the soil in December, probably due to mineralisation of pasture residues. The high result after pasture fits in with data from other crops in this and other studies[1]. The Greenhill site's March levels are still far above the required level for potato seed crops, which should be the highest amount left at harvest, as discussed earlier. As found previously, a site that started with very high N-levels, finished with excessive amounts as well. The Combes site started with acceptable levels.

Graph 11 - Soil nitrate nitrogen levels, 0-30 cm soil depth [kg/ha], McCain sites



Nutrient uptake, McCain sites

Graph 12 - Petiole sap levels [ppm] for two McCain sites



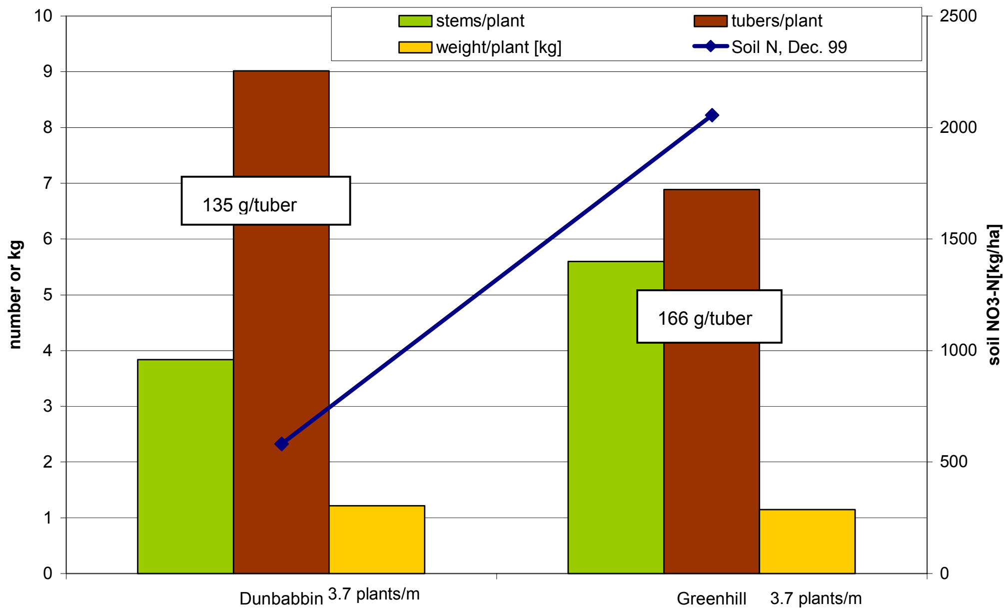
[1] Serve-Ag Pty Ltd, unpublished data

Nutrient uptake represented by one sample each for the two Cranbrook sites shows that the high N site, Greenhill, had below optimum N and P uptake, low K and Zn levels and relatively high Mg and Ca levels. The Dunbabbin crop had good levels of N and K, slightly low Mg and too low P uptake. Usually high soil mineral nitrogen availability leads to high nitrate levels in petiole sap. This does not apply when cold temperatures, water logging, root diseases or other conditions that affect root distribution and health, inhibit uptake. The Greenhill crop was badly affected by *Fusarium*, which may be the reason for its poor nutritional standard in December. Again, consecutive sampling would have allowed a better assessment of the nutritional status of the McCain crops.

Pre-harvest assessments – McCain sites

Only two McCain crops (Cranbrook) received a pre-harvest assessment as the third crop was a long distance away and only one soil sample had been taken. The Greenhill site, which had excessive nitrate in the soil after planting had a lower tuber set and higher tuber weight than the Dunbabbin crop, which had started off with very high N levels. The stem number at Greenhill was higher. Yield was identical at both sites. The Greenhill crop produced very poor seed with high *Fusarium* infection, while the Dunbabbin crop met all quality requirements according to McCain. From the given data set, it is hard to say whether extreme nitrogen availability had a negative influence on the Greenhill crop, but it may have been involved in producing a lower tuber set and less disease tolerance.

Graph 13 - Pre-harvest assessment, McCain sites

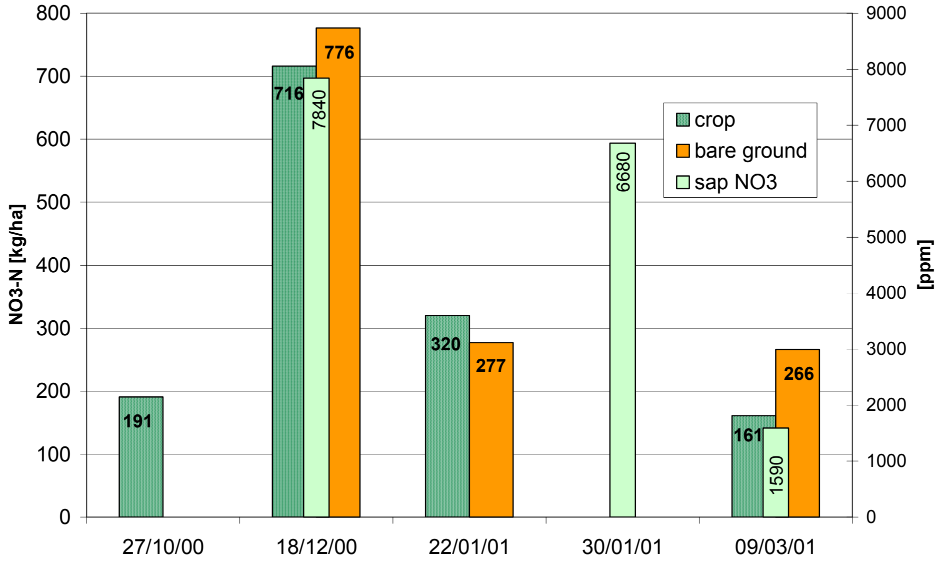


2000/01 Season crop monitoring results

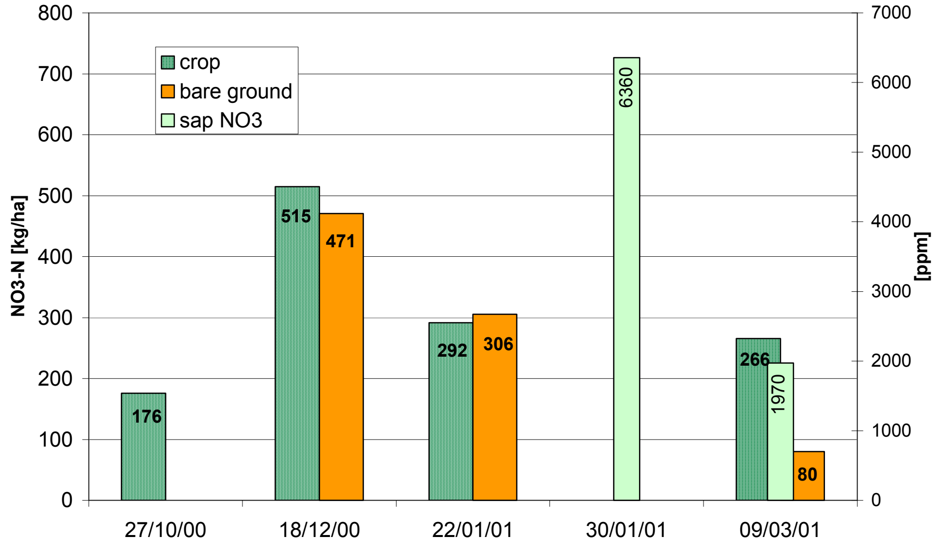
After reviewing the 1999/2000 season, the representatives of participating companies decided to select two crops per company to sample more intensively. Site selection was to include one site with high crop residues (e.g. pasture or *brassica*) and one with low crop residues (e.g. poppies or fallow). The second and third project years were an extension of the 1999/00 pilot year, which required separate funding approval. The approval was granted late, so one company could not commit to a sampling program in time to get data for the 2000/01 season.

Soil nitrate nitrogen and nitrogen uptake - Simplot sites

Graph 14 - Soil nitrate nitrogen levels [kg/ha], 0-30 cm depth, following old pasture, Langham 1, Russet Burbank, Krasnozem, 2000/01 Simplot



Graph 15 - Soil nitrate nitrogen levels [kg/ha], 0-30 cm depth, following poppies, 2000/01, Langham 2, Russet Burbank, Krasnozem Simplot



The pre-planting soil mineral N levels were identical in both Simplot crops (Graphs 14 and 15). This is probably due to the fact that mineralisation increases rapidly when soil temperatures exceed 12°C. In most years, this occurs around mid-November in Tasmania[1]. Two months later, in mid-December, the ex-pasture site had experienced an increase in soil nitrate nitrogen in the cropped topsoil (0-30 cm) of 525 kg/ha and an additional 60 kg/ha in the bare ground. The ex-poppy site increased about half this amount (339 kg/ha) in the cropped ground and slightly less (295 kg/ha) in the bare ground. The difference in N accumulation in bare ground between the 1999/00 and the 2000/01 seasons was a change of location for taking 'bare ground samples'. Industry representatives had decided that the irrigation run was not representative for uncropped soil. Samples in 2000/01 were therefore taken in an unplanted area in the paddock.

Within one-month, nitrogen levels at both sites had declined. It amounted to 396 kg/ha, 44.7% of peak level, in the ex-pasture crop, and 223 kg/ha, 56.7% of peak level, in the ex-poppy crop. As discussed with results from the previous season, the N-decline was, to a large extent, due to immobilisation of mineral N in soil microbes/humus and plant uptake; denitrification and leaching may also play a role. In clay rich soil, NH_4 may be fixed in clay minerals, similar to potassium[2]. Bare and cropped ground figures were quite similar in spite of the lack of losses due to plant uptake. Losses due to denitrification and leaching in bare ground under irrigation (no plant water uptake) must be responsible for this. The above discussion shows that nitrogen dynamics in different crops and soils will need further supporting data to better understand findings of monitoring.

Before harvest, nitrate levels in the ex-pasture crop were half of the January value, while there was only a slight change in the ex-poppy crop (minus 26 kg/ha). As can be seen from pre-harvest assessment figures for these crops (Graph 19), the ex-pasture crop produced a higher number of tubers per stem and higher tuber weight per plant than the ex-poppy site. The nitrogen supply may have been a factor in this, but other, not measured factors, could have been just as relevant (soil structure, organic matter, irrigation). The ex-poppy site still produced the higher yield due to its higher plant density (Graph 20).

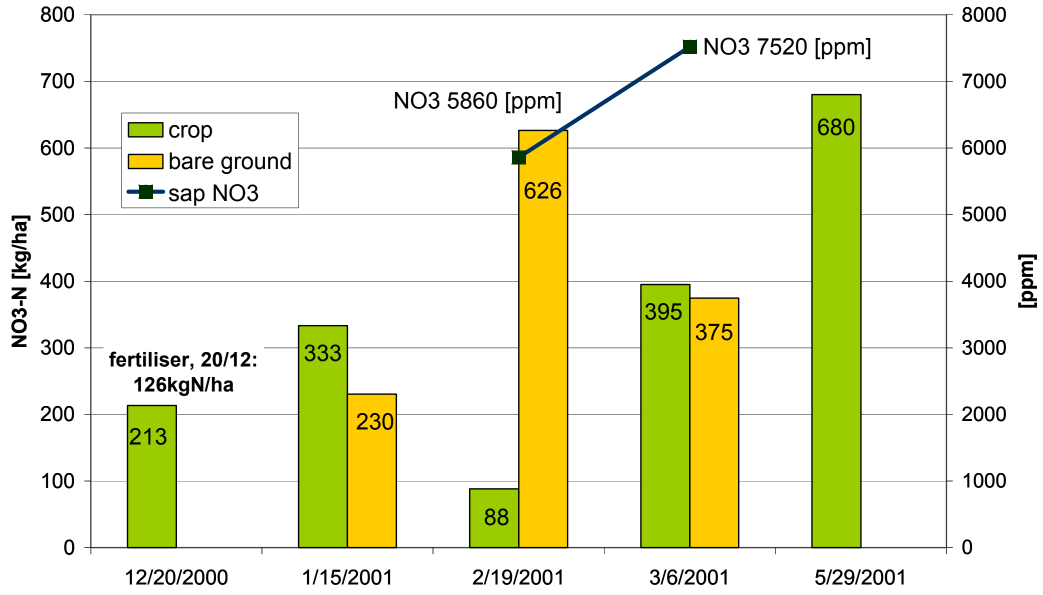
Soil nitrate nitrogen and nitrogen uptake - McCain sites

The McCain crops had been planted nearly two months later than the Simplot crops (October vs. December). While both Simplot crops were on the same soil type, grown by the same grower, the McCain crops were on different soil types, clay loam for the ex-pasture site (Graph 16) and sandy loam for the ex-poppy site (Graph 17). They commenced with similar soil nitrate nitrogen levels, but by January the ex-pasture site contained about 100 kg/ha more in the crop and 80 kg/ha more in bare ground than the ex-poppy site. The N-peak, which had occurred in December at the Simplot sites, was found in February at the McCain sites. At the ex-pasture site it occurred in the crop, and at the poppy site in bare soil. The timing was two months after planting in both cases (Simplot and McCain sites). This suggests that mineralisation may not only be increasing due to a rise in soil temperature in early summer, but its intensity may also be influenced by the timing of soil aeration, e.g. for soil management or planting. The high N-level in the ex-poppy bare ground and the low one in the ex-pasture bare ground are surprising and cannot be explained from the available information.

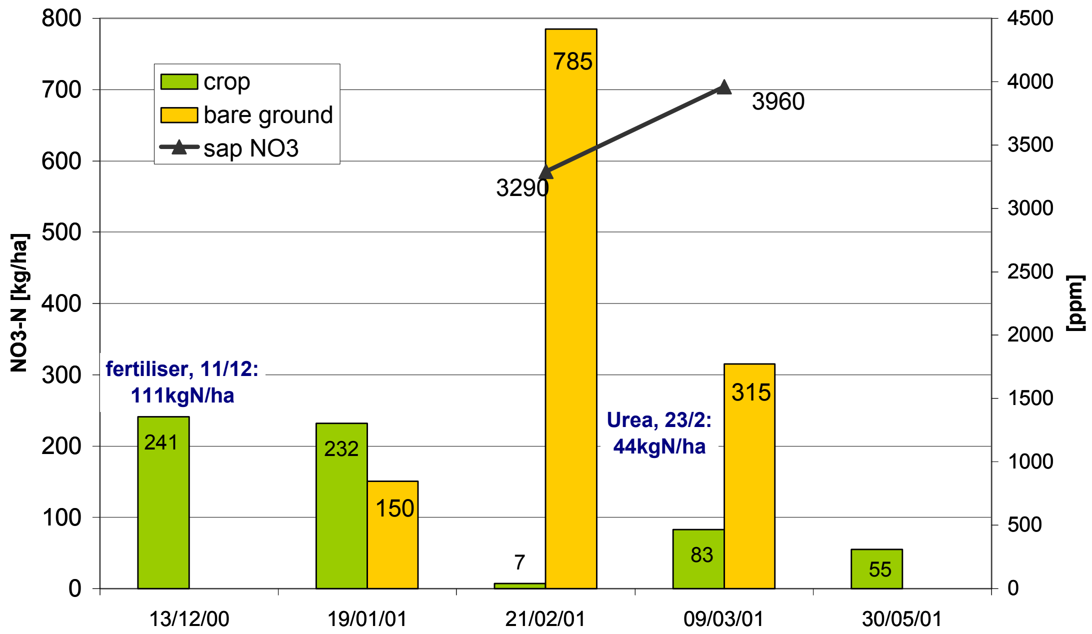
Crop soil nitrate nitrogen levels at both sites fit in with paddock history and soil type. Levels were very low in the ex-poppy site in February due to crop uptake. Sap levels were below optimum. A fertiliser application brought soil and sap levels up, but they still remained too low. The crop finished with a low residual soil nitrate nitrogen level.

[1] Serve-Ag Pty Ltd and Tasmanian Alkaloids Pty Ltd, unpublished data
[2] John Angus, CSIRO Plant Industry, personal communication

Graph 16 - Soil nitrate nitrogen levels [kg/ha] following old pasture, Astell, Shepody, Clay Loam, 2000/01, McCain



Graph 17 - Soil nitrate nitrogen levels [kg/ha] following poppies, Dunbabbin, Shepody, Sandy Loam, 2000/01, McCain

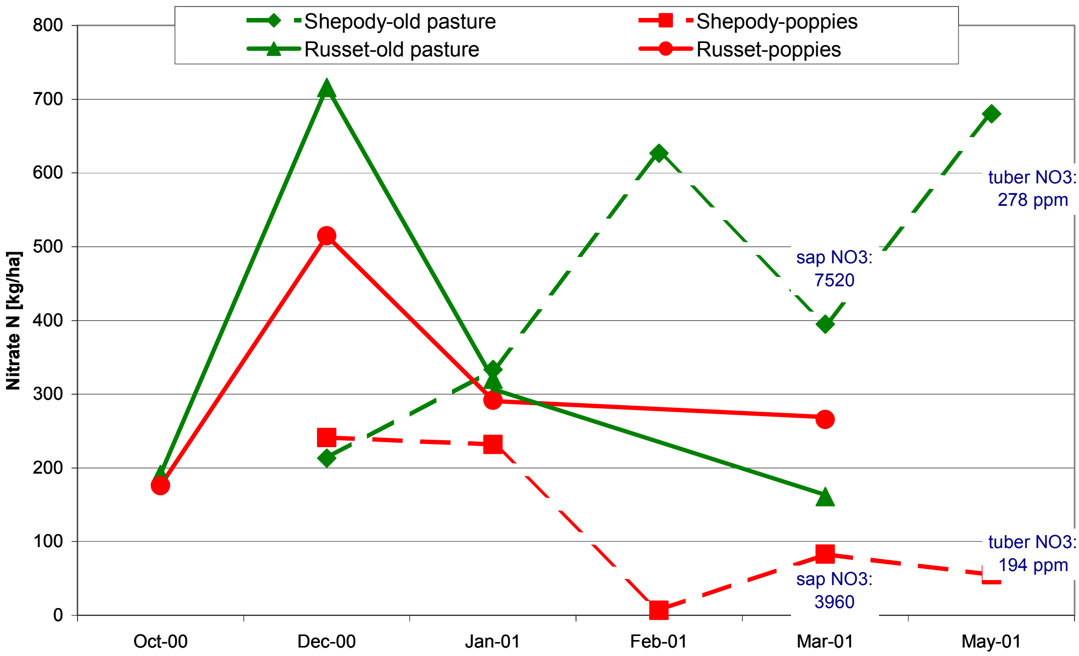


Soil nitrate nitrogen levels in the ex-pasture site (Graph 16) had dropped by about 230 kg/ha in March, which is more than the crop would have used. Denitrification and/or leaching and/or fixing of N in organic matter must also have occurred. Nitrogen uptake figures show that sap nitrate levels increase between February and March. The March level has to be considered high for the crop stage. Soil nitrate nitrogen increased again towards autumn when plant uptake and irrigation (potential for leaching and denitrification) had ceased but mineralisation was still active.

Nitrogen site comparison

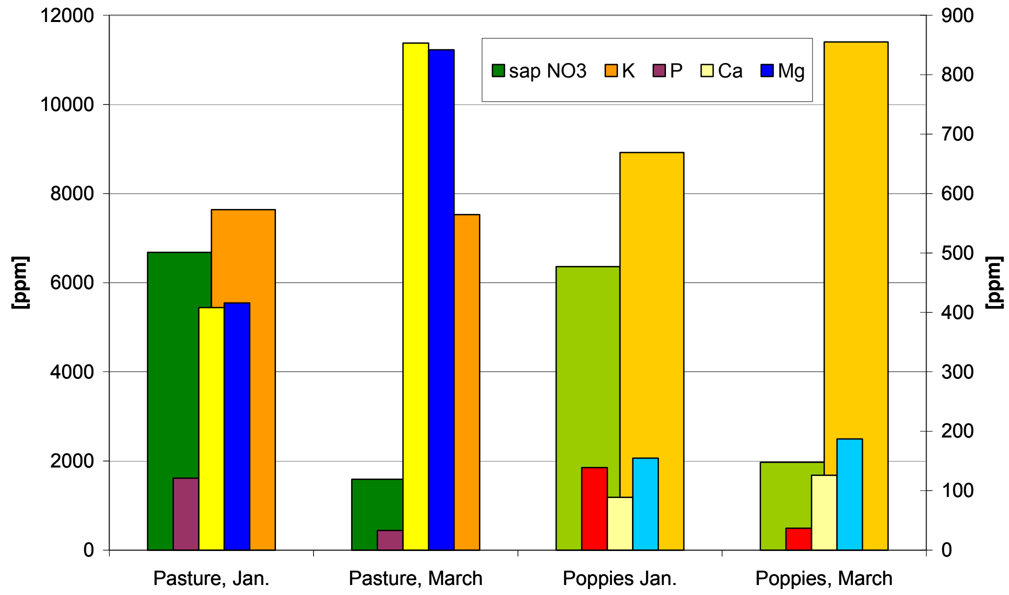
Results from the McCain and Simplot crops, both grown after the same previous crops, still differ in N dynamics as planting time, variety, soil type and management etc. influence the nitrogen cycle in each crop (Graph 18). It seems to be the case that previous poppy crops mineralise less nitrogen, than previous pasture, which makes sense, considering the amount of biomass and the C/N ratio of both sources of organic material. It has to be concluded that nitrogen management must occur on a paddock by paddock basis, based on monitoring rather than using recipes, even if these include information on previous crop, variety, climate etc.

Graph 18 - Soil nitrate nitrogen levels [kg/ha], 0-30 cm depth, in four seed potato crops, two after poppies and two after pasture (Russet [Burbank] = Simplot crops, Shepody = McCain crops)

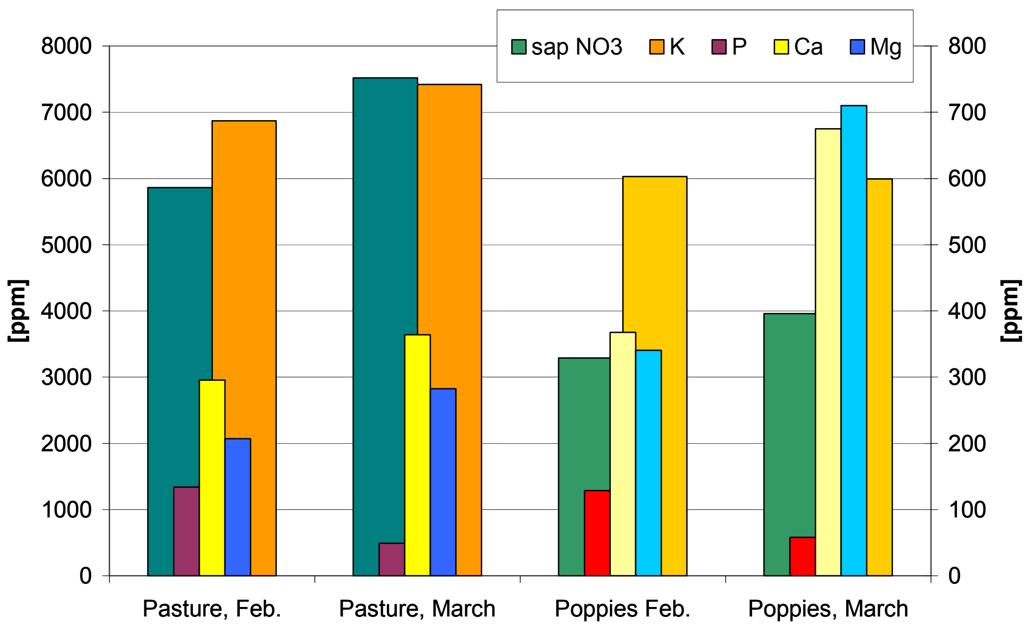


Nutrient uptake - Simplot and McCain sites

Graph 21 - Nutrient uptake as sap nutrients, (N and K on left axis, P, Ca, and Mg on right) Russet Burbank, Simplot sites 2000/01



Graph 21 - Nutrient uptake as sap nutrients, (N and K on left axis, P, Ca, and Mg on right) Shepody, McCain sites 2000/01



Nitrate levels in the sap were very similar for both Simplot sites, whereas potassium was higher at the ex-poppy site, especially in March (Graph 21). Probably due to the high K uptake, Ca and Mg levels were low after poppies. After pasture, Ca and Mg were high, especially in March. An increase in cations in the sap during the season is typical for most plants, as is the ion competition between them. P uptake was similar at both sites.

At the McCain sites, N uptake was lower after poppies, as mentioned earlier (Graphs 22 and 17), and potassium was higher after pasture. Mg and Ca uptake were in a normal range after pasture and poppies in February, but high after poppies in March. P levels were similar after both previous crops.

Differences in nutrient uptake for elements other than nitrogen between sites will be influenced by several years of paddock history, not only by the previous and current crops. There is not enough site information available to interpret nutrient levels other than nitrogen.

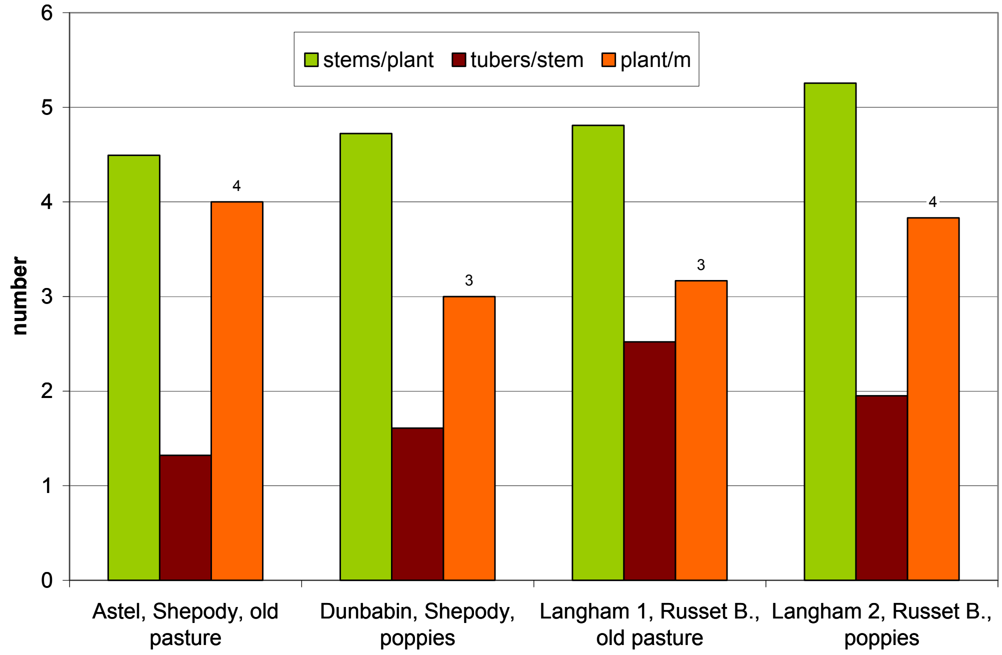
Pre-harvest assessments, Simplot and McCain sites

Graph 19 shows results from pre-harvest assessments for the Simplot and McCain crops. As mentioned above for Simplot crops, the ex-pasture site had better tuber set and tuber weight than the ex-poppy site, but a lower plant density and the same yield as the ex-poppy site. Plant density also had an overriding effect on paddock yield at the McCain site (Graphs 19 and 20) with the ex-poppy site having the lower density, but a higher tuber weight per plant.

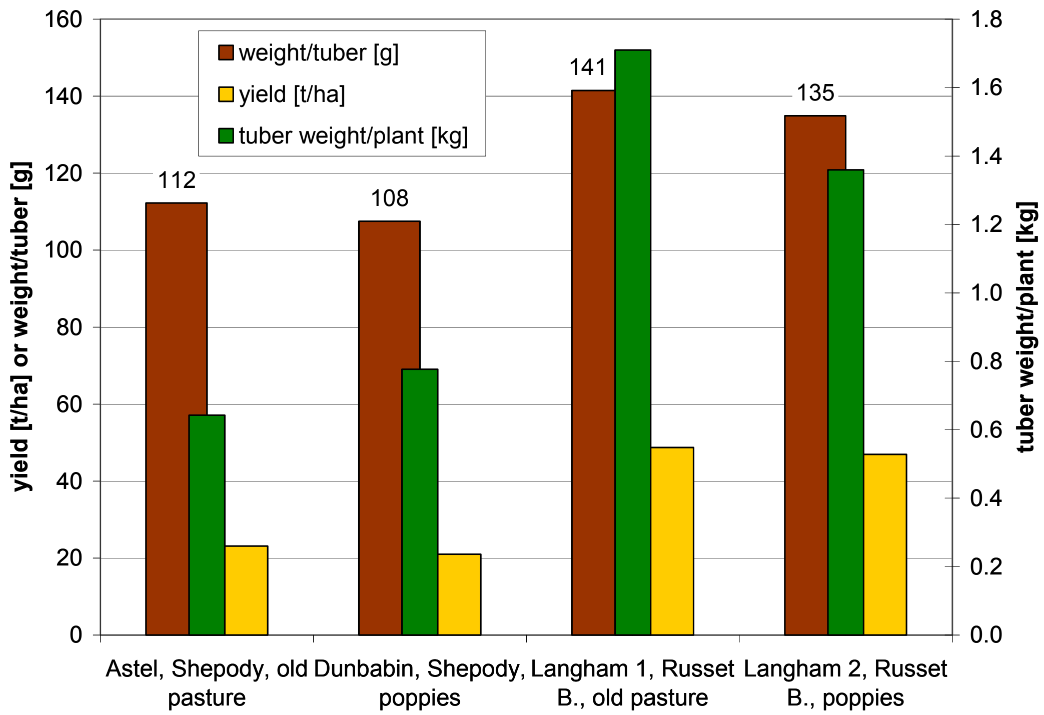
Tuber set and tuber weights were comparatively low for Shepody crops, leading to low yield at both sites. Russet crops had acceptable yields.

The pre-harvest assessment did not show major differences that could be attributed to the previous crop and site nitrogen dynamics.

Graph 19 - Number of stems per plant, tubers per stem, and plants per meter, 2000/01 crops



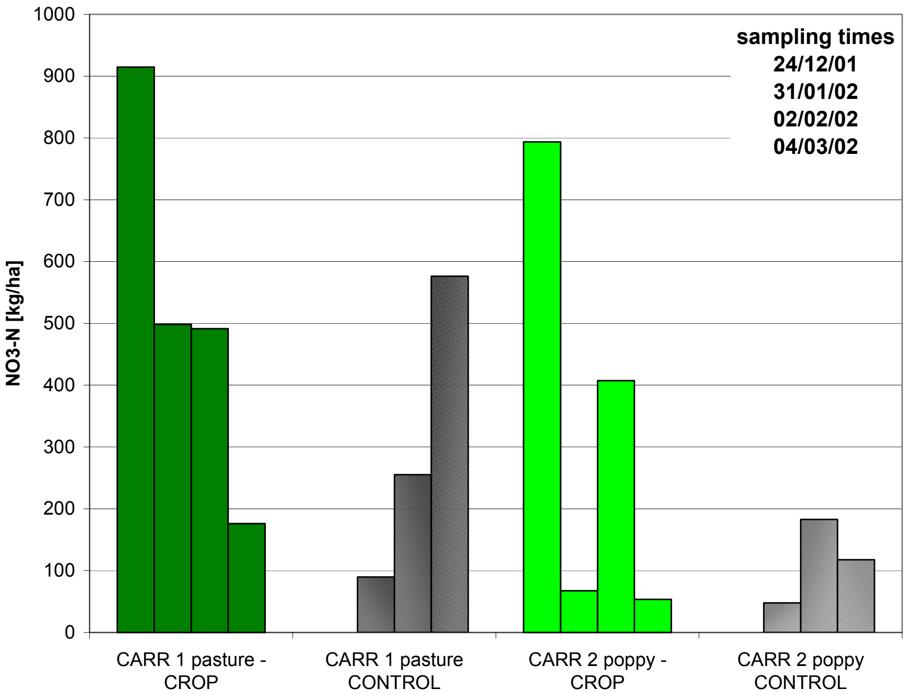
Graph 20 - Yield, tuber weight per plant, and plants per meter of row, 2000/01 crops



2001/02 Season crop monitoring results

Soil nitrate nitrogen - Simplot sites

Graph 23 - Soil nitrate nitrogen [kg/ha], 0-30 cm soil depth, for two seed potato crops and bare ground (control) after pasture (Carr 1) and after poppies (Carr 2)



Both Simplot crops, Carr 1 after pasture and Carr 2 after poppies, started off with rather high soil nitrate nitrogen levels, far in excess of requirements (Graph 23). The high level after poppies is not considered typical. By the end of January, levels were more typical for ex-pasture and ex-poppy sites. The ex-poppy site had dropped rather low at a time when the desirable level would be around 100 kg/ha. The low level was corrected via a fertiliser application[1], leading to rather high levels in February, which again dropped to low at the end of the season, where a low level is desirable.

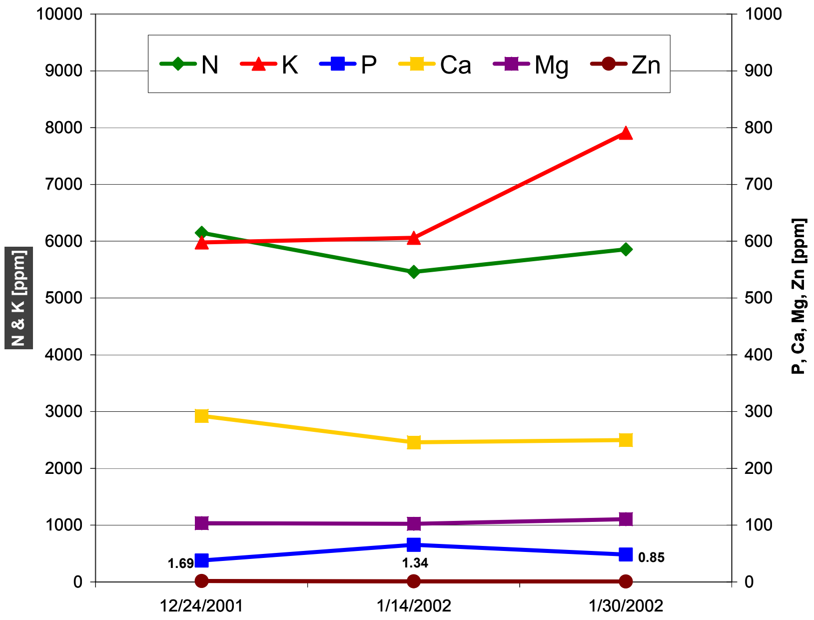
The ex-pasture crop retained rather high soil nitrate nitrogen levels in January and February, finishing off reasonably high at the end of the season. The bare soil (control) accumulated nitrogen during the season. This meant that there had been little loss due to uptake, denitrification or leaching. The bare soil (control) after poppies accumulated little nitrogen, but finished with slightly higher levels than the crop (due to fewer losses). At the end of the season, levels at the ex-poppy control were considerably lower than levels in the control after pasture.

Graphs 24 and 25 show nutrient uptake at three fortnightly sampling times between the end of December and the end of January. Both Carr crops showed sufficient nutrient levels at all sampling times. Calcium and magnesium levels increased considerably in the poppy site towards the end of January, while potassium showed a bigger increase at the pasture site at the same sampling time. The different cation balance in different paddocks is believed to be a result of different paddock history rather than being purely due to the different previous crops.

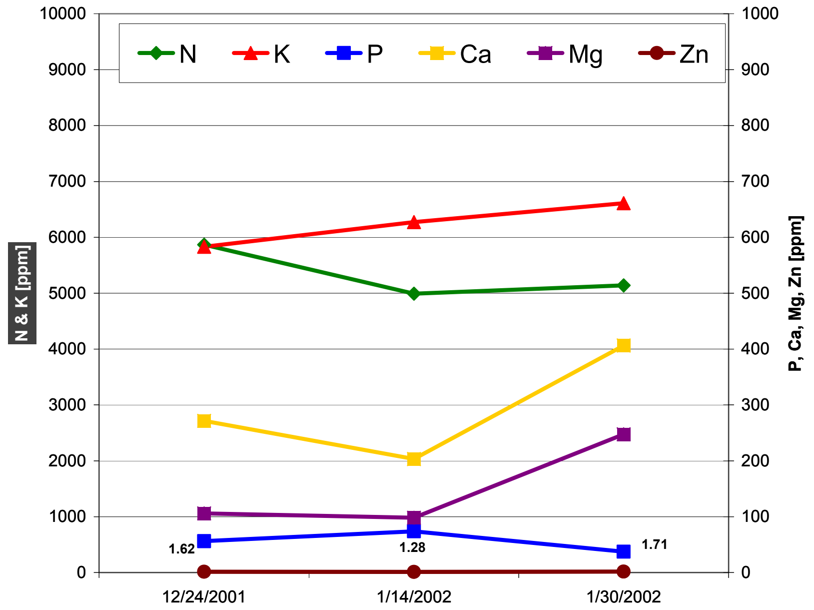
[1] Frank Mulcahy, Simplot, personal communication

Nutrient uptake - Simplot sites

Graph 24 - Nutrient uptake into petiole sap [ppm] at three dates, Carr 1 after pasture, Simplot, 2001/02

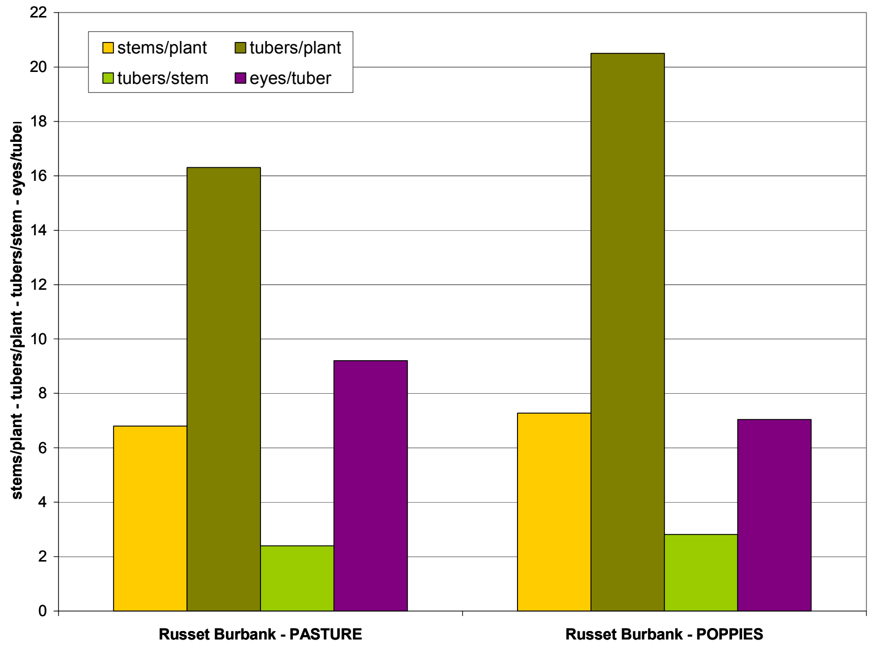


Graph 25 - Nutrient uptake into petiole sap [ppm] at three dates, Carr 2 after poppies, Simplot, 2001/02

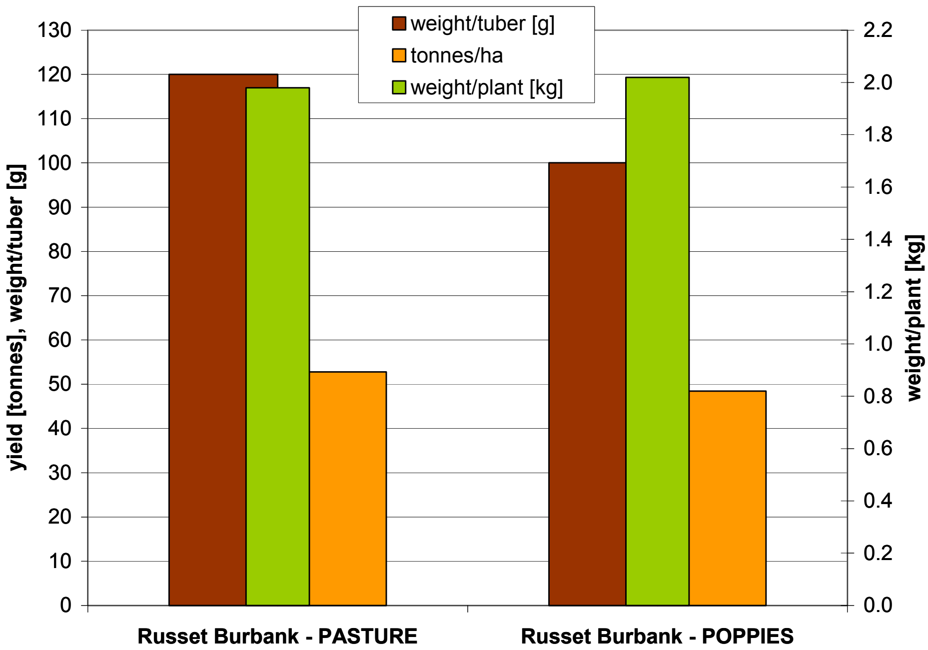


Pre-harvest assessments - Simplot sites

Graph 26 - Pre-harvest assessment counts, Carr 1 after pasture and Carr 2 after poppies, Simplot 2001/02



Graph 27 - Pre-harvest assessment weights, Carr 1 after pasture and Carr 2 after poppies, Simplot 2001/02



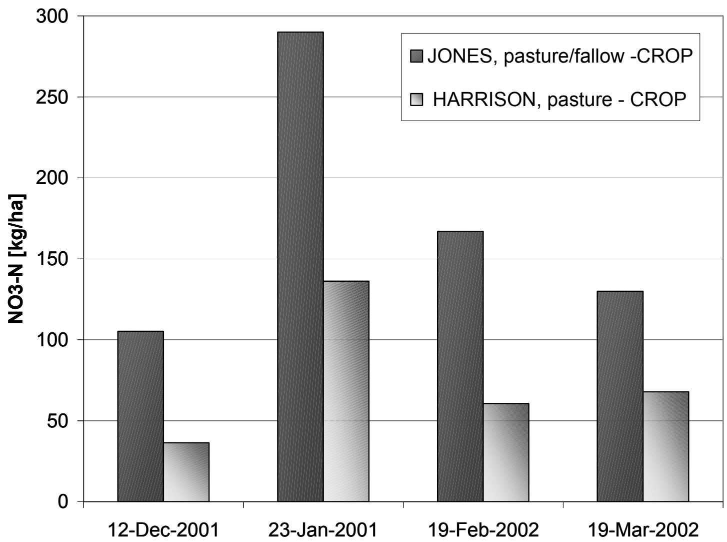
The pre-harvest assessment results for the two Simplot sites, Carr 1 after pasture and Carr 2 after poppies, are shown in Graphs 26 and 27. Stem numbers per plant were the same for each crop but the tuber set per stem, and thus per plant, was higher after poppies (Graph 26). The higher tuber set after poppies led to smaller (lighter) tubers, with the weight per plant being nearly identical in both crops (Graph 27). The yield was slightly higher after pasture.

Even though the nitrogen dynamics differed in both crops, all other results were similar, apart from the smaller tuber size and higher tuber numbers of the ex-poppy crop. The available data does not allow attributing the higher tuber set solely to the influence of the previous crop and soil nitrate nitrogen dynamics.

Soil nitrate nitrogen - Harvest Moon sites

Harvest Moon grows a range of ware potato varieties. Goldstar and Redstar originated from the same Dutch breeding program.

Graph 28 - Soil nitrate nitrogen levels [kg/ha], 0-30 cm depth, for two seed potato crops, Jones, Red Star, grown after pasture/fallow, Harrison, and Gold Star G3, grown after pasture, Harvest Moon, 2001/02

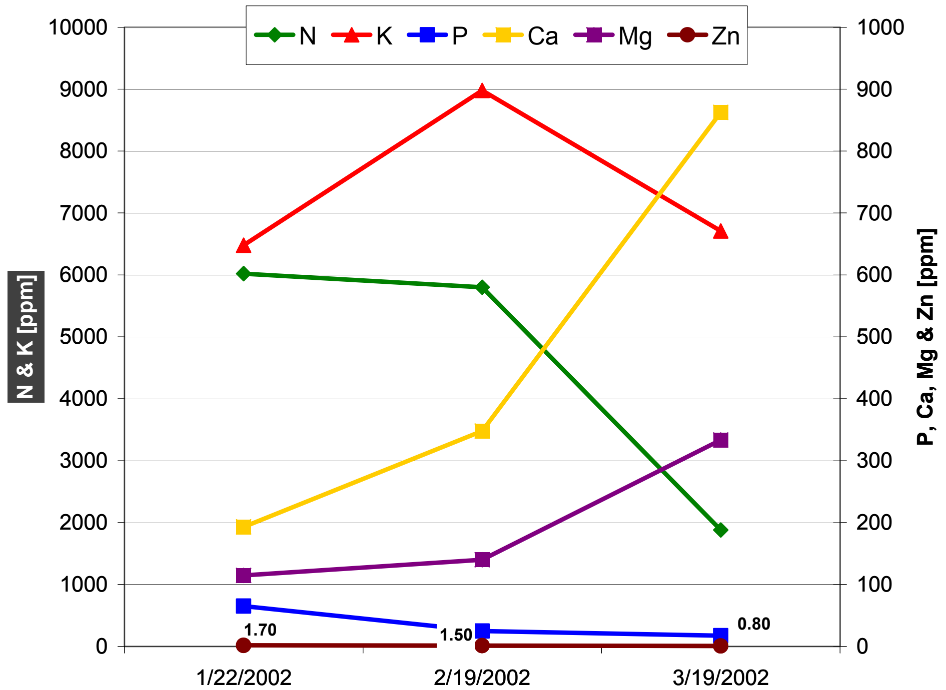


Graph 28 shows that the crop that had a several month fallow period between ploughing and planting of potato seed had higher soil nitrate nitrogen levels throughout the season. The January level was above requirements for a seed potato crop, considering that nitrogen uptake would be between 200 and 250 kg N/ha over the entire crop life. The crop after pasture, Harrison, does not show the high N release observed in other years after pasture. This indicates that the pasture had, most likely, been run down.

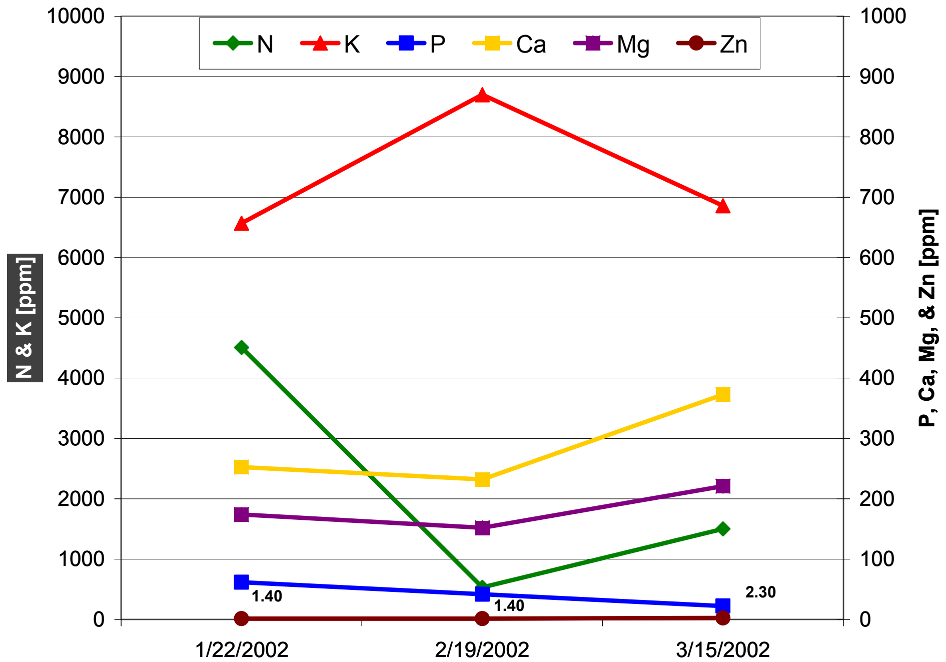
Nutrient uptake – Harvest Moon sites

Nitrogen uptake of Harvest Moon crops over time relates well to soil levels (Graphs 29 and 30). Jones's levels show the typical reduction in nitrogen uptake towards the end of the season. Harrison's levels were too low in February, indicating that a soil level of around 50-60 kg/ha is too low at that time and that the January value should have been above, not below, 150 kg/ha. Potassium uptake was the same in both paddocks. Mg and especially Ca increased markedly in Jones's crop, whereas they were at the low side of desirable levels at Harrison's throughout the season. Phosphorus uptake was below desirable levels in February and March for both crops.

Graph 29 - Nutrient uptake at three dates, Jones, Redstar, after pasture/fallow, Harvest Moon, 2001/02

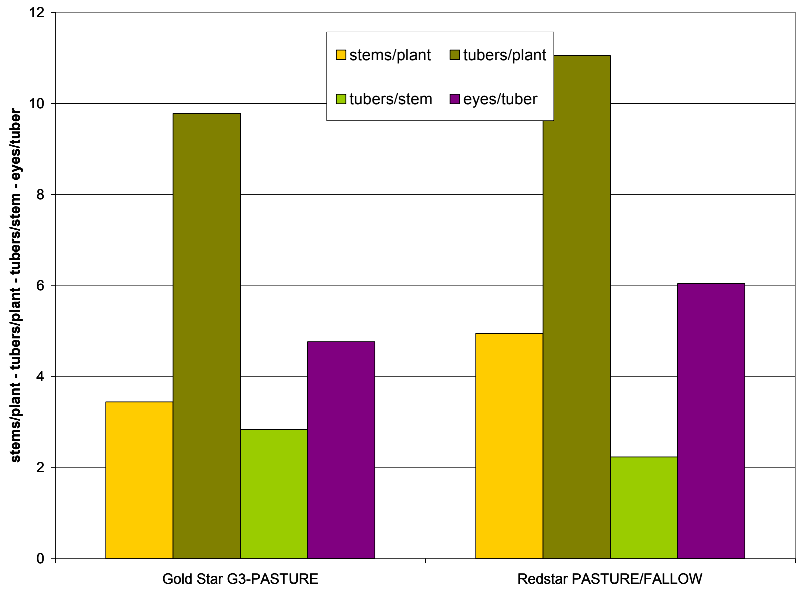


Graph 30 - Nutrient uptake at three dates, Harrison, Goldstar, after pasture, Harvest Moon, 2001/02

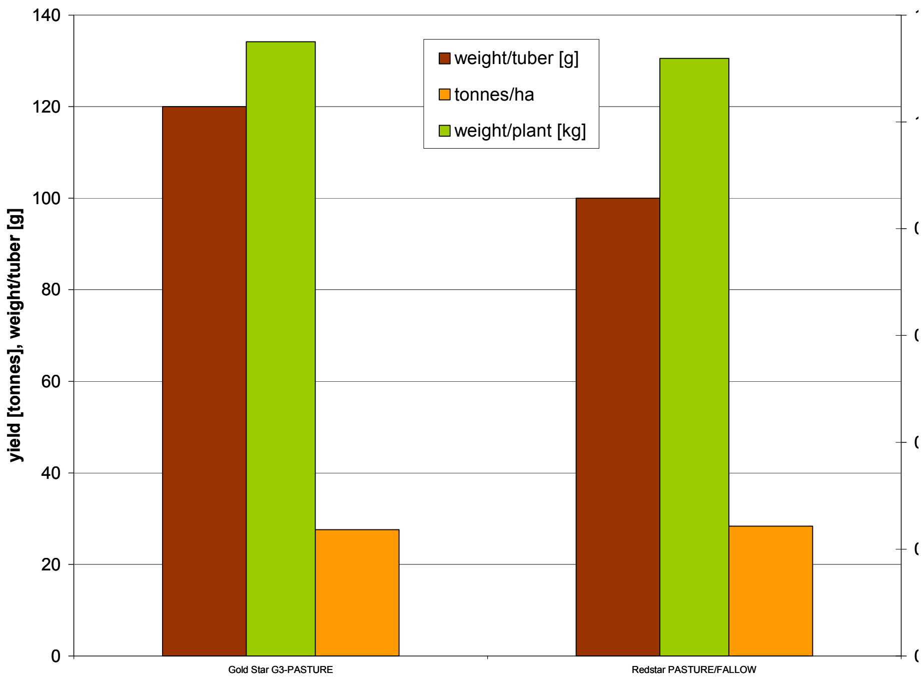


Pre-harvest assessments – Harvest Moon sites

Graph 26 - Pre-harvest assessment counts, Jones after pasture/fallow and Harrison after pasture, Harvest Moon 2001/02



Graph 26 - Pre-harvest assessment weights, Jones after pasture/fallow and Harrison after pasture, Harvest Moon 2001/02

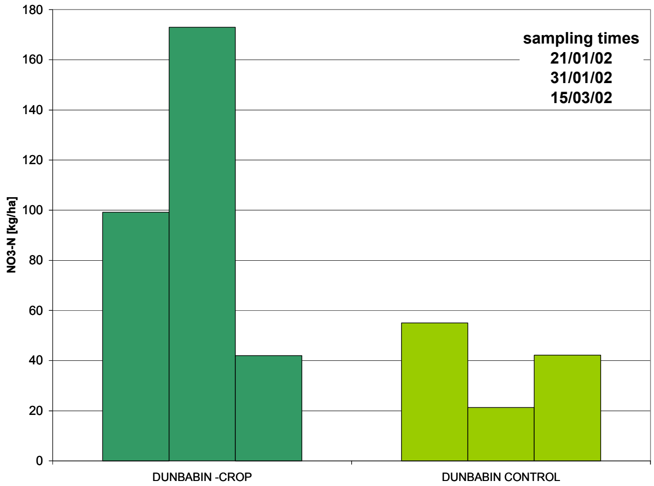


Soil nitrate nitrogen - McCain Site 1

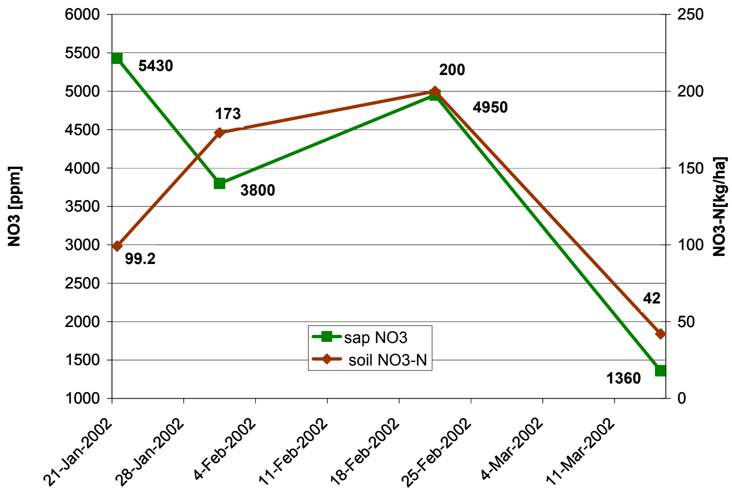
Graph 31 shows soil nitrate nitrogen levels for the Dunbabbin crop after poppies. As usually experienced after poppies, nitrate levels remained comparatively low. They dropped from the highest level of 170 kg/ha in late January to 40 kg/ha in mid-March. The bare ground (control) never contained more than 60 kg/ha. Again, this would be due to lower rates of mineralisation, denitrification, leaching and the absence of banded fertiliser.

Dunbabbin soil nitrate nitrogen levels are reflected in nitrate uptake (Graph 32). Similar to the Jones crop (Graph 29) plant levels plummet as soil levels drop below from about 170 to 50 kg/ha. Graph 33 illustrates that potassium uptake was satisfactory, Ca and Mg showed a relatively steep increase as seen in previous ex-poppy seed potato crops (Graphs 22 and 25), but also in an ex-pasture crop in the first year of monitoring (Graph 4c). P-levels were very good during main crop development.

Graph 31 - Available soil nitrate nitrogen [kg/ha], 0-30 cm depth, Dunbabbin, 2001/02, McCain

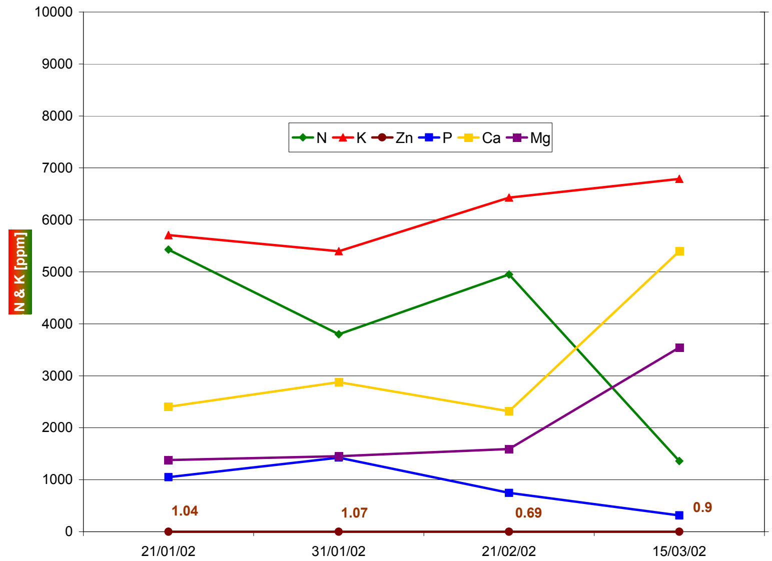


Graph 32 - Available soil nitrate nitrogen [kg/ha], 0-30 cm, and nitrate uptake [ppm], Dunbabbin, 2001/02, McCain,



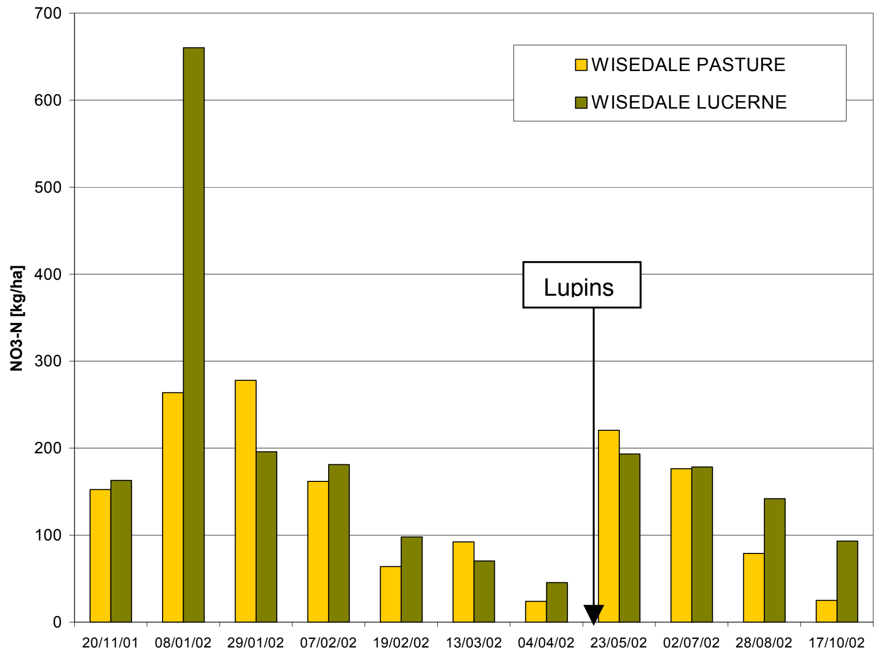
Nutrient uptake - McCain Site 1

Graph 33 - Nutrient uptake [ppm], Dunbabbin, 2001/02, McCain



Soil nitrate nitrogen - McCain Site 2

Graph 34 - Available soil nitrate nitrogen [kg/ha], 0-30 cm, Wisedale after pasture and lucerne, during seed potato production and a subsequent lupin cover crop, 2001/02, McCain

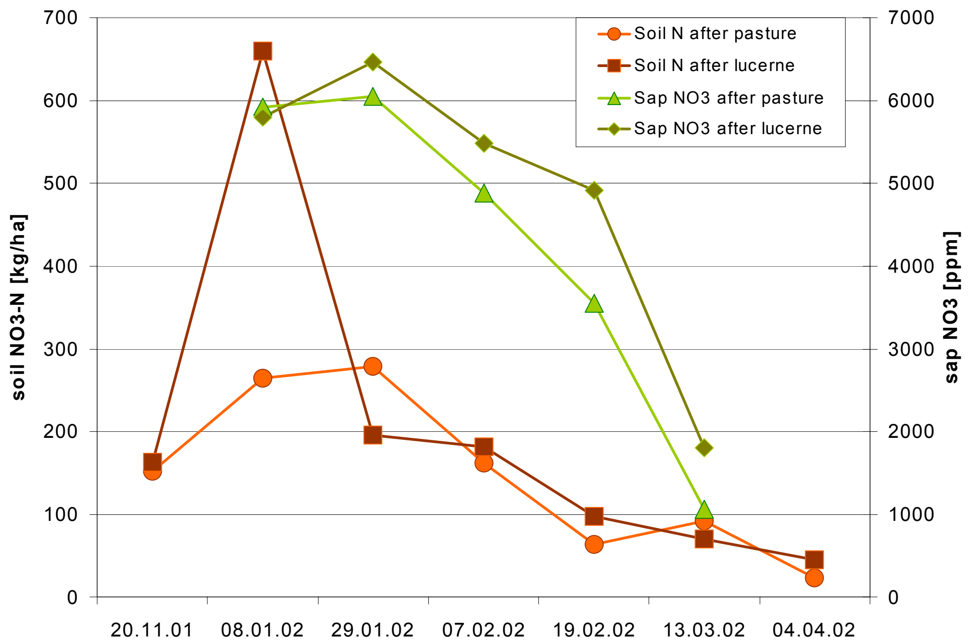


Graph 34 shows soil nitrate nitrogen levels for the seed potato crop grown in a previously divided paddock after lucerne and pasture (Appendix ii). The paddock was monitored for some time after seed harvest to check on developments over winter during a lupin cover crop.

Even though seed potato source and crop management were identical in both paddock halves, the lupins released more than double the amount of nitrogen than pasture in January. The pasture was run down by the time it was ploughed in, while the lucerne provided a comparatively large amount of fresh organic matter. The reasons for the 'mineralisation peak' after incorporation of large amounts of fresh organic material with a low C/N ratio have been discussed earlier in this report, in relation to Graphs 7a and 7b. Once the peak had subsided, N levels were comparable in both paddock halves. The paddock was sown to lupins in May 2002, after a base dressing which included close to 50 kg of nitrogen. In August and October 2002, the lucerne part of the paddock again provided more nitrate through mineralisation, than the pasture part.

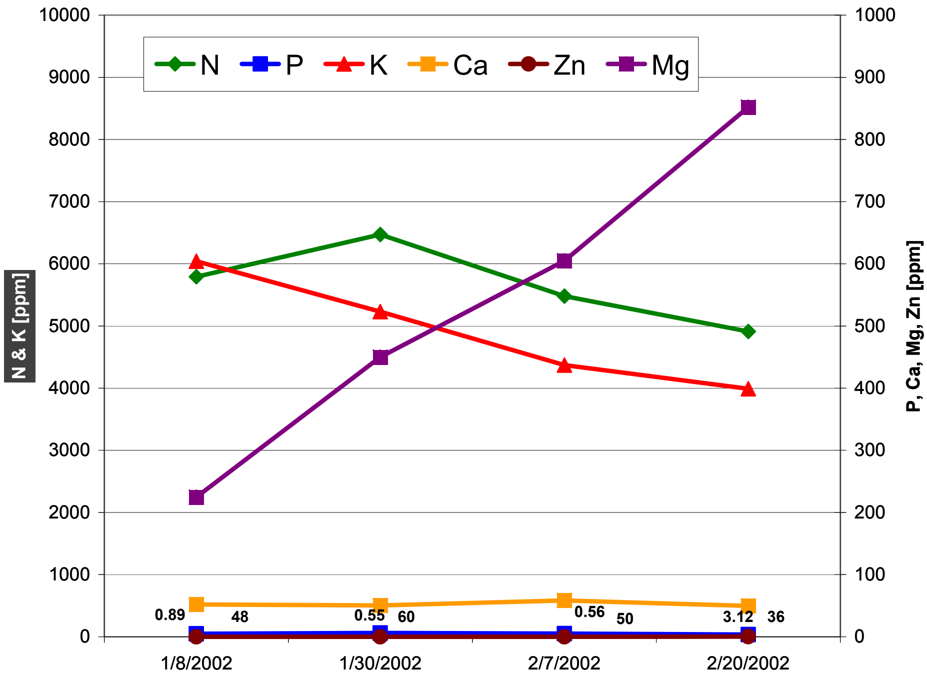
Graph 35 shows soil nitrate nitrogen levels and nitrate uptake during the potato crop. While there was a major difference in soil levels in January, sap levels were identical. After January, the ex-lucerne part of the crop showed slightly higher N uptake than the ex-pasture site. The trend was similar in both cases. As mentioned before, overly high soil nitrate nitrogen levels do not lead to extremely high plant levels, as uptake is limited as plants maintain electric neutrality through selective uptake and discharge of negative and positive ions and molecules. This means that plant analysis is not a good tool to judge N oversupply in the soil.

Graph 35 - Available soil nitrate nitrogen [kg/ha], 0-30 cm, and nitrate uptake [ppm], Wisedale after pasture and lucerne, 2001/02, McCain

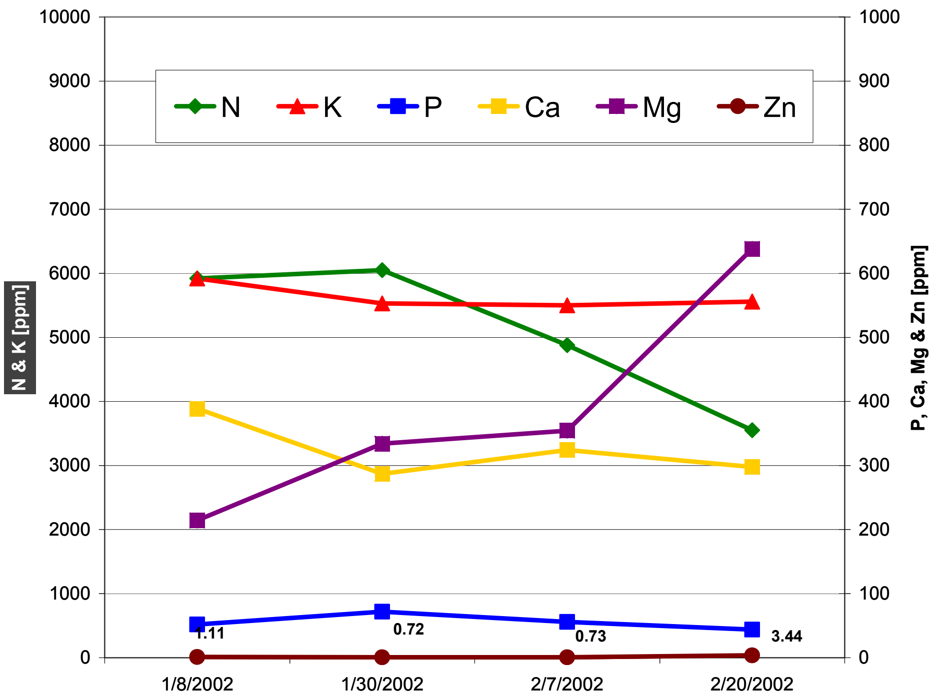


Nutrient uptake - McCain Site 2

Graph 36 - Nutrient uptake [ppm], Wisedale after lucerne, 2001/02, McCain



Graph 37 - Nutrient uptake [ppm], Wisedale after pasture, 2001/02, McCain



Graphs 36 and 37 show uptake of N, K, P, Ca, Mg and Zn. After lucerne, Mg levels increased rapidly during the season, up to a relatively high level. Atypically, potassium levels declined. They should have increased or remained constant. The K decline and probably the low Ca levels throughout the season may have been due to the high Mg uptake (ion competition). P levels are very low in this crop.

After pasture, nutrient uptake levels were more balanced. Mg increased towards the end of the season while Ca and K levels were more or less constant. The differences in nutrient uptake between the paddock halves may have been due to the different prior crops but also the long-term history of the previously divided paddocks.

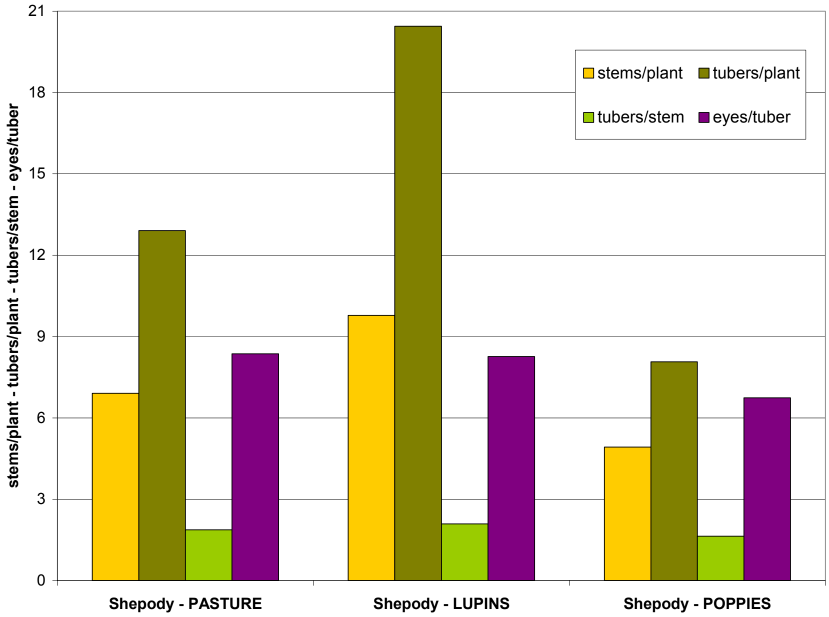
The soil in the ex-lucerne area was softer and had developed tubers to a greater depth than in the ex-pasture area. The low P and Ca levels after lucerne may have been due to this greater rooting depth, as nutrient uptake would have taken place from areas in the soil profile with low Ca and P levels. The soil, a sandy loam, would have been naturally low in Ca and P. Fertiliser P and Ca would not have moved far enough through the profile to be available to deep roots.

The nutrient uptake data shows the importance of seasonal monitoring. Crops under identical management and environmental conditions can still be subject to a very different nutrient uptake situation.

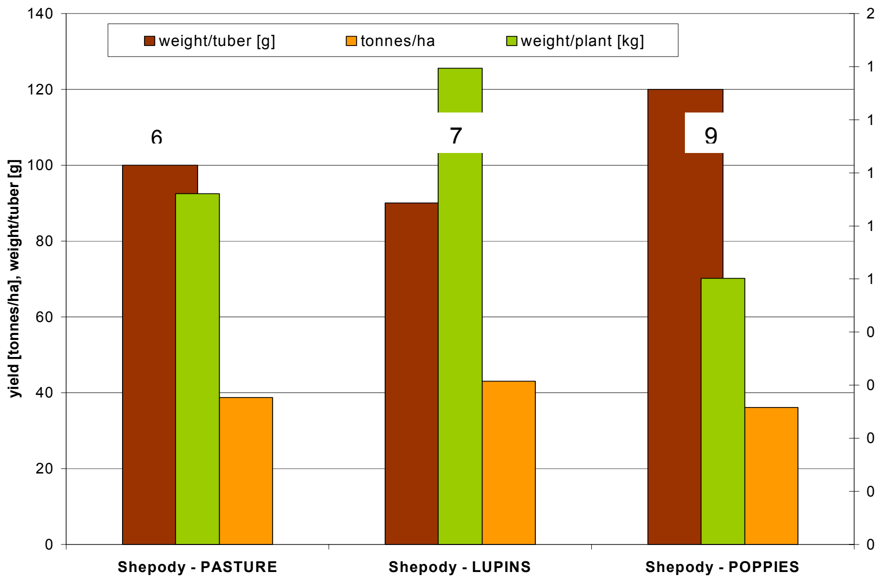
Pre-harvest assessments – McCain sites

The seed potato crop after poppies (Dunbabbin) had the lowest stem number per plant. This may have been due to the physiological age of seed. At the Wisedale site, planted with identical seed, the lucerne part had the higher stem and tuber number per plant. Tuber numbers per stem, and eye counts, were identical (Graph 38). After poppies (Dunbabbin), the tuber numbers per stem were slightly lower than at Wisedale. In combination with the considerably lower stem numbers, this reduced the tuber number per plant to less than half that of the ex-pasture site. The eye count numbers per tuber of the two Wisedale crop parts were identical, while the Dunbabbin site had a slightly lower number of eyes per tuber, even though the tuber size was the highest of all crops (Graph 39). Due to the higher tuber weight and plant density, the Dunbabbin crop did not fall far behind the Wisedale crop in overall yield, in spite of the lower yield per plant (Graph 39). The Wisedale ex-pasture area had a higher weight per tuber, but a lower yield per plant. In combination with the lower plant density, this contributed to a slightly lower yield than at the ex-lucerne area.

Graph 38 - Pre-harvest assessment counts, Wisedale after ½ pasture, ½ lucerne and Dunbabbin after poppies, McCain 2001/02



Graph 39 - Pre-harvest assessment weights, Wisedale after ½ pasture, ½ lucerne and Dunbabbin after poppies, McCain 2001/02



Field trial with stored seed from 2000/01 monitored crops, 2001/02

Tuber assessments ex-store

Table 7 - Visual ratings of tuber quality and firmness (penetration resistance, [kg/cm^2] for seed tubers from the 2000/01 monitored seed crops prior to planting 31/10/01

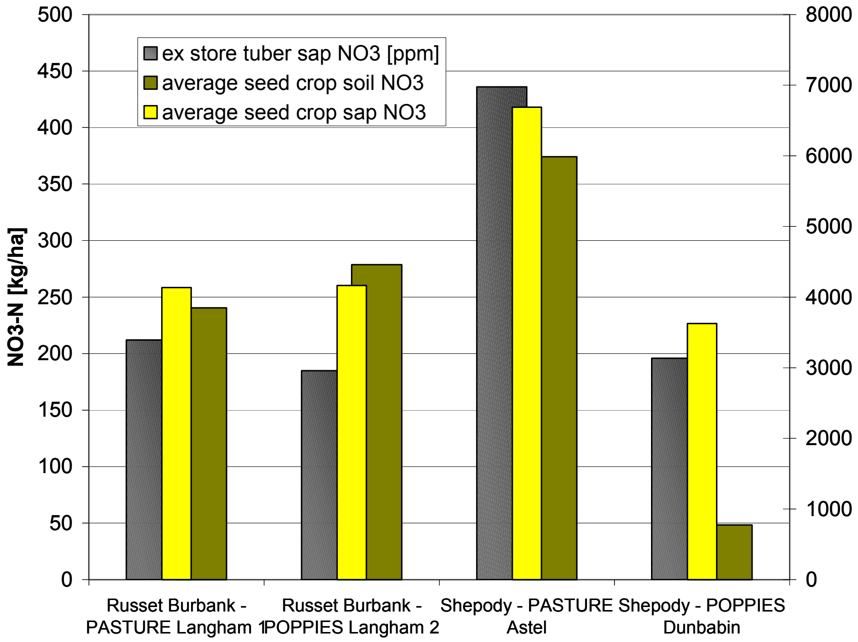
Previous crop	Company and variety	Crop	Sprouting score	Firmness [kg/cm^2]	Soft breakdown score	Dry rot score	Scab score
PASTURE	Simplot Russet Burbank	Langham 1	1.63	6.13	1.00	1.00	1.10
POPPIES		Langham 2	1.50	5.17	1.00	1.00	1.00
PASTURE	McCain Shepody	Astel	No data				
POPPIES		Dunbabbin	1.00	5.07	1.05	1.30	1.00
PASTURE	Harvest Moon Gold Star G3	Harrison	1.20	5.48	1.03	1.00	1.00
PASTURE/ FALLOW		Kelly	1.25	4.81	1.03	1.35	1.00

Seed was stored in half tonne bins in conventional cool stores set at 3-4^{o}C. Assessments were done after seed was removed from the stores and warmed to ambient temperature, prior to cutting. Unfortunately seed from Astel had been cut and treated with fungicide by mistake so that the assessments described in Table 7 could not been performed for that seed line.

Table 7 shows that disease levels were very low and there were no differences between seed lines. The sprouting scores, even though low overall, were highest for the Russet Burbank seed and lowest for Shepody. Sprouting would be more strongly influenced by handling and storage conditions and thus physiological age, rather than nitrogen during seed production alone. The two ex-pasture crops had firmer tubers than the ex-poppy and pasture/fallow crops. However, this could be coincidence. As explained earlier, the Harvest Moon seed was from crops with different previous crops, which were not monitored during the 2000/01 season.

Once seed had settled in the stores, samples were taken from four accessible crops for a tuber sap nutrient analysis to find out which elements were actively metabolised. This analysis was repeated after seed was removed from storage. The results for Simplot (Langham 1 and 2), Harvest Moon (Kelly) and McCain (Dunbabbin) seed are shown in Appendix 1. All nutrients changed during storage. However, trends were not consistent for certain nutrients, and there was not enough data to relate the tuber sap trends to seed crop management or commercial crop performance. It may be worth investigating tuber nutrient analysis (tissue test or sap analysis) as an indicator for subsequent crop potential, in combination with seed health and physiological age, if a quality indicator for potato seed is required.

Graph 40 - Tuber sap NO_3 [ppm] after storage (01/11/01) and average soil nitrate nitrogen availability and nitrate uptake during seed crop growth (2000/01), Simplot and McCain crops



Graph 40 shows nitrate levels in tuber sap after storage (01/11/01) and average nitrate N levels in soil and plant sap nitrate during the growing season. Russet Burbank crops had similar overall levels, whereas the Shepody crop after pasture had the highest, and the one after poppies, the lowest overall levels. The data suggests that seed grown with high exposure to nitrogen may have higher N levels in the tuber, even after storage. This observation would have to be confirmed in separate trials, if considered relevant for seed and commercial crop management.

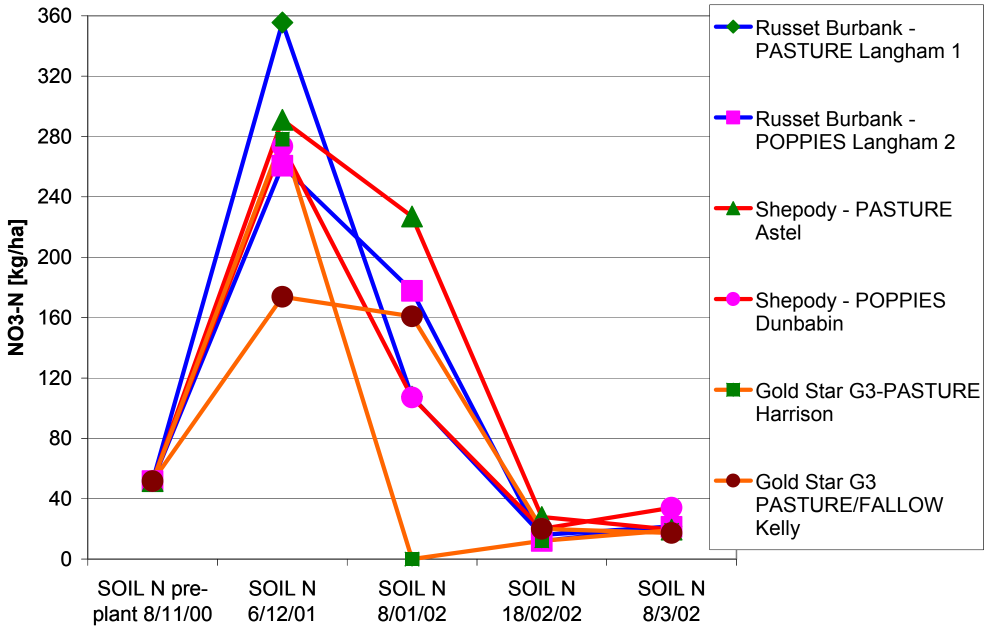
Soil nitrate nitrogen

Graph 41 shows that the different seed sources withdrew different amounts of N from the soil. Soil nitrate nitrogen levels varied considerably about one month after planting. If comparing within varieties, the seed from ex-pasture sites had somewhat higher soil nitrate nitrogen levels than those after poppies or fallow/pasture. It may have been expected that the highest soil nitrate nitrogen level would be found in plots were tubers with the highest levels were planted; however, that was not the case. The variation in soil nitrate N levels was unexpected. It may have been due to the speed of root development and/or reserves in the tuber tissue and sap.

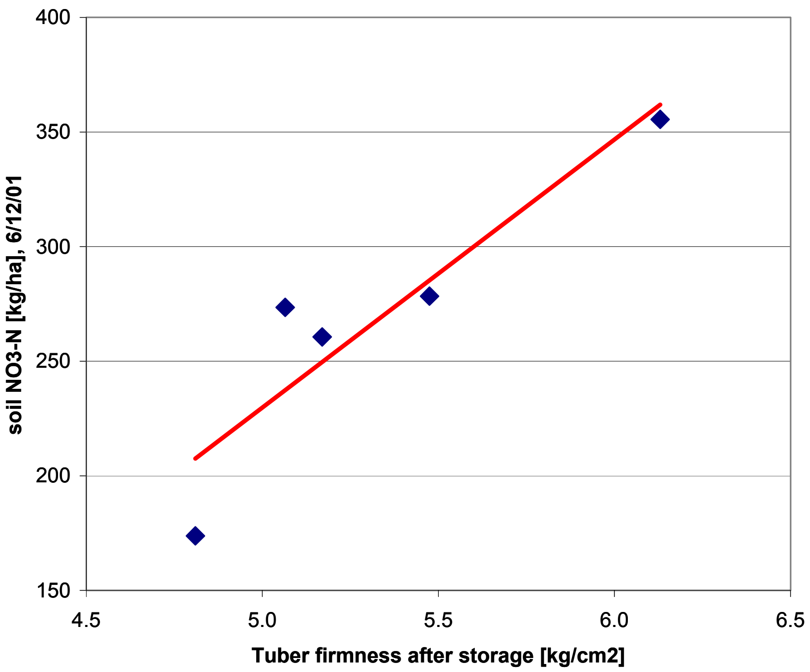
In January, two months after planting, soil nitrate nitrogen levels still varied, but were not in the same ratio to each other as before. In February, soil levels had dropped very low, and remained low into March. The trial was not top-dressed to establish whether the ‘N history’ of seed had an influence on subsequent crop performance.

Graph 42 shows that there was a relationship between tuber firmness after storage and soil nitrate nitrogen levels one month after planting. Plants from firmer tubers seemed to withdraw less N from the soil. This relationship would need further investigation to establish its relevance to commercial crop performance.

Graph 41 - Soil nitrate nitrogen levels (NO_3–N[kg/ha]) in the commercial crop performance trial



Graph 42 - Relationship between soil nitrate nitrogen levels (NO_3–N[kg/ha]) in the commercial crop performance trial one month after planting and tuber firmness [kg/cm^2] after storage



Nutrient uptake

Table 8 - Nitrate, phosphorus and potassium uptake of potatoes in a commercial crop performance trial, 2001/02

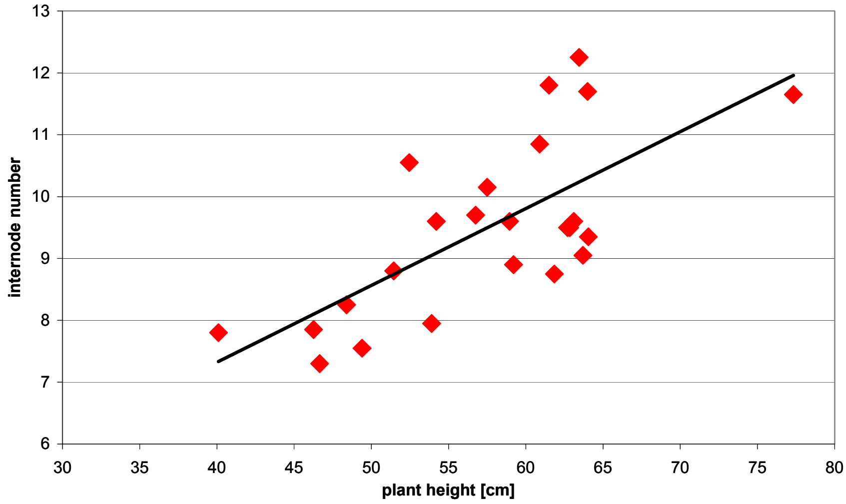
Variety	NO_3 uptake [ppm]		P uptake [ppm]		K uptake [ppm]	
	7/12/01	15/02/02	7/12/01	15/02/02	7/12/01	15/02/02
Russet Burbank - PASTURE Langham 1	6830	905	56.8	18.1	5450	5295
Russet Burbank - POPPIES Langham 2	6860	953	59.5	13.1	5320	4055
Shepody - PASTURE Astel	7190	2510	73.3	30.3	5070	5735
Shepody - POPPIES Dunbabbin	6860	1113	85.6	22.4	4980	5360
Gold Star G3 - PASTURE Harrison	7160	1490	69.4	22.3	6000	5725
Gold Star G3 - PASTURE/FALLOW Kelly	7230	1367	68.6	23.5	5780	4950

Table 8 shows N, P, and K uptake at one and three months after planting. Nitrate uptake does not differ much within varieties at the first date (7/12/01). This is interesting, considering that soil levels were different at this time, with ex-pasture seed plots having higher soil levels, suggesting less uptake. A stronger depletion of N in the immediate root zone may also have been responsible for higher overall soil nitrate levels, if root distribution and density differed between seed lines. Samples were taken between plants. At the second date (15/02/02), plant nitrate levels of all seed sources had dropped below the desirable range. The plants from Shepody ex-pasture seed had the highest level. The seed also had the highest exposure to nitrogen during seed production and the highest tuber sap levels after storage. However, this may be coincidental.

P uptake varied mainly between seed lines, with Russet Burbank having low and extremely low uptake at both sampling dates. For Shepody, levels were acceptable at the first date but low at the second, and Gold Star dropped from marginal to low levels. P uptake is an indication of the ability of the root system to exploit the soil. Russet Burbank is known to have the poorest root system of the three varieties. As P is taken up by root interception, a poor root system is a disadvantage and the crop needs careful P management. Phosphorus is involved in all physiological processes needing energy transfer. Low P uptake is likely to affect the reaching of full yield and specific gravity (SG) potential.

Potassium levels were acceptable for all varieties and dates. In all cases, straight ex-pasture seed had slightly higher levels. K dropped in Russet Burbank and Gold Star, but increased in Shepody. An increase is the expected seasonal uptake trend for cations. Potassium is important for the plant's water balance and carbohydrate metabolism.

Graph 43 - Relationship between plant height [cm] and internode number over all varieties (four plots per seed line) in a commercial crop performance trial, 2001/02



Graph 43 shows the close relationship between plant height and internode number in the trial. This relationship may not exist if potatoes grow in height due to ample nitrogen supply, i.e. height is due to long (etiolated) internodes. As discussed previously, the trial was grown with a relatively low N supply.

Harvest assessments

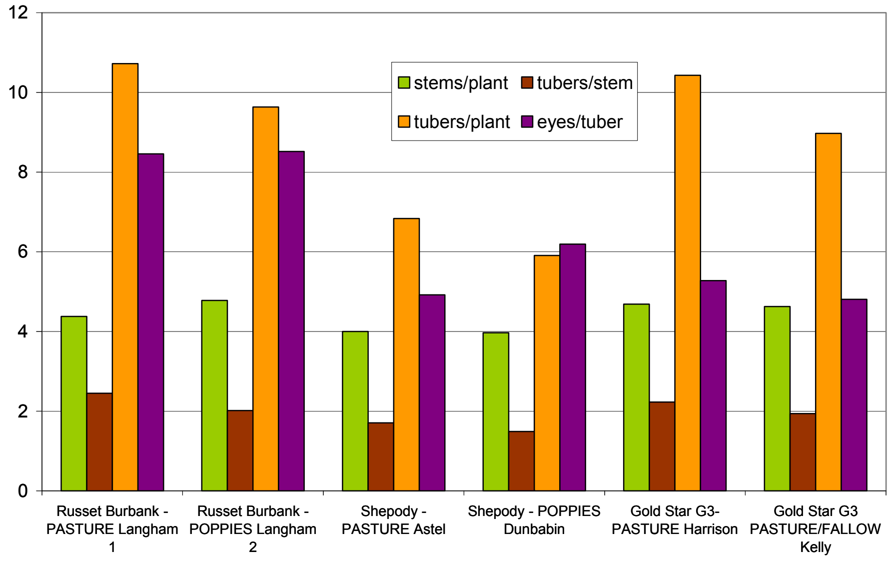
Graphs 44 and 45 show results from the yield assessment. Differences between varieties were more pronounced than differences between sites within a variety. Plants had an average of four stems for Shepody, and slightly above four for the other two varieties. They had around two tubers per stem for Russet Burbank and Gold Star and less for Shepody (Graph 45). There was no statistically significant relationship between stem and tuber numbers per plant. The slightly lower stem and tuber numbers per Shepody plant resulted in the lowest number of tubers per plant in that variety.

The lower tuber numbers led to larger tubers (weight/tuber, Graphs 45 and 46). However, the weight per plant was lower than that of the other varieties. Shepody had the lowest plant spacing (20 cm, compared to 33 cm for Russet Burbank and 25 cm for Gold Star), which brought the yield nearly up to the Russet Burbank level. In commercial crops where poor seed pieces due to machine cutting, disease or storage damage (CO_2), planter misses or poor planter calibration may occur, density may be the greatest factor influencing yield. This was also evident in the monitored seed crops.

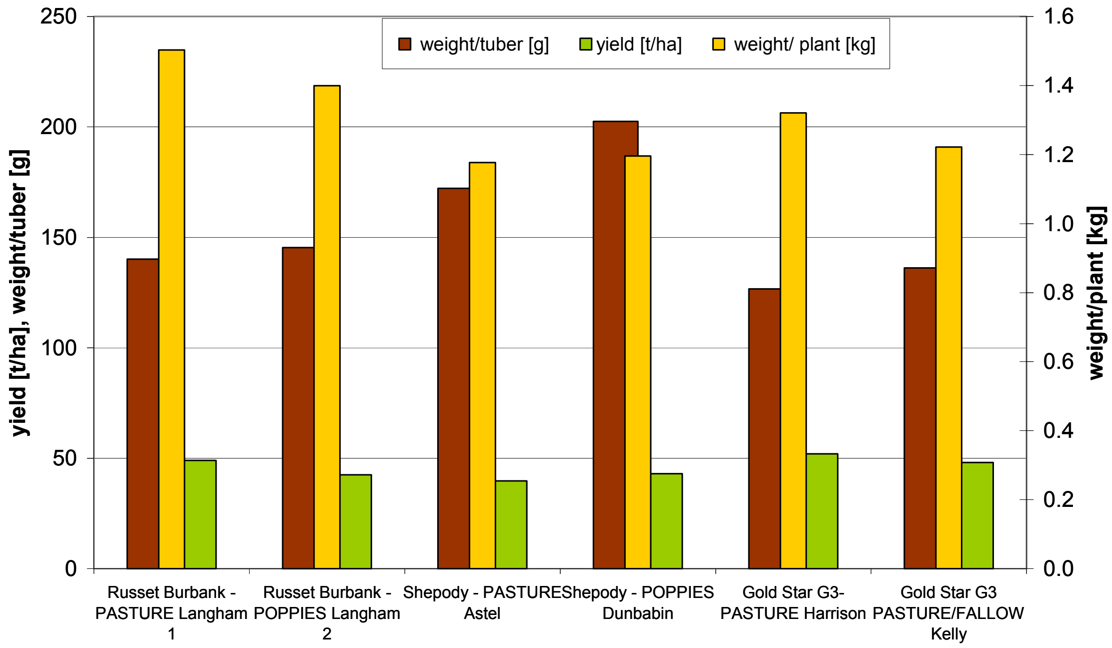
Russet Burbank had the highest number of eyes per tuber (Graph 45), even though average tuber weight (Graph 44) was lower than that for Shepody and about the same as for Gold Star. The only differences between seed source were that ex-pasture sites seemed to have produced a slightly higher stem number for all varieties and weight per plant for Russet Burbank and Gold Star. However, the counts and weight assessment did not produce statistically significant differences.

Graph 47 shows that plant height was positively related to tuber weight per plant over all varieties. As previously mentioned, plant height was correlated to internode numbers. The correlation between internode numbers and tuber weight per plant is r = 0.856. This means that the important factor in the plant height / tuber weight relationship is to have long shoots with lots of internodes rather than etiolated shoot, e.g. due to high N input only.

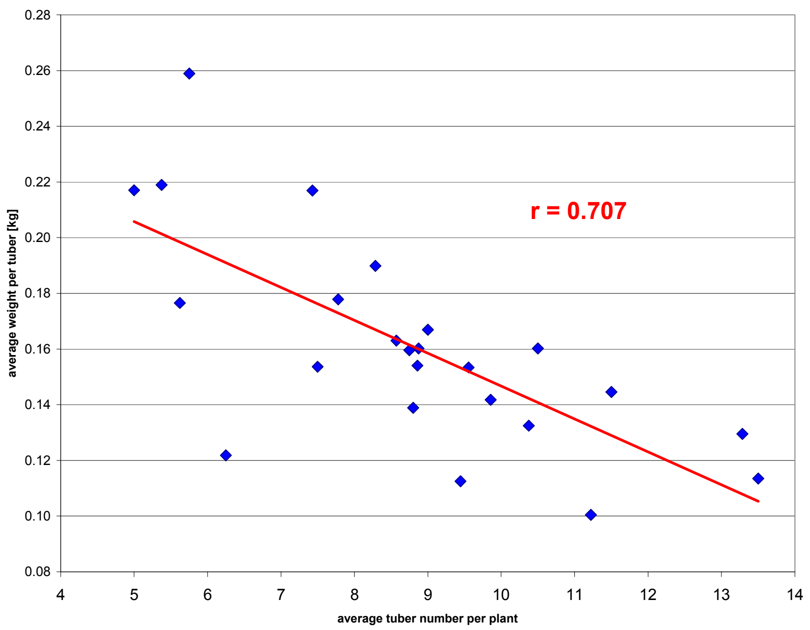
Graph 44 - Pre-harvest assessment counts for the commercial crop performance trial 2001/02, for three varieties of seed grown after different previous crops



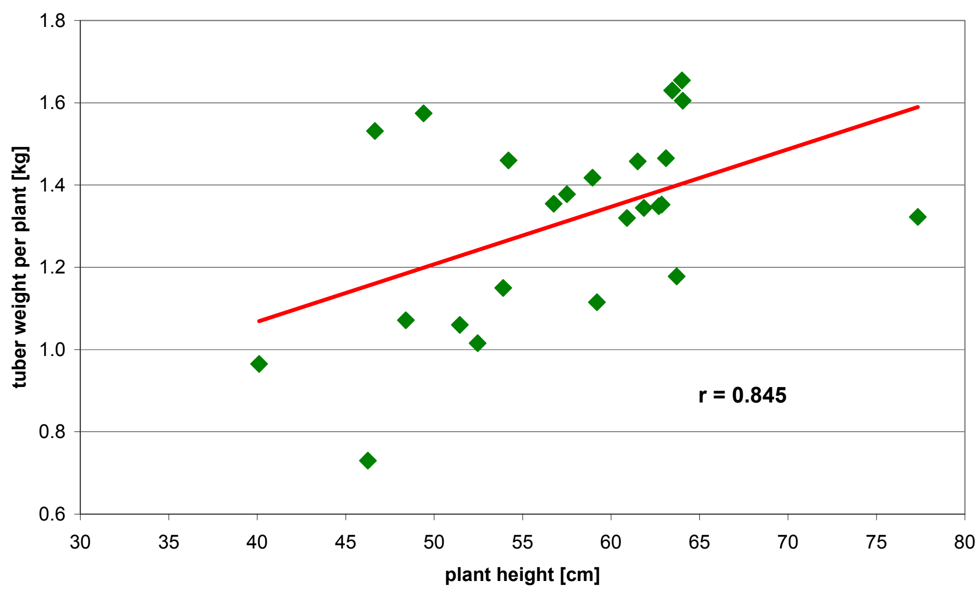
Graph 45 - Pre-harvest assessment weights for the commercial crop performance trial 2001/02, for three varieties of seed grown after different previous crops



Graph 46 - Relationship between average weight per tuber [kg] and average tuber number per plant over all varieties (four plots per seed line) in the commercial crop performance trial 2001/02



Graph 47 - Relationship between plant height [cm] and internode number over all varieties (four plots per seed line) in the commercial crop performance trial 2001/02



Seed crop monitoring

- The nature of a previous crop had an influence on nitrogen dynamics in a seed potato crop. This could be monitored by measuring available soil nitrogen (N-check) and nitrogen uptake into petiole sap (NU-test).
- NU-test also allowed monitoring of uptake and balance of other nutrients (e.g. P, K, Ca, Mg, Zn). These levels may be influenced by long-term paddock history and not only by the previous crop.
- Identical previous crops led to similar N release through mineralisation. Amounts and release patterns were not identical due to the impact the following factors:
  - *Amount of biomass incorporated (yield of previous crop, grazing/feeding off, etc.)*
  - *Timing of incorporation (aeration in relation to soil temperature)*
  - *Incorporation method (size of incorporated particles)*
  - *Soil type*
  - *Soil moisture during the season*
  - *Climate*
  - *Biological activity of soil*
  - *Fertiliser applications (amount, timing, type)*
- Each crop should be managed according to its own site-specific history and monitoring results (soil and plant tests) rather than following production recipes to optimise yield and quality.
- The data set (number of paddocks monitored per previous crop over three years) did not allow a statistical analysis of nitrogen and other factors in relation to pre-harvest assessments (stem, plant, tuber and eye numbers, tuber weights and yield).
- Seed crops were, at times, under or oversupplied with nitrogen. Monitoring of soil levels and adjustments of fertiliser applications according to a nitrogen budget should lead to a more balanced nitrogen supply during the season.
- A balanced nitrogen supply would assist in an improved nutrient balance. Other nutrients should be applied based on soil test results and crop removal figures. If the soil test result does not show any deficiencies, the amount of nutrients applied should match removal with harvest (and feeding off, if practised).

Crop nitrogen budgets

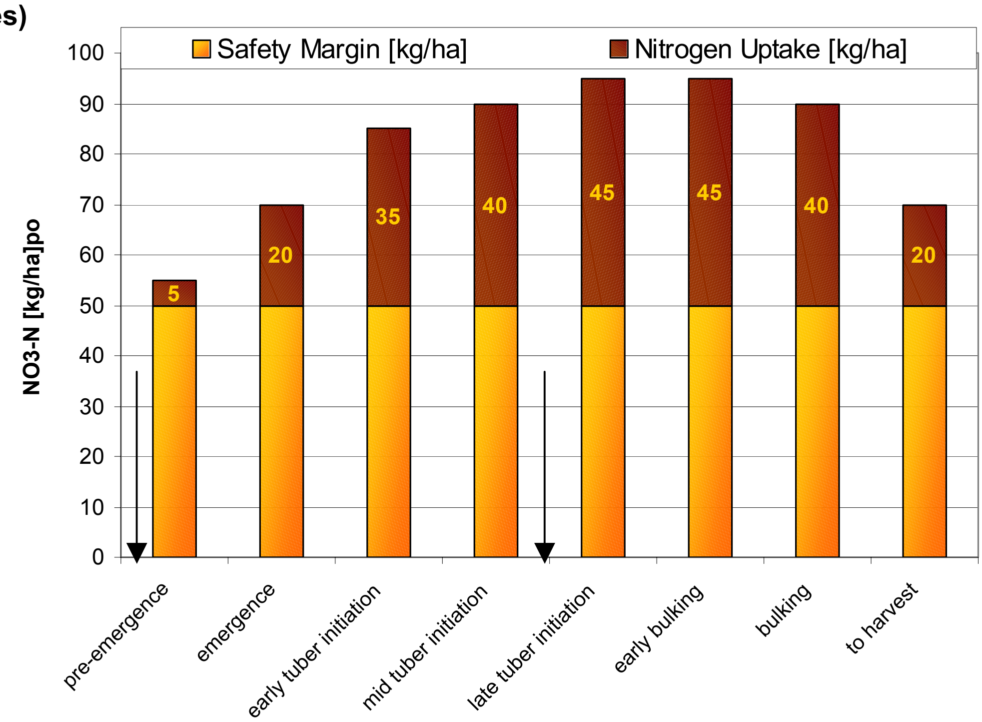
Graph 48 shows a draft nitrogen budget for seed potatoes. In the budget, all crop stages cover approximately a two-week period. The uptake figures are the N amount [kg/ha] that is taken up into the entire plant during that crop stage. In this budget, uptake totals 250 kg N/ha.

While the total nitrogen uptake into the plant (= the N content of the mature plant) represents a certain amount of nitrogen needed to produce its biomass, it does not, on its own, fully reflect the general nitrogen "needs" of the plant. For optimal growth, the plant requires additional nitrogen to be present in the soil, even though this nitrogen is normally not absorbed. This additional amount is called the safety margin [1]. The safety margin for seed potato crops is a constant 50 kg N/ha in the example in Graph 48.

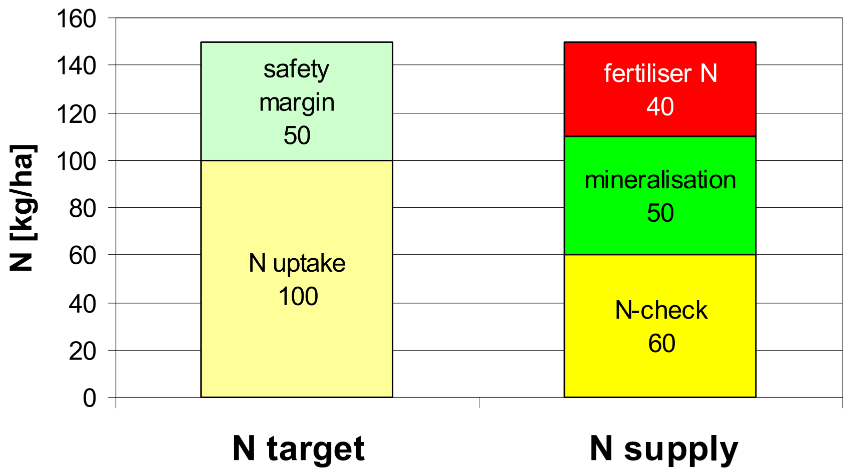
[1] Sometimes the term 'uptake efficiency' is used instead of 'safety margin'. If a crop takes up 200 kg N/ha into its biomass and the safety margin is 100 kg/ha, the uptake efficiency is 66%.

It may be somewhat lower late in the season, or higher during major growth periods. Further research would assist in finetuning the safety margin. The nitrogen uptake over a certain growing period,[1] plus the safety margin, represents the amount that should be made available to the crop (N target, Graph 49).

Graph 48 - Draft nitrogen budget for seed potatoes (arrows show suggested sampling times)



Graph 49 - Illustration of nitrogen target and nitrogen supply for a given time period (e.g. planting to sampling/top dressing prior to late tuber initiation)



[1] The growing period could be from planting to harvest, planting to top dressing, top dressing to top dressing or top dressing to harvest. Top dressing would be done at certain growth stages as listed in the N budget.

The N budget helps in setting N targets. The columns show fortnightly nitrogen uptake and the safety margin. Uptake figures are based on total nitrogen uptake over the life of the crop for a certain yield level and a growth curve. The yield also determines crop N removal and residual N (Table 9).

Table 9 - Biomass production, removal with harvest and crop residues and associated nitrogen contents

Biomass	Tonnes/ha	N [kg/ha]
Total production and N uptake	83	249
Removal at harvest (yield)	43	129
Crop residues and residual N	40	120

To calculate the N target for a certain time period, the uptake figures for the selected growing period are added up, and the safety margin value is added once (see example in Graph 49). If it is assumed that the safety margin may change over the selected time period, a mean safety margin value is added. The safety margin may be adjusted for specific growing conditions:

- If root volume is restricted (compaction, water logging, disease) and/or soil fertility is poor, the safety margin should be increased.
- If root penetration is good and soil is in good condition (good rotation and structure, disease free), the safety margin should be decreased.
- If substantial N losses due to leaching or N immobilisation are expected, the safety margin should be increased

The N target for the selected time period (Nitrogen uptake + safety margin) has to be matched by the nitrogen supply over the same period (Graph 49, N-check result + mineralisation estimate + fertiliser N). A guideline for estimating mineralisation from crop residues is listed in Table 10.

Under normal production conditions, in a temperate climate, an estimate of 5 kg N/ha per week can be used when accounting for mineralisation from organic matter. This level of mineralisation was determined after extensive studies under many conditions. As a rule of thumb, it is easily adaptable to growing seasons of different lengths. Mineralisation increases rapidly once soil temperature exceeds 12°C[1]. Under Australian dryland conditions, mineralisation rates are 1-2 kg/ha x week.[2]

Table 11 gives an example on how to use N-budgets and soil nitrogen testing (N-check) to determine fertiliser requirements. The example includes possible N input through irrigation. Irrigation at a rate of 20mm (=20 L/m^2) with water containing 50 mg/L NO_3, supplies the soil with the equivalent of 10 kg/ha of nitrate (= 2.2 kg N) per application (calculation: 20 L/m^2 x 50 mg/L x 10.000 m^2/ha x 1 kg / 1.000.000 mg). If irrigation is repeated 10 times throughout the season, the total input is 100 kg/ha of NO_3, of which 22.6 % (or in this case 22.6 kg) is N, an amount that warrants consideration in a nitrogen balance.

[1] Tremblay et al, 2001: Nitrogen management in field vegetables - a guide to efficient fertilisation. Agriculture and Agri-Food Canada, ISBN 0-662-30494-2
[2] John Angus, CSIRO Plant Industries, personal communication

Table 10 - Potential nitrogen mineralisation from crop residues

Crop	Fresh biomass normally incorporated after harvest (t/ha)	Potential nitrogen from mineralisation over a period of about 8-10 weeks (kg/ha)
Brussels sprout	50-60	150-200
Cabbage, red Cabbage, white (processing)	40-50	120-150
Broccoli, Cauliflower, Peas Cabbage, white & savoy (fresh)	30-40	90-120
Beans, Carrots, Celery, Lettuce	20-30	60-90
Leeks, Spinach	10-20	30-90
Lettuce, Radish, Poppies	<10	<30

Table 11 - N-balance - calculating fertiliser requirements using N-check and N budgets

FACTORS		UNIT	EXAMPLE
(1) Nitrogen uptake for selected growing period		kg/ha	70
(2) Safety margin (buffer)		kg/ha	90
equals			
(3) N target	0	kg/ha	160
subtract			
(4) mineralisation from organic matter		kg/ha	10
subtract			
(5) mineralisation from crop residues		kg/ha	40
subtract			
(6) N from irrigation water (if required)		kg/ha	10
subtract			
(7) **N-check** result		kg/ha	70
equals			
(8) Non fertiliser N available	0	kg/ha	130
deducted from N target equals			
(9) Fertiliser N requirement [kg/ha] (=(3)-(8))	0	kg/ha	30
(10) Fertiliser type			NH4-NO3
(11) % N in selected fertiliser type		%	34
(12) Fertiliser application of selected type		kg/ha	88.2

Commercial crop performance trial

The commercial performance trial provided some noteworthy results. However, it was not possible to clearly relate the effects of seed origin and N dynamics to trial results. This is mainly due to the small number of seed crops that could be monitored within the project budget. Agronomy and seed handling and storage factors had an influence on commercial crop performance. To eliminate these factors, they would have had to be monitored and controlled. A project set up to produce results for a statistical analysis needed to include at least 24 crops over three years.

It may have been worthwhile to monitor commercial crop performance in actual crops as well as in trials.

It may be worthwhile to further investigate some results from the trial, such as:

- Significance of tuber nutrient levels for subsequent crops;
- Desirable seed tuber nutrient levels after harvest and/or storage to be used as seed quality indicator in combination with tuber health and physiological age information;
- Relationship between ex-store tuber firmness, early root development and nutrient uptake.

Technology transfer

One of the project objectives was to facilitate technology transfer through involvement of company staff. Company field officers and their supervisors have to deal with a wide range of operational issues, which understandably distracted their attention from crop monitoring for the project at times. As a result, although the involved company staff agreed at the beginning of each season on the number of crops to sample and information to collect, and were given all required work instructions (field book), delivery was variable.

A second reason for involving company staff was to allow the gathering of relevant information on a relatively small budget. Field officers visit the seed crops regularly, and it was thought that they could take samples and record information during visits. Technical research staff would have had to travel to the sites at extra cost. The use of technical staff would have produced a more uniform data set. Site numbers and thus the budget, would have needed to be higher for results to be analysed statistically.

In spite of some of the difficulties in data collection, the project and a general focus on producing ‘better seed’ increased the use of crop monitoring in seed potato crops. A training session on real time crop monitoring was held in winter 2002. Nitrogen budgeting information published in this report will be made available to the industry participants in the form of an explanatory manual.

Acknowledgments

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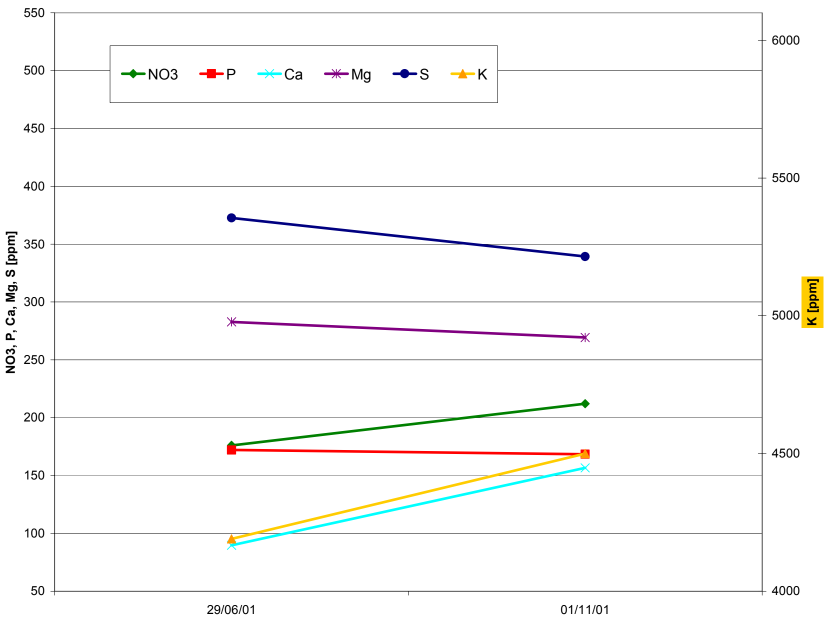
The replicated field trial was set up at the Forthside Vegetable Research Station, Department of Primary Industries, Water and Environment, Tasmania. The assistance of station staff in managing the trial site was much appreciated.

Dr Leigh Sparrow, Tasmanian Institute of Agricultural Research, assisted with planning of project activities.

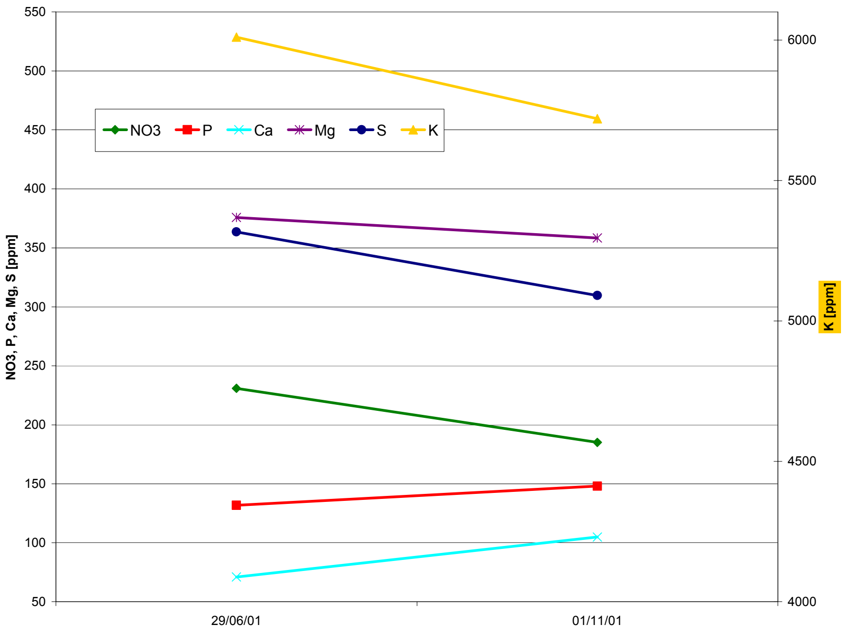
The following Serve-Ag staff contributed to this project: Sophie Wadley, Sarah Lamprey and Mary Trebilco, from Serve-Ag Research, and Judy Westbrook and Lisa Hurry, from Serve-Ag Analytical Services.

Appendix i - Tuber sap levels - commercial performance trial

Simplot - Langham 1

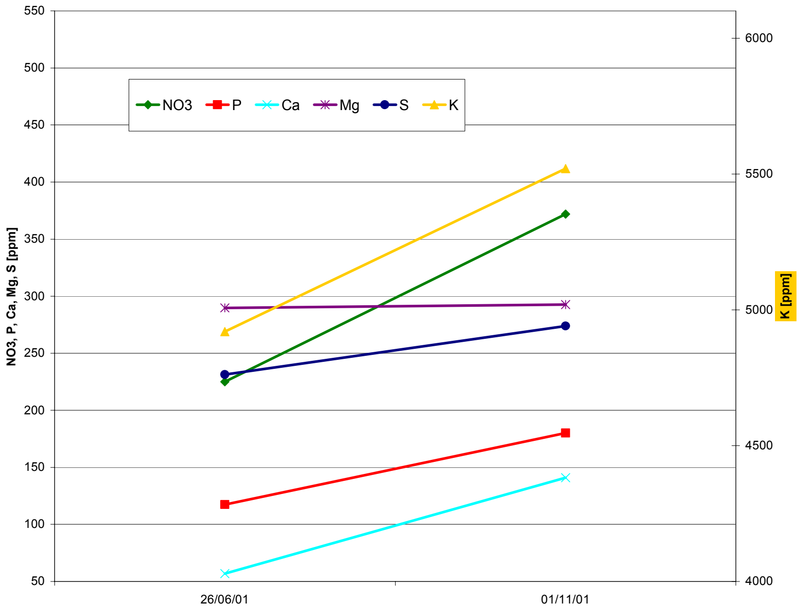


Simplot - Langham 2

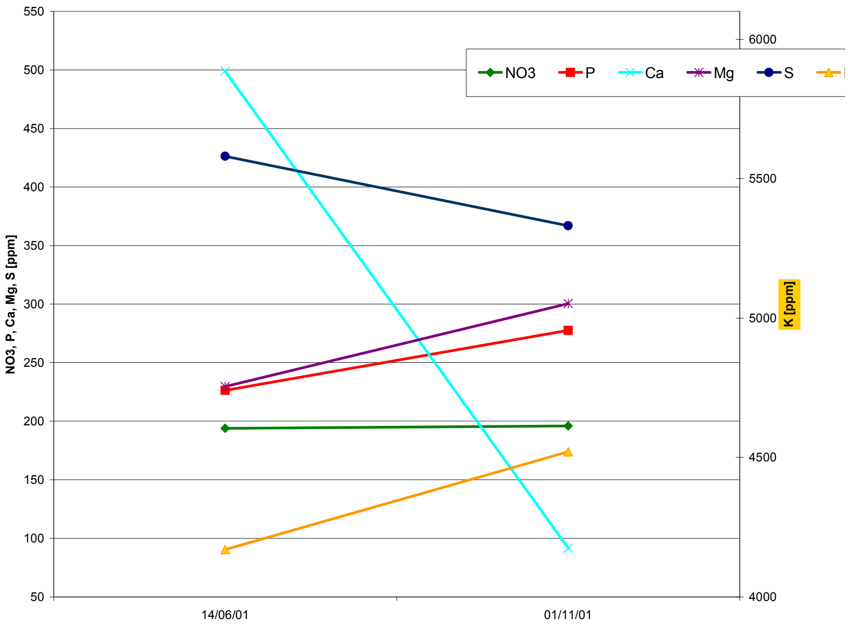


Appendix i - Tuber sap levels - commercial performance trial [cont.]

Harvest Moon - Kelly



McCain - Dunbabbin



Appendix ii - Wisedale paddock view