Developing guidelines for environmentally sustainable use of mineral fertilisers

Dennis Phillips
Department of Agriculture & Food Western Australia

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DEVELOPING GUIDELINES FOR ENVIRONMENTALLY SUSTAINABLE USE OF MINERAL FERTILISERS

Dennis Phillips, Aileen Reid, Gavin D'Adhemar and David Gatter
Department of Agriculture and Food, Western Australia (DAFWA)

HORTICULTURE AUSTRALIA PROJECT NO. VG07036

DEVELOPING GUIDELINES FOR ENVIRONMENTALLY SUSTAINABLE USE OF MINERAL FERTILISERS

The purpose of this report is to communicate the findings of Project VG07036 which investigated practical ways in which a range of leafy vegetable crops could be grown using more efficient means of applying fertiliser in order to reduce fertiliser leaching into the groundwater.

Project Leader: Dennis Phillips, Senior Development Officer
Department of Agriculture and Food, Western Australia
Locked Bag 4, Bentley Delivery Centre WA 6983
Phone: (08) 9368 3319 Fax: (08) 9368 2958
Email: dennis.phillips@agric.wa.gov.au

Researcher: Aileen Reid, Development Officer,
Department of Agriculture and Food, Western Australia
Locked Bag 4, Bentley Delivery Centre, WA 6983
Phone: (08) 9368 3393 Fax: (08) 9368 2958
Email: aileen.reid@agric.wa.gov.au

Technical Officers: Gavin D'Adhemar, Technical Officer
Department of Agriculture and Food, Western Australia
60 Abercrombie Road, Medina, WA 6167
Phone: (08) 9419 2908 Fax: (08) 9419 2589
Email: gavin.dadhemar@agric.wa.gov.au

David Gatter, Technical Officer
Department of Agriculture and Food, Western Australia
Locked Bag 4, Bentley Delivery Centre, WA 6983
Phone: (08) 9419 2908 Fax: (08) 9419 2589
Email: david.gatter@agric.wa.gov.au

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MEDIA SUMMARY

Vegetable production on sandy soils is under ongoing scrutiny by environmental regulators as a major contributor to nitrate pollution of groundwater. Project VG07036 'Developing guidelines for environmentally sustainable use of mineral fertilisers' has shown that the 3Phase method for fertilising leafy vegetable crops is able to reduce leaching of nitrate to levels well below the current industry average, especially where those crops have a significant proportion of their nutrition supplied upfront, either in the form of animal manures or mineral fertiliser. The average nitrate leaching fraction we achieved in our trials with broccoli, cabbage, celery and iceberg lettuce was in the range of 0.3-0.55 compared to levels frequently around 1.0 or higher among growers on the sandy soils of the Swan Coastal Plain. This represents a true, positive benefit to the environment from the 3Phase method. Rain causes most leaching over winter months while in summer, leaching can be minimised by timing nitrogen application to match crop growth and good irrigation scheduling practice.

The 3Phase method for sandy soils sets benchmark rates of nitrogen, phosphorus and potassium for crops according to growth stage and includes advice on placement, products and low-cost application methods. This project has now refined the 3Phase technique making it even simpler to adopt. A light dressing of granular NPK fertiliser at planting is now fundamental to all crop programs. This is followed by the option of spraying a mixture of potassium nitrate and urea OR broadcasting granular NPK fertiliser, once or twice a week in the early establishment stage of crop growth (Phase 1). Banding of granular NPK fertiliser comprises Phase 2 until row closure and Phase 3 (which may or may not be needed depending on the crop and time of year) consists of fertigation, often with urea only or perhaps with potassium nitrate added, again depending on the crop.

A survey of growers showed that several have now embraced elements of the 3Phase technique as a means of reducing costs, improving crop quality and minimising their impact on the groundwater.

TECHNICAL SUMMARY

This project built on the research completed in VG04018 'Enhancing fertiliser efficiency for transplanted vegetables'. The fertiliser program developed in that project set benchmark rates of nitrogen, phosphorus and potassium for crops according to growth stage and included advice on placement, products and low-cost application methods.

At the conclusion of that research work there was a need to improve on fertiliser programs for some of the slower growing crops such as cabbage and celery. Additional trials to fine-tune blueprints for lettuce and broccoli were also identified as a necessity prior to producing an all-year-round production schedule for those crops. In addition, slow uptake of the technique by growers showed a need for one-on-one support to growers to assist change. On-farm demonstrations tailoring the technique to individual situations was thought to be one way to facilitate this process.

At an early stage the fertiliser program was rebadged as 3Phase for easy recognition by growers. Phase 1 being the establishment phase, lasting two weeks in summer and three to five weeks in winter depending on crop. Phase 2 is the rapid growth phase leading up to row closure and Phase 3, maturation, until harvest.

The research station program comprised a series of trials, each using an entire sprinkler bay (100 m x 12 m). Crops of broccoli, cabbage, celery and lettuce were grown in a sequential rotation using commercial row-crop layouts enabling mechanised fertiliser spreading and spraying where appropriate. Early trials used seedling drenches where they had been found beneficial but due to the logistical problems of this process for many growers it was dropped. Instead a low rate of granular NPK fertiliser (200 kg/ha) broadcast at planting time was trialled, proved beneficial and is now a general recommendation.

In an effort to provide alternatives for use in Phase 1 that might facilitate industry adoption several option were trialled. These included a weekly spray application of urea (20 g/L) and potassium nitrate (also 20 g/L) at twice the rate (2000 L/ha) instead of twice-weekly at 1000 L/ha. The rate of each of these fertilisers was also simplified to '20 plus 20' as opposed to the previous '22.5 plus 20'.

For those growers who preferred not to spray we provided the option of using granular NPK fertiliser, broadcast to give comparable rates of nitrogen on a weekly basis. Again, as a weekly or twice-weekly alternative. At rainy times of the year this proved a better option in many cases.

Fertiliser recommendations in Phase 2 remain, for the most part, banding of granular NPK fertiliser. This series of trials evaluated lower rates of banding (300 or 400 kg/ha instead of 500 kg/ha) for some crops and briefly explored omitting this phase altogether and going straight to Phase 3 for some crops.

Efforts to reduce costs by using cheaper alternatives to Nitrophoska Blue Special® such as Turf Special® or Hort Special® were largely unsuccessful.

One advantage for growers in using a granular NPK fertiliser in Phases 1 and 2 is that moderate rates of phosphorus, potassium and trace elements are applied at the same time and for most of our trials this enabled us to omit the base dressings of superphosphate, K-Mag® and trace elements that we used routinely in the previous project— a saving in fertiliser costs and labour. Periodic soil testing is still encouraged to assist in checking levels of essential nutrients and for specific crops, additional pre-plant and side dressings of magnesium or manganese may still be advised.

Phase 3 has now been fine-tuned for all crops. The need for potassium as well as nitrogen during that stage is now thought to be superfluous and urea appears a suitable source of nitrogen even over the winter months. We assume that the use of granular NPK during the first two phases provides an ample background supply of potassium to carry the crops through to maturity.

The first stage of the on-farm demonstration program comprised spray trials on grower properties using plots within their existing crops. The spray trials evaluated rates and sources of nitrogen applied at various times after transplanting. This is an important step to gain grower confidence in using these treatments, particularly for growers of gourmet lettuce and other leafy salad vegetables as those crops can not sustain any degree of visible damage on almost any leaves at any stage of growth. Two of those growers have now adopted most elements of the 3Phase method for their crops. Another grower who decided to trial our sprays on a large scale before we believed he was thoroughly conversant with the technique, experienced problems with burning and dropped out of the program.

Ongoing work with a number of growers as part of another HAL project has also seen elements of the program adopted by several. A small survey of participating and non participating growers and field day attendees helped clarify the reasons for adoption or not of the 3Phase method and so enable us to better target research and development in the future.

1. GENERAL INTRODUCTION

The irrigation and nutrition practices of vegetable growers are continuing to be scrutinised by environmental regulators in all states of Australia as sources of nitrate contamination of groundwater. This is particularly so in relation to the effects that excessive fertiliser applications have on water quality where groundwater is used for public water supply as well as irrigation.

Protection of the environment is also an important issue for consumers of vegetables in Australia and overseas. These concerns are being addressed by major retailers with the introduction of quality and environmental assurance schemes for their grower suppliers. To be credible, these schemes will need to be audited and both auditors and growers will need fertiliser practice targets with which to work.

Two previous projects (VG99014 and VG04018) investigated techniques to reduce mineral fertiliser rates and cost for transplanted leafy and Brassica vegetables. The programs developed as part of those two projects showed it is possible to grow high quality crops without using poultry manure. Replicated trials extended our methodology to include broccoli, cauliflower, cabbage, celery, Cos lettuce and Chinese cabbage and alternative sources of nitrogen to ammonium nitrate were identified.

The results from these projects indicate that groundwater pollution from vegetable growing on sandy soils can be significantly reduced if these methods are widely adopted. However, at the end of the second project it was recognised that was room for further improvement. Leaching data showed that certain times of the year were problematic. Peaks in nitrate leaching still existed during the banding phase. It had also not been possible to cover all times of the year for the range of crops trialled. We aimed to fill in the gaps in the research phase of this project as detailed in the first part of this report.

In addition to those research elements, we recognised that adoption of the new fertiliser blueprints required significant change in work practices and scheduling of operations, and growers would need on-farm help to customise the program for their own circumstances. This comprises the second part of this project and is detailed from Chapter 8.

The program has been rebadged for easy recognition by growers as the ‘3Phase’ method and is referred to as such in the report.

General methods

The method used to test these fertiliser strategies established a series of field trials on virgin field sites at the Department of Agriculture's Medina Research Station. The trials compared methods and types of fertiliser application over a range of leafy vegetable crops at different times of the year. All trials had four replicates and either 10 or 12 individual treatments.

Medina Research Station is located on the Swan Coastal Plain south of Perth, Western Australia (32º South latitude). Medina offered the advantages that it was located in a vegetable producing district in Western Australia, inputs to production could be carefully controlled and the work could be done on some of the least fertile sandy soils in Australia, with no previous vegetable cropping history, using irrigation water virtually free of fertiliser contamination.

The assumption in these trials was that fertiliser levels required to give high yields in this situation would be a 'worst case' scenario that growers on better soils in other parts of Australia should not have to exceed to get good results.

All field trials were 'row crop' layouts, typical of commercial production, enabling mechanised fertiliser spreading and spraying where appropriate. All crops were sprinkler irrigated using fixed sprinklers at 12 m spacings. Trial layouts and treatment combinations were constrained by the need to maintain uniform 'bay histories' for future trial work. Thus, the minimum unit size for a trial was one 'sprinkler bay' 12 m wide and 100 m long. Within each bay the standard plot width was a tractor wheel spacing of 1.5 m ('a bed'). Six beds fitted across a bay, and the outside two beds were always planted as a 'buffer' around the reps in that bed. Row spacings for the crops tested ranged from three per bed for broccoli to four per bed for lettuce.

Sprays and drenches (Phase 1)

Early trials used a standard seedling drench treatment derived from past research with lettuce, this being 40 g/L of potassium nitrate at a rate of approximately 500 mL of solution per 100 seedlings. This was dropped in later trials due to the resistance of many grower to adopting the process.

The basic spray treatment was 20 g/L potassium nitrate plus 20 g/L urea applied at 1000 L/ha on a twice-weekly basis. Over the course of the trial program, variations were trialled including a double rate spray (i.e. 2000 L/ha) once a week. The alternative was a light rate of granular NPK fertiliser applied once (200 g/ha) or twice a week (100 kg/ha). In most cases this was Nitrophoska Blue Special® but in some trials, in an effort to reduce costs this was changed to Hort Special®, Turf Special® or di-ammonium phosphate (DAP).

Topdressing (Phase 2)

Past research showed that sufficient root system was established by 14–28 days (depending on crop and time of year) after transplanting, allowing a response to granular fertiliser applications banded between pairs of rows. Both potassium and nitrogen leach readily on these poor sandy soils, and both need to be topdressed frequently to ensure steady growth. A guiding principle behind this work was that fertiliser practices tested and developed should minimise labour cost for application, because time is money. All Phase 2 fertiliser strategies we tested required no fertiliser mixing before application, to save labour time and make machinery calibration simpler. Hence, each topdressing was a single product. We used mostly Nitrophoska Blue Special® containing 12N:5P:14K and trace elements. This cost more than some alternatives, but offers the convenience of a single product, allowing banding equipment calibration to be 'set and forget' as well as applying phosphorus regularly where it was expected to leach.

Variations to the strategy outlined were applied as the project evolved. In some later trials, in an effort to reduce costs, Hort Special® or Turf Special® were trialled as an alternative to Nitrophoska Blue Special®.

Simulated fertigation (Phase 3) for banding – in most cases

Some crops do not require fertiliser applications beyond row closure, especially in the warmer months of the year. For those that do, however, we use a simulated fertigation technique which involves spraying the individual plots in the same manner as for Phase 1 but this time the spray application is washed off immediately after to avoid burning.

Site preparation and general management

The sites for each trial were rotary hoed prior to transplanting. Fumigation was not routinely carried out prior to each crop (see trial specific methods), but when used , consisted of metham sodium at 500 L/ha, 14 days prior to planting, and aeration by hoeing 7 days later. For information on the base dressings used, refer to the trial specific methods.

Beds were formed at 1.5 m centres, levelled and pre-marked immediately before transplanting.

Irrigation immediately after transplanting was standard at 6 mm but the rest of the schedule was crop specific.

Weather records, including evaporation data, for Medina research station are included in Appendix 1.

Pest, disease and weed control

Post emergence herbicides were used specific to each crop for weed control, applied immediately after planting and watered in.

Pest and disease control strategies were based on resistance management strategies for each crop, where applicable, and pesticides used were chosen from those registered for each crop.

2. BROCCOLI

Winter 2006

Introduction

Broccoli is widely grown from 'tray-grown' seedlings produced by specialist nurseries in Australia. In Western Australia it is almost exclusively grown this way commercially year-round on sandy soils of the Swan Coastal Plain, up to 200 km north and south of Perth. Broccoli is also grown on sandy loam soils in summer in the lower south west of the State in districts such as Manjimup.

The crop is often rotated with other leafy vegetables such as lettuce and celery. Traditional nutrition practice is broadcasting poultry manure before planting and/or banding between rows after planting. Mineral fertilisers are also routinely applied as topdressings and fertigation is widely used.

The potential benefits of the '3Phase' technique are reduced leaching of fertiliser into groundwater from lower fertiliser applications and better placement than achieved by current commercial practices. This is particularly so, soon after transplanting when the plant has a poorly developed root system and low fertiliser demand.

In Horticulture Australia Project VG04018, broccoli was planted in mid-March and subjected to one of five spray treatments (S1 to S5) commencing one day after planting. The treatments consisted of twice-weekly applications of a range of the following spray treatments for a total of three weeks (six applications in total):

S1 No spray

S4 11.3 kg/ha urea (U) plus 40 kg/ha potassium nitrate (63.3 kg/ha nitrogen, 92 kg potassium in total)

S5 22.5 kg/ha urea plus 20 kg/ha potassium nitrate (78.4 kg/ha nitrogen, 46 kg potassium in total).

This was followed by a series of one of four topdressing treatments as detailed in Table 2.1. The prilled or granular fertilisers were banded into a shallow furrow between pairs of broccoli rows and Spurt-N® was simulation fertigated, commencing 16 days after transplanting and ending at row closure. Treatments were as follows:

B1 Prilled potassium nitrate (KN) 400 kg/ha at day 16 followed by prilled ammonium nitrate (AN) 200 kg/ha – 68N

B2 Nitrophoska Blue Special® 550 kg/ha – 66N

B3 Prilled potassium nitrate (KN) 400 kg/ha at day 16 followed by prilled urea (low biuret) 150 kg/ha – 69N

B4 Prilled potassium nitrate (KN) 400 kg/ha at day 16 followed by Spurt-N® 200 kg/ha – 64N.

Table 2.1 **Topdressing treatments (B1–B4) applied to broccoli (kg/ha)**

Banding treatment	**B1**		**B2**	**B3**		**B4**	
Day no.	**KN**	**High AN**	**Nitrophoska Blue®**	**KN**	**U**	**KN**	**Spurt-N®**
16	400		550	400		400	
22		200	550		150		200
30		200	550		150		200
35		200	550		150		200
44		200	550		150		200
49		200	550		150		200

These trials showed no advantage from a pre-plant seedling drench. S4 and S5 both produced yields approximately threefold that of S1. There were no yield differences between any of the four topdressing fertilisers, however the cost of Nitrophoska Blue Special® was up to $1200 more than some of the other better yielding treatments. Potassium deficiency symptoms near harvest indicated that additional strategies were needed to overcome that problem as well as investigate whether further yield increases might be possible by applying nitrogen fertiliser after row closure.

With those outcomes in mind the next trial was designed.

Method

The site used for this trial was new with no immediate fertiliser history so a comprehensive base dressing regime was required. Poultry manure was applied at and incorporated into all four replicates of the control treatment (treatment 1) a week prior to planting at 70 m^3/ha. All plots of the other nine treatments received a broadcast application of 2500 kg/ha of double superphosphate, 150 kg/ha of Hi-Trace® and 200 kg/ha K-Mag®.

Seedlings (cultivar ‘Endurance’) for the trial were bought in from a specialist nursery and planted on 31 August 2006. The seedling trays were drenched with 40 g/L potassium nitrate at 500 mL/tray (100 cells) within one hour of planting with the exception of treatment 1, the grower control.

Seedlings were planted by hand in the field at three rows per bed with 450 mm between rows and 300 mm between plants (66,666 plants/hectare). There were 36 plants in each plot. Each trial plot was equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting, Dacthal® was applied by boom-spray for weed control at 6 kg/ha and this was followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Table 2.2. outlines the fertiliser treatments applied.

Table 2.2 **Schedule of treatments applied to August planting of broccoli. Row closure was between days 35 and 42. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat ment	Pre-plant	Day no.															
		0	3	7	10	14	17	21	24	28	31	35#	42	49	56	96 Harvest	Total N
1	PM (70 m^3/ha)			46.8		57.0		PM (15 m^3/ha)		57		38.4	38.4	38.4	38.4		314.4 (plus CM)
2	Seedling drench			65.6		65.6		65.6		65.6							262.4
3	Seedling drench	S1	S1	S1	S1	65.6		65.6		65.6							314.4
4	Seedling drench	S1	S1	S1	S1	S1	S1	65.6		65.6		65.6					274.8
5	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	65.6		65.6					235.2
6	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	65.6					195.6
7	Seedling drench	S1	S1	S1	S1	49.2		49.2		49.2		28.7	28.7	28.7	28.7		314.4
8	Seedling drench	S1	S1	S1	S1	S1	S1	37.4		37.4		30.5	30.5	30.5	30.5		274.8
9	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	32.8		24.6	24.6	24.6	24.6		235.2
10	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	16.4	16.4	16.4	16.4		195.6

Note: In the weeks of changeover from spraying to banding, the final spray was applied on Tuesday and banding commenced on Thursday of the same week.

S1 = 22.5 g/L low biuret urea plus 20 g/L potassium nitrate in 1000 L/ha water sprayed without wash off

(yellow) = Nitrophoska Blue Special®(12-5.2-14) banded at the nitrogen rate shown

(light green) = Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen per hectare shown)

PM = Untreated Poultry manure

(green) = Lysimeter buried under this treatment

Results

Treatment 1, the grower control, grew better than all other treatments throughout the life of the crop. Leaf area was greater and by harvest it was the only treatment not showing signs of a foliar deficiency (see Figure 2.1).

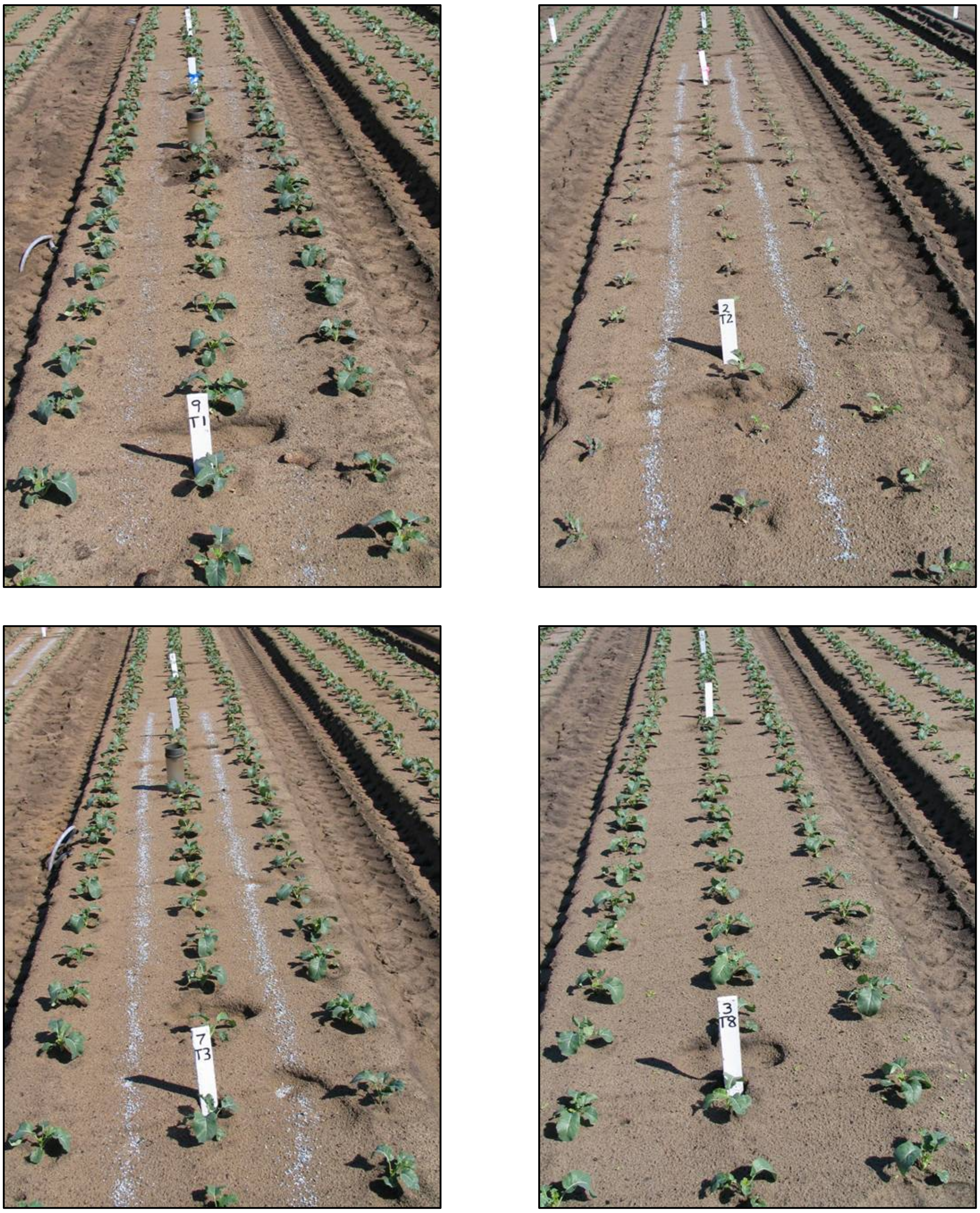

Figure 2.1 **Comparison of treatment effects in broccoli crop 21 days after transplanting, clockwise from top left T1, T2, T3 and T8**

The crop was harvested over three days (3, 6 and 8 November, days 64–69 after transplanting). The aim was to maximise the number of heads meeting export size parameters at each date of harvest. The optimum head size was considered to be around 300 grams. This harvesting method resulted in lower yields than if the optimum head size was set larger than 300 grams.

The final harvest (57 per cent of the crop) consisted largely of treatment 2.

The heads were light for their size which was felt to be a trait of the particular variety. So, while the heads were picked according to the expected size of a 300 g head, they were actually much lighter.

When the data were analysed over all harvests, mean head size was significantly greater for treatment 1, the grower control (225.6 g). Treatments 3, 4 and 7 all had lighter heads but not significantly different from each other. However, when total plot weight was analysed, treatments 1 and 3 came out as significantly better than all others (Figure 2.2).

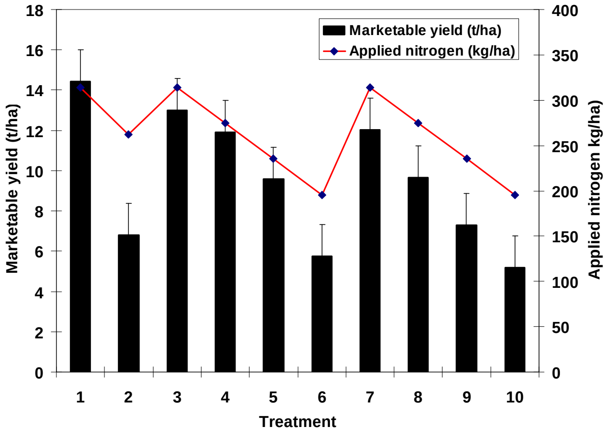

Figure 2.2 **Marketable yield (t/ha) for a spring broccoli crop subjected to a range of fertiliser treatments**

The data were also analysed for the first harvest only (41 per cent of the crop). There was no significant difference for any of the treatments when total head weight per plot was analysed but there was a highly significant difference between treatments for mean head weight size (see Figure 2.3). T1, T3 and T7 were the best treatments, each with a mean head weight above 200 g.

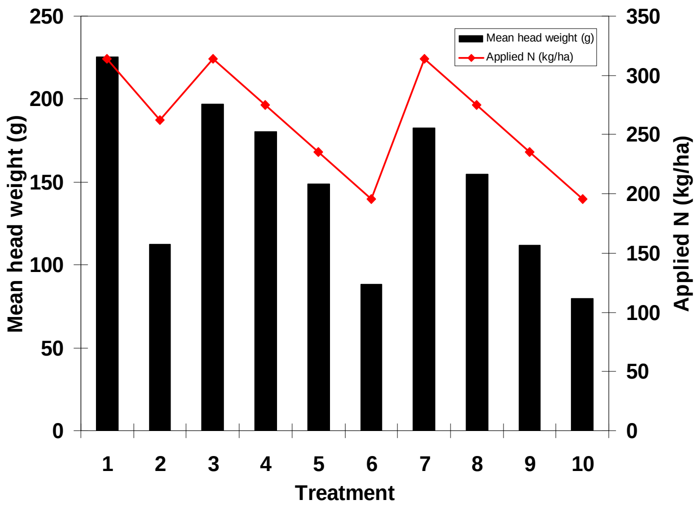

Figure 2.3 **Mean head size for first harvest only of a spring broccoli crop subjected to 10 fertiliser treatments**

When yield was plotted against applied nitrogen there was a highly significant linear relationship (r = 80.1). Comparing treatments with the same amount of total applied nitrogen, there appeared to be a consistent, though not significant, benefit from applying a higher proportion of nitrogen prior to row closure. This implies there is no benefit to applying nitrogen in Phase 3. That benefit appears greater when spraying is extended. For example, for the total harvest, with only two weeks of spraying as in T3 and T7, the yield difference was only 14.4 g/head. With three weeks of spraying the difference was 25.7 g and with four weeks of spraying the difference was 37.2 g. A comparable effect existed for the yield data.

The first harvest data alone showed a similar pattern for mean head weight. In this case the differences were 2.2, 8.5 g and 41.5 g respectively. A consistent pattern for total weight was non-existent at this stage. Towards the end of the trial, many treatments displayed a purpling on the leaves which was believed to be nitrogen deficiency (Figure 2.4). This does not necessarily depress yield as the nitrogen is pulled out of the leaves into the developing inflorescence.

Figure 2.4 **Nitrogen deficiency symptoms as evidenced by purpling on leaves, was evident in some treatments towards the end of the trial. T1 (upper left) had almost no symptoms but T10 (top right) was severe and T7 (bottom) intermediate.**

Leaching data

Figure 2.5 shows nitrogen leaching on a weekly basis (lysimeters were pumped every Wednesday) and rainfall (also collated on a weekly basis). Treatment 1, the grower control which used conditioned manure, leached much more nitrogen compared than other treatments.

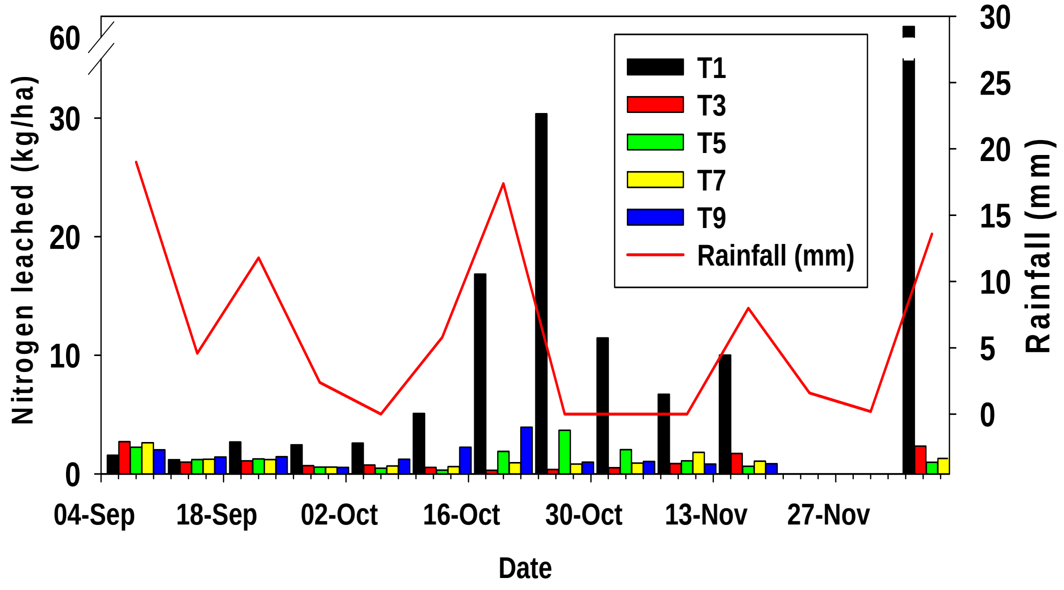

Figure 2.5 **Nitrogen leaching and weekly rainfall during the trial**

Analysis of the lysimeter data showed that 156 kg/ha was leached from the grower control whereas only 21-33 kg/ha was leached from the treatments using only mineral fertiliser.

Conclusion

When these results are put into context, total yield is probably the most important outcome to consider as growers are paid by weight. Both the grower control and treatment 3 yielded significantly more than the other treatments, with T4 and T 7 close behind. This trial has proven that a spring broccoli crop can be grown successfully without poultry manure using 314 kg/ha of nitrogen. The savings in terms of nitrate leaching are substantial.

At this time of year, no fertiliser applications after row closure appeared necessary. The extension of Phase 1 sprays as a way of reducing fertiliser rates was unsuccessful.

February 2007

Introduction

This trial tried to further refine fertiliser rates. Many of the rates in the previous trial were inadequate so the range of nitrogen rates was increased slightly to 250–350 kg/ha. Apart from that, the treatment regime was largely similar.

Method

This crop was preceded by a Cos lettuce crop which had been harvested on 19 January 2007. Therefore the base dressing was amended to allow for the fact that some residual phosphorus would have been present. Poultry manure was applied at and incorporated into all treatment 1 plots a week prior to planting at 70 m^3/ha. The remaining treatment plots received 2500 kg/ha of double superphosphate and 200 kg/ha K-Mag broadcast and incorporated just prior to planting.

Seedlings (cultivar ‘Atomic’) for the trial were bought in from a specialist nursery and planted on 14 February 2007. The seedling trays were drenched with 40 g/L potassium nitrate at 500 mL/tray (100 cells) within one hour of planting except for treatment 1, the grower control.

Seedlings were planted by hand in the field at three rows per bed with 450 mm between rows and 350 mm between plants (57,140 per hectare). There were 30 plants in total per plot. Each trial plot was equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting, Dacthal® was applied by boom-spray for weed control at 6 kg/ha and this was followed with 6 mm irrigation. Irrigation was as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Table 2.3 outlines the fertiliser treatments applied.

Table 2.3 **Schedule of treatments applied to February planting of broccoli. Row closure was between days 28 and 35. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	Pre-plant	Day number												
		0	3	7	10	14	17	21	28	35	42	49	Harvest	Total N
1	CM			50		50		50	50	50	50	50		350
2	Seedling drench					66		66	66					198
3	Seedling drench	S1	S1	S1	S1	66		66	66					250
4	Seedling drench	S1	S1	S1	S1	40		50	66	70	74			352
5	Seedling drench	S1	S1	S1	S1			50	66	84	100			352
6	Seedling drench	S1	S1	S1	S1	50		50	50	50	50	50		352
7	Seedling drench	S1	S1	S1	S1	S1	S1	50	50	50	50	50		328
8	Seedling drench	S1	S1	S1	S1	S1	S1	40	40	50	55	65		328
9	Seedling drench	S2		S2		66		66	66					250
10	Seedling drench	S2		S2		66		66	66	33	33	33		349

S1 = 22.5 kg/ha low biuret urea plus 20 kg/ha potassium nitrate (12.8 kg/ha N per application) in 1000 L water sprayed without wash off.

S2 =45 kg/ha low biuret urea plus 40 kg/ha potassium nitrate (12.8 kg/ha N per application) in 1000 L water sprayed without wash off

= Nitrophoska Blue Special® (12-5.2-14) banded between the outer pairs of rows (rate of nitrogen per hectare shown)

= Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen per hectare shown)

= Urea sprayed and watered in at the N rate shown

= Conditioned (partially composted) poultry manure (CM) broadcast at 70 cubic metres per hectare

= Lysimeters buried under these treatments.

Results

Figure 2.6 **Comparison of treatment effects in a summer broccoli crop 21 days after transplanting: T1 (top left)—the grower control, which received conditioned manure and T2 (top right) (no sprayed fertiliser in the first 14 days) were both well behind T4 (bottom left) and T8 (bottom right). These both received sprayed fertiliser in the first 14 days.**

The broccoli crop grew well from the outset. No signs of any deficiency were evident at any time. Until heading, visible differences were slight with the exception of T2 which was discernibly behind. At harvest time, however, it was apparent that both T1 and T2 were significantly behind the other treatments. This was in contrast to the first broccoli crop where T1 outperformed all other treatments in foliage growth and later equalled several other treatments in head size and yield. The difference was that T1 in the August 2006 broccoli trial was grown with a total 85 m^3/ha of untreated poultry manure whereas this crop was grown on the residue of a 25 m^3/ha application of conditioned manure prior to the previous Cos lettuce crop and a 70 m^3/ha pre planting application to this crop. From the initial growth of these crops it was apparent that the conditioned manure was substantially lower in nitrogen than the fresh chicken manure. This was verified by the nitrate levels taken from the lysimeters. Neither application of conditioned manure caused the increased level of nitrate leaching seen after the fresh chicken manure application.

The trial was harvested over four days on 11, 13, 16 and 18 April (56-63 days). Thirty-seven per cent was harvested on the first day and 83 per cent by the end of the second day. T4 was the most advanced on 11 April followed by T7. Roughly equal amounts of T3, T6 and T8 were harvested on both days while for T5, T9 and T10, more was harvested on the second day. Both T1 and T2 lagged considerably behind the other treatments with nearly all of them being harvested on 16 and 18 April, whereas none of the other treatments was harvested on either of those dates.

Figure 2.7 shows the yields at the end of the first two harvest dates. Analysis of variance using Genstat showed there was a highly significant difference between treatments. T4, T5, T6, T7 and T8 yielded significantly more than the remaining treatments and were not significantly different to each other.

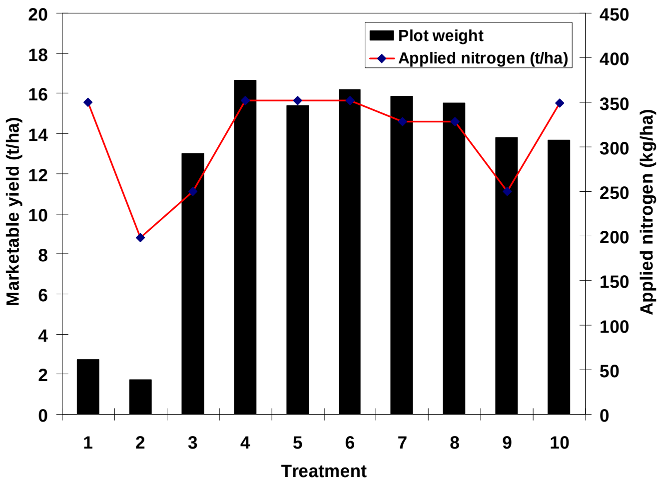

Figure 2.7 **Marketable yield of a broccoli crop planted in February and subjected to a range of fertiliser treatments**

The correlation between applied nitrogen and yield was not as clear. While a good rate of nitrogen was applied to T1 throughout the crop life it appears as though the lack of a seedling drench combined with the probable poor nitrogen content of the chicken manure set the crop off to a bad start and the initial poor growth was never regained. Again, T2 received no spray treatment in the first 14 days and that loss of early growth seems never to be recouped. The inferior result for T10 was possibly due to the lower rate of N applied late in the life of the crop.

Leaching data

Nitrogen leaching for the conditioned manure treatment was higher than all others (160 kg/ha cf 60-110 kg/ha). Figure 2.8 shows the strong correlation between rainfall events and leaching during the trial.

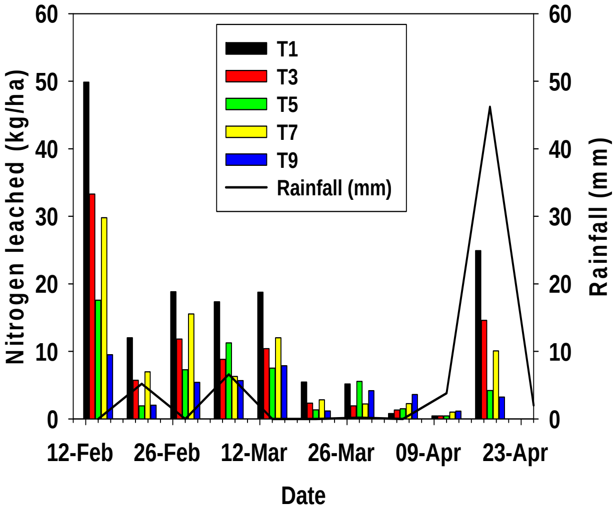

Figure 2.8 **Nitrogen leaching and weekly rainfall during the trial**

Conclusion

The poor results for treatments 1 and 2 confirmed the importance of good early nutrition during Phase 1. The yields obtained were comparable to previous trials and achieved with 330-350 kg/ha nitrogen. All the higher yielding treatments received fertigation after row closure.

Winter 2008

Introduction

Treatment changes applied in this trial were similar to those used for the winter iceberg crop planted at about the same time and included:

- a weekly spray treatment at double the rate of the twice-weekly spray treatment to see if it was equally effective to reduce labour costs
- a weekly and twice-weekly broadcast granular NPK treatment to compare with the spray treatment for possible increased efficacy and reduced leaching in rainy periods
- treatment with broadcast di-ammonium phosphate to compare with the broadcast granular NPK fertiliser to try and reduce costs
- two treatments using a stronger spray treatment to replace the first banding with granular NPK fertiliser to try and increase crop uniformity
- fertigation treatment with supplemental potassium instead of nitrogen only after row closure (a single treatment with no fertigation after row closure was left in for comparison).

Method

The bay for this trial had been recently planted to lettuce which had been harvested over several days finishing 3 April. The crop had been quite uneven and so soil samples were taken from selected plots and analysed for phosphorus, potassium and organic carbon. Unfortunately there was no clear pattern when the results for 'better' and 'worse' plots were compared. Phosphorus ranged from 98 to 189 mg/kg, potassium from 25 to 133 mg/kg and organic carbon from 0.2 to 1.29 per cent.

Seedlings for the trial (cultivar 'Ironman') were bought in from a specialist nursery and planted on 15 May 2008. Seedlings were planted at four rows per bed with 350 mm between rows and 470 mm between plants (56 700 per hectare). Each plot consisted of 28 plants equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting, Dacthal® was applied at 6 kg/ha and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

The fertiliser treatment schedule is detailed in Table 2.4. Prior to planting 500 kg/ha double super, 200 kg/ha K-Mag® and 150 kg/ha of Hi-Trace® were applied. The cost of those pre-plant treatments is not included in Table 2.4.

Table 2.4 **Schedule of treatments applied to a winter broccoli crop. Row closure was between days 35 and 42. All quantities shown are in kg/ha of nitrogen (as contained in the product).**

		Day number																	
Treat-ment	**At planting**	**0**	**3**	**7**	**10**	**14**	**17**	**21**	**24**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**84**	**91 Harvest**
1	nil	S2		S2		S2		S2		S5	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
2	nil	S2		S2		S2		S2		Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
3	nil	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
4	nil	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro4	Nitro4	Nitro4		F6			F6	
5	Nitro2	S2		S2		S2		S2		Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
6	Nitro2	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
7	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
8	Nitro2		Nitro2		Nitro2		Nitro2		Nitro2	Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
9	Nitro2	S2		S2		S2		S2		S5	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
10	DAP2	S2		S2		S2		S2		Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
11	DAP2		DAP2		DAP2		DAP2		DAP2	Nitro4	Nitro4	Nitro4	Nitro4	F5	F6	F5		F6	
12	nil	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro4	Nitro4	Nitro4						

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N) without wash off
S2 = Spray 45 g/L urea + 20 g/L KNO_3 at 1000 L/ha (23N) without wash off
S5 = Spray 45 g/L urea + 20 g/L KNO_3 at 2000 L/ha (46N) without wash off
F5 = Fertigate by boom-spray 75 kg/ha urea (34.5 N) and wash off
F6 = Fertigate by boom-spray 75 kg/ha urea (34.5 N) plus 200 L/ha Spurt KS (60 K) and wash off

= Lysimeter buried under these plots
= Broadcast application
= Banded application
= Fertigated application
= Fertigated application

Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro4 = Nitrophoska Blue Special 500 kg/ha (60N)
DAP2 = DAP 130 kg/ha (23N)

Table 2.5 **NPK analysis and cost of fertiliser treatments for broccoli crop**

Treatment	Total N (kg/ha)	Total P (kg/ha)	Total K (kg/ha)	Cost to first banding ($)	Cost to row closure	Cost from row closure to harvest	Total cost ($)
1	458	78	377	583	1935	1190	**3708**
2	472	104	432	389	2580	1190	**4159**
3	473	104	462	541	2580	1190	**4311**
4	404	104	462	541	2580	1013	**4133**
5	496	114	460	647	2580	1190	**3910**
6	497	114	490	799	2580	1190	**4063**
7	498	156	543	1290	2580	1190	**5060**
8	498	156	543	1290	2580	1190	**5060**
9	482	88	405	583	2193	1190	**3966**
10	494	130	432	638	2064	1190	**3892**
11	492	234	402	1247	2580	1190	**5017**
12	335	104	343	541	2580	$0	**3121**

Results

The crop grew well with much less unevenness than the previous lettuce crop (Figure 2.9). The DAP treatment (11), grew well at first but then lagged behind the others. Treatments 7 and 8 which used broadcast Nitrophoska Blue Special instead of the spray treatments, appeared to grow better in terms of leaf area than other treatments although it was uncertain if this would translate in marketable heads. By the last week, deficiency symptoms were becoming apparent on the leaves of several treatments.

It was decided to harvest the trial over several days. The first heads were picked on 8 August followed by further harvests on 11, 13, 15, 18 and 21 August (85-98 days). Heads were cut with long stems and weighed, then recut to short export-style stems, thus covering the range of presentation commonly seen in the market. The poorer treatments had a greater proportion of the harvest on day 98 and shown in Table 2.6.

Table 2.6 **Percentage of winter broccoli crop picked before 98 days and marketable yield by treatment**

Treatment	Yield before day 98 (%)	Yield before day 98 (t/ha)		Picked on day 98 (%)	Total yield (t/ha)	
		Long*	Short*		Long*	Short*
1	**29**	**6.9**	**5.6**	**71**	**22.8**	**18.2**
2	**30**	**6.7**	**5.5**	**70**	**21.0**	**17.0**
3	**38**	**9.1**	**7.4**	**62**	**22.2**	**17.7**
4	**38**	**7.9**	**6.4**	**63**	**19.9**	**15.6**
5	**42**	**10.0**	**7.9**	**58**	**23.4**	**19.0**
6	**54**	**14.1**	**11.4**	**46**	**25.4**	**20.5**
7	**75**	**18.8**	**15.4**	**25**	**24.8**	**20.3**
8	**56**	**14.6**	**11.9**	**44**	**26.0**	**21.2**
9	**36**	**8.6**	**7.0**	**64**	**23.4**	**19.0**
10	**35**	**8.9**	**7.3**	**65**	**24.0**	**19.7**
11	**47**	**11.4**	**9.4**	**53**	**24.3**	**19.9**
12	**38**	**7.4**	**6.0**	**62**	**19.0**	**15.1**

*Long denotes broccoli heads picked with a long stalk as for domestic market. Short heads were picked as for export with stem cut at level of first branch.

Figure 2.8 shows the total plot yields excluding the last harvest. It was felt that time to harvest was important and so heads remaining after 98 days were deemed unmarketable.

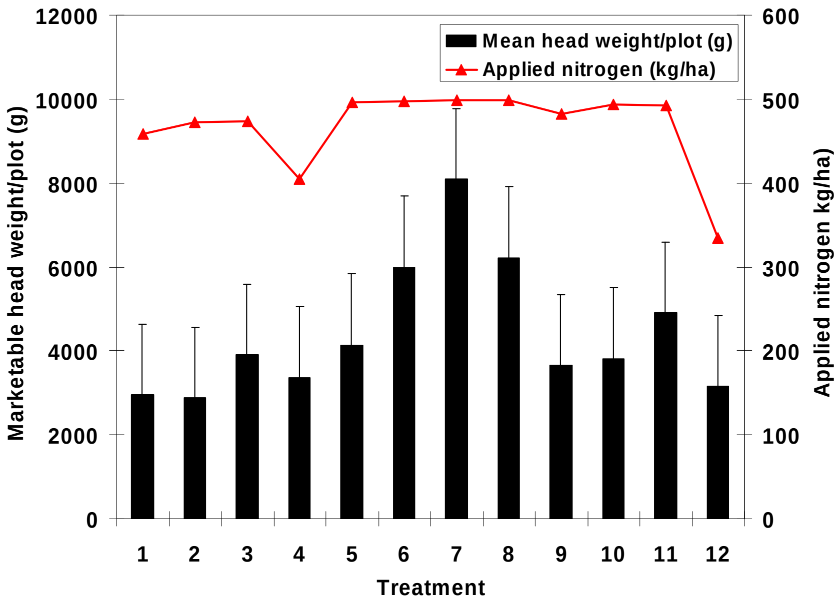

Figure 2.8 **Comparison of yields from winter broccoli crop subjected to a range of fertiliser regimes and graphed against applied nitrogen levels**

Statistical analysis showed that treatment 7 yielded significantly better than all others before 21 August. When the final harvest date was included, marketable yields for treatments 5–11 and treatment 1 were not significantly different.

All treatments that received twice-weekly fertiliser applications in Phase 1 performed better than those that received only weekly applications whether they were spray applications or granular NPK.

All the highest yielding treatments included topdressing after row closure, considered essential for broccoli.

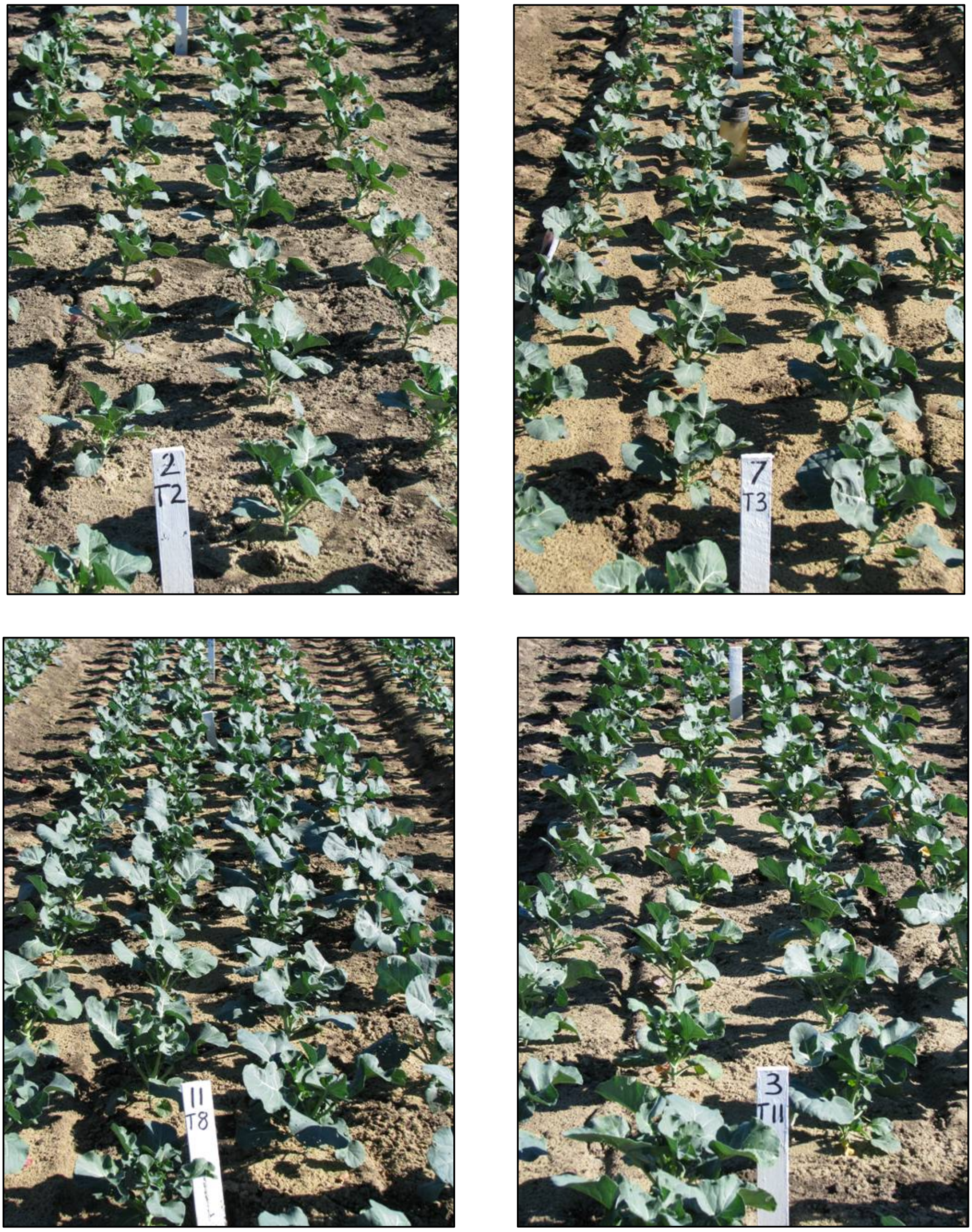

Figure 2.9 **Response to fertiliser treatment in broccoli fertiliser trial 48 days after transplanting. T2 (top left) had weekly sprays compared to T3 (top right) which had twice-weekly sprays while T8 (bottom left) received weekly broadcast granular NPK and T11 (bottom right) received weekly broadcast DAP**

Leaching data

Figure 2.10 shows the close relationship between rainfall and nitrate leaching for this winter broccoli crop. Overall there was not a big difference between treatments in the amount of nitrogen leached in this trial (186-207 kg/ha).

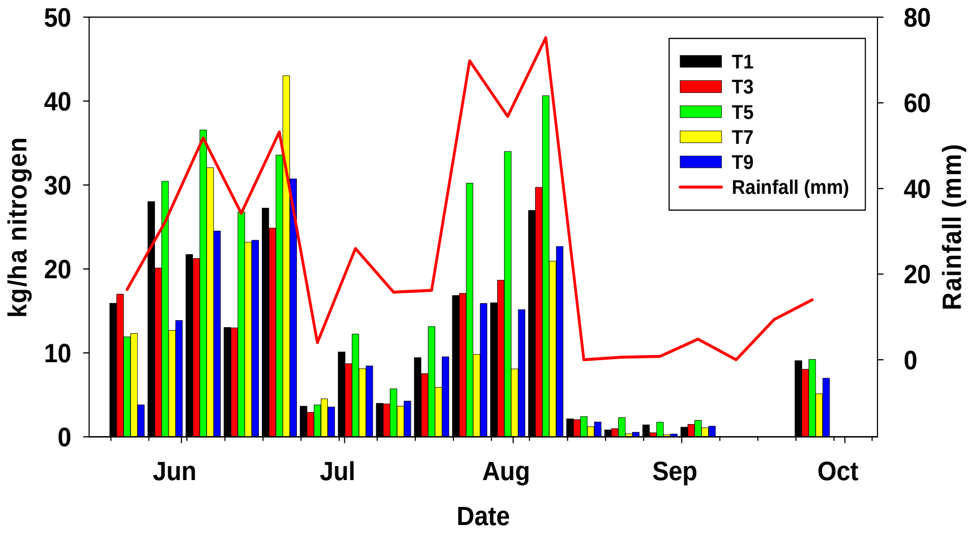

Figure 2.10 **Nitrate leaching from selected treatments in a winter broccoli crop**

Conclusion

A winter broccoli crop requires almost 500 kg/ha nitrogen, substantially more than spring or summer crops which need about 300-350 kg/ha. This is because winter rainfall events leach significant amounts of the applied fertiliser. For this reason, broadcast granular NPK fertilisers are more effective at this time of year. While treatment 7 was one of the most expensive treatments for fertiliser (by about $1000/ha), growers would be compensated by a quicker crop turnaround and better quality heads. The higher yields would also easily overcome the additional fertiliser cost.

Efforts to reduce costs by using DAP were not successful.

Spring 2008

Introduction

Because fertiliser prices remained high, the treatments in this trial again prioritised reducing costs and were similar to those used on other crops at this time i.e. the trial focused on three aspects of fertilising:

- reducing cost by examining lower cost alternatives to Nitrophoska Blue Special® such as Turf Special® and Hort Special®
- continuing comparison of weekly or twice-weekly fertiliser application in the first three weeks after transplanting
- evaluation of the impact of reducing the rates of banded fertiliser to further reduce leaching and cost (the banding period is consistently the period of greatest leaching).

Method

The bay for this trial had been recently planted to iceberg lettuce which had been harvested on 16 August 2008. Samples were taken from selected plots to establish the phosphorus status of the soil. Results showed 149-162 mg/kg phosphorus (bic P), therefore no phosphorus was applied up front to any treatments apart from treatment 12 where the intention was to determine if there might be a response to freshly applied phosphorus. Potassium levels were also good at 78-107 mg/kg. The only base dressing applied was 500 kg/ha magnesium sulphate the day before planting.

Seedlings for the trial (cultivar 'Endurance') were bought in from a specialist nursery and planted on 26 September 2008. Seedlings were planted at four rows per bed with 300 mm between rows and 470 mm between plants (56,700 plants per hectare). Each plot consisted of 28 plants equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting Dacthal® was applied at 6 kg/ha and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Table 2.5 details the treatment schedule.

Table 2.5 **Schedule of treatments applied to a summer broccoli crop. Row closure was between days 28 and 35. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat-ment	At planting	Day number														Total		
		0	3	7	10	14	17	21	28	35	42	49	56	63	70 Harvest	N	P	K
1	Nil	S1	S1	S1	S1	S1	S1	Nitro3	Nitro3	S2	S2	S2	S2	S2		261	31	206
2	Nil	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	S4	S4	S4	S4	S4		427	52	339
3	Nil	S3	S3	S3	S3	S3	S3	Nitro5	Nitro5	S5	S5	S5	S5	S5		429	52	339
4	Nil	S2		S2		S2		Nitro5	Nitro5	S4	S4	S4	S4	S4		427	52	339
5	Hort2		Hort1	Hort1	Hort1	Hort1	Hort1	Hort5	Hort5	S4	S4	S4	S4	S4		443	60	323
6	Nitro2	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	S4	S4	S4	S4	S4		451	62	367
7	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	Nitro5	S4	S4	S4	S4	S4		428	83	378
8	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S4	S4	S4	S4	S4		404	73	349
9	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro3	Nitro3	S4	S4	S4	S4	S4		380	62	321
10	Nitro2			Nitro2		Nitro2		Nitro5	Nitro5	S4	S4	S4	S4	S4		428	83	378
11	Turf2		Turf1	Turf1	Turf1	Turf1	Turf1	Turf5	Turf5	S4	S4	S4	S4	S4		445	31	257
12	Double	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	S4	S4	S4	S4	S4		427	82	339

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N: 7.5K) without wash off
S2 = Spray 40 g/L urea + 40 g/L KNO_3 at 1000 L/ha (24N: 15K) without wash off
S3 = Spray 14 g/L urea + 40 g/L KNO_3 at 1000 L/ha (12N: 15K) without wash off
S4 = Spray 40 g/L urea + 40 g/L KNO_3 at 2000 L/ha (48N: 30K) and wash off
S5 = Spray 44 g/L urea + 28 g/L KNO_3 at 2000 L/ha (48N: 21K) and wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro3 = Nitrophoska Blue Special 300 kg/ha (36N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)
Nitro5 = Nitrophoska Blue Special 500 kg/ha (60N)
Hort1 = Horticulture Special 100 kg/ha (12N)
Hort2 = Horticulture Special 200 kg/ha (24N)

□ = Lysimeter under this plot
□ = Broadcast application
□ = Banded application
□ = Fertigated application

Hort5 = Horticulture Special 500 kg/ha (60N)
Turf1 =Turf Special 100 kg/ha (12N)
Turf2 =Turf Special 200 kg/ha (24N)
Turf5 =Turf Special 500 kg/ha (60N)
Double =Double Super 170 kg/ha (30P)

Results

The crop established well and growth appeared even. There was some rain in the first 10 days of which 6 mm was on the planting day. For that reason, broadcast fertiliser only was applied on that day and the spray treatments were withheld until the next day. A graph of rain during the trial is show in Figure 2.11.

In the second week after transplanting some insect damage, believed to have been Rutherglen bug, was apparent in some plots (Figure 2.12). This damage was mostly confined to a few plots in replicate 1.

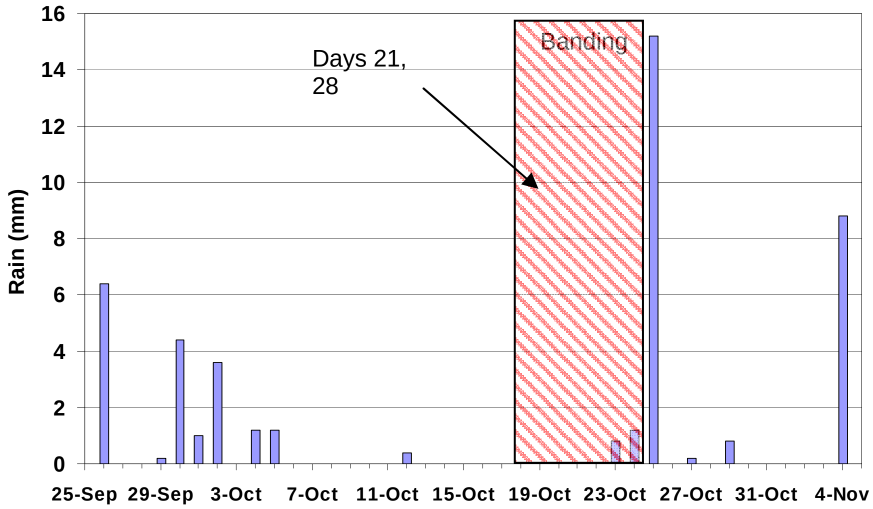

Figure 2.11 **Rainfall recorded during broccoli fertiliser trial at Medina Research Station**

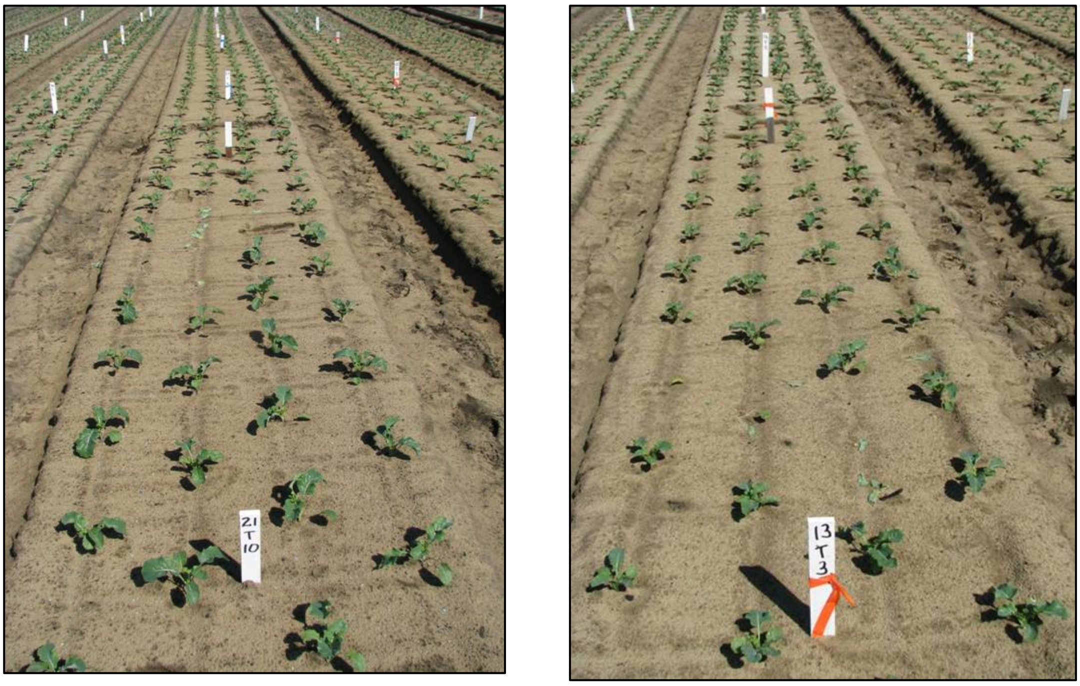

Figure 2.12 **Plant losses due to possible Rutherglen bug damage**

In the last two weeks of the trial some signs of nutrient deficiency (probably nitrogen) were becoming apparent in the older leaves of some treatments.

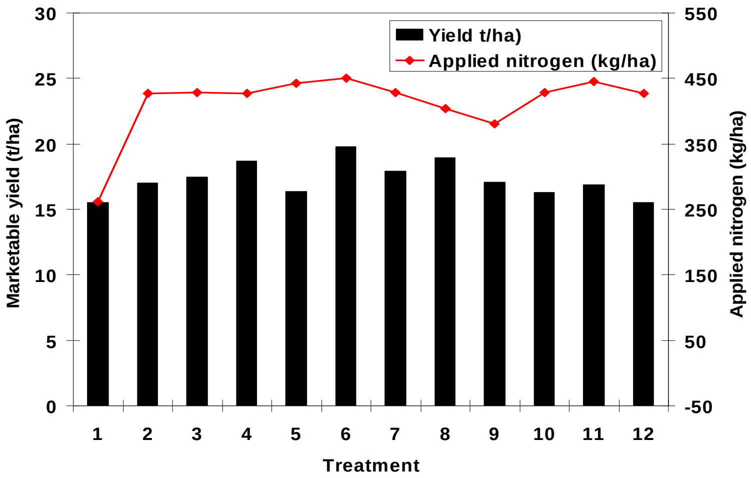

Figure 2.13 **Total marketable yield over all harvests, in a spring planted broccoli crop in response to various fertiliser treatments**

The decision of when to harvest was discussed at length. Our aim was to establish which treatments performed best rather than trying to achieve estimates of maximum yield. We assumed the best treatments were those that matured first i.e. there would be a spread of maturity times over all plots and all treatments. Initially we had thought we might aim for a single harvest but the spread of maturity was so great we harvested twice, first on 28 November and then on 4 December, 63 and 69 days after transplanting. The aim of the first harvest was to pick all stems that had achieved 'export' size, approximately 250 g. Heads were picked and weighed with long stems as for the local market then trimmed as for export and weighed again. All heads were rated for quality including shape, colour (purpling), stem cracking and other defects. Almost half the crop was picked at the first harvest. ANOVA on the data showed there were highly significant differences between treatments.

The first harvest was also analysed using a baseline weight of either 200 or 250 g (trimmed) to eliminate some of the variability, but the results and the degree of significance remained very similar.

As seen from Figure 2.14, treatments 6, 7, 10 and 11 performed significantly better than all others at the first harvest.

Treatments 8 and 9 were used to test reducing the banding rate to 400 and 300 kg/ha respectively. In both cases the yield was significantly reduced. Hort Special® performed poorly though it is unclear why, given it is a 50:50 formulation of NPK Blue Special® and Turf Special®. Growth and yield from Turf Special® were not significantly different from Nitrophoska Blue Special® at the first harvest.

Analysis of variance was also performed on the second harvest (separately) and combined with the first harvest (Figure 2.15). The results, though significant ($p<0.056$) were not as clear and it was apparent there were several problems with this approach. Where plants were blind, a replacement head was picked but there were also a number of plants in some plots that did not produce heads of any consequence—less than 5 cm across for example, and these impacted greatly on the total yield. However, since this may have been a treatment effect those heads were included in the data to be analysed.

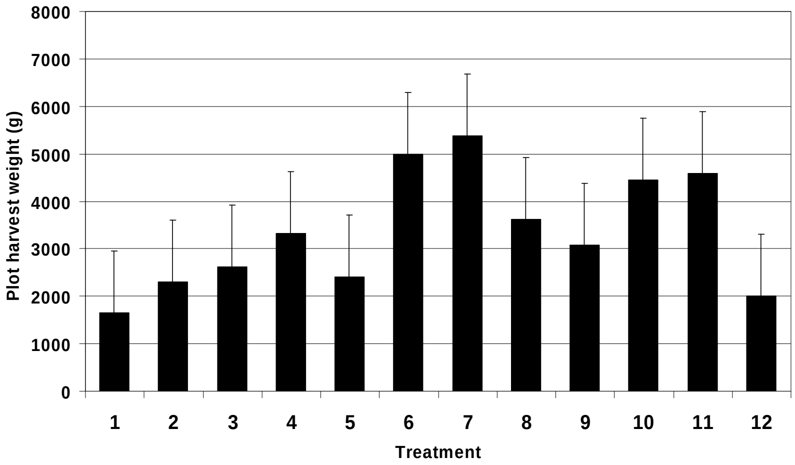

Figure 2.14 **Yield of spring broccoli (per plot basis for the first harvest only) subjected to a range of fertiliser treatments.**

There was little correlation between the rate of applied nitrogen and yield.

Planting density was high, considering 'Endurance' is a very leafy variety. It is possible that when some plants had a growth advantage at an early stage, this carried through to harvest and those shaded plants failed to produce marketable heads for that reason. However this could still have been a treatment effect.

Quality

Defects such as purpling and irregular shape (Figures 2.16, 2.17) were tabulated and analysed using Genstat. The difference in the incidence of both those defects between treatments was found to be highly significant. In both cases, treatment 1 had much higher levels of both defects, possibly due to the low nitrogen rate used.

Figure 2.16 **Examples of the irregular shape of broccoli heads from this crop.**

Figure 2.17 **The range of defects encountered in this harvest included size variation (left), maturity variation (centre) and purpling in the heads (right)**

Leaching data

Only one lysimeter was installed under this broccoli crop (T7). About 250 kg/ha nitrogen was leached from this crop. There was a significant amount of rain in the middle of the trial - 47.4 mm from 29 October to 12 September during Phase 2 (banding) (Figure 2.18).

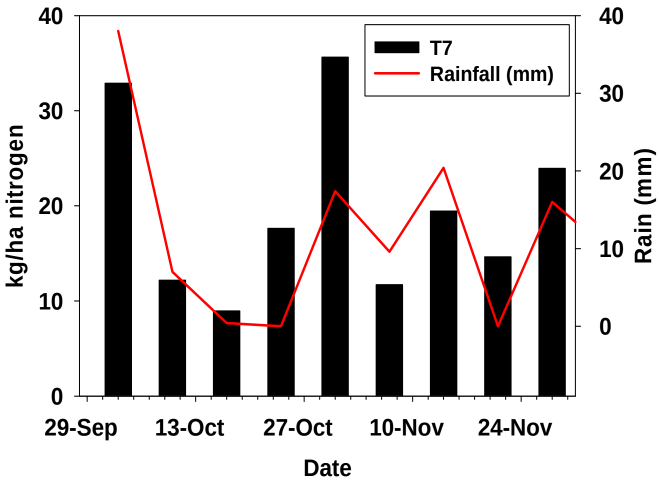

Figure 2.18 **Nitrogen leaching and weekly rainfall during the trial**

Conclusion

Treatments 6, 7, 10 and 11 performed best at the first harvest, supporting the use of granular fertiliser broadcast at planting time. At a cost of only $270 this single application at planting appears to provide a disproportionate yield benefit. The lower rate of banding used in treatments 8 and 9 reduced yield so growers should continue to use 500 kg/ha for banding.

It is not clear why the results for Hort Special should be so anomalous, given it is a 50:50 formulation of NPK Blue Special and Turf Special and at this stage we cannot recommend it as an alternative.

However, growth and yield from Turf Special was not significantly different to that from Nitrophoska Blue Special and further evaluation of Turf Special as a cheaper alternative to Nitrophoska Blue Special is warranted.

Treatments 2 and 3 which evaluated changes in the timing of potassium applications did not show any particular value in early or late applications, in fact Turf Special which had one of the lower amounts of potassium prior to banding was one of the better treatments.

3. CABBAGE

Summer 2009

Introduction

Cabbage is a crop that is widely transplanted in the field from ‘tray-grown’ seedlings produced by specialist nurseries in Australia. In Western Australia it is almost exclusively grown this way in commercial practice, and it is grown year-round on sandy soils of the Swan Coastal Plain, up to 200 km north and south of Perth.

The crop is often rotated with crops such as lettuce and broccoli. Traditional nutrition practice for these crops is poultry manure as a broadcast treatment before planting and/or banded between rows after planting. Mineral fertilisers are also routinely applied as topdressings on these crops, and fertigation is widely used. The potential benefits of the ‘3Phase’ technique are reduced leaching of fertiliser into groundwater from lower fertiliser application rates and better placement of fertiliser than achieved by current commercial practices. This is, particularly the case soon after transplanting when the plant has a poorly developed root system and low fertiliser demand.

In Horticulture Australia Project VG04018, cabbage was planted in mid-July and subjected to one of four spray treatments commencing one day after planting. The treatments were applied twice-weekly for a total of 21 days (six applications). The treatments were as follows:

- S1 No spray
- S2 40 kg/ha potassium nitrate only (92 kg potassium in total)
- S3 11.3 kg/ha urea only (63.3 kg/ha nitrogen)
- S5 22.5 kg/ha urea plus 20 kg/ha potassium nitrate (78.4 kg/ha nitrogen, 46 kg potassium in total).

This was followed by a series of one of four topdressing treatments as detailed in Table 3.1. The prilled or granular fertilisers were banded into a shallow furrow between pairs of broccoli rows and Spurt-N® was simulation fertigated, commencing 16 days after transplanting and ending at row closure. Treatments were as follows:

- B1 Prilled potassium nitrate (KN) 400 kg/ha at day 16 followed by prilled ammonium nitrate (AN) 200 kg/ha—68N
- B2 Nitrophoska Blue Special® 550 kg/ha—66N
- B3 Prilled potassium nitrate (KN) 400 kg/ha at day 16 followed by prilled urea (low biuret) 150 kg/ha—69N
- B4 Prilled potassium nitrate (KN) 400 kg/ha at day 16 followed by Spurt-N® 200 kg/ha—64N.

Table 3.1 **Topdressing treatments (B1-B4) applied to cabbage (kg/ha)**

Banding treatment	B1		B2	B3		B4	
Day no.	KN	High AN	Nitrophoska Blue Special®	KN	U	KN	Spurt-N®
18	**400**		**550**	**400**		**400**	
26			**550**		**150**		**200**
27		**200**					
34	**500**		**550**	**500**			

This program was supplemented with two top-up applications of potassium nitrate (300 kg/ha) plus ammonium nitrate (80 kg/ha) on days 70 and 89.

The final results showed that seedling drenches had an adverse effect. The best treatment combination for cabbage grown in winter was undrenched seedlings, followed by six sprays of a mixture of 22.5 kg/ha urea plus 20 kg/ha potassium nitrate applied in 1000 L/ha of water at three to four day intervals for the first 21 days after planting. Spray treatments should be followed by Nitrophoska Blue Special® banded between the rows at 550 kg/ha until row closure and then fertigation with nitrogen and potassium were required to a total of 600 kg/ha of potassium nitrate and 160 kg/ha of ammonium nitrate.

The yield of 67 t/ha was not considered high and so further trials need to focus on increasing yields. Given the degree to which crop growth slowed in the latter stages, fertigation after row closure is considered a high priority for investigation. Recent trials with other leafy vegetables have also shown benefits from the use of broadcast NPK fertiliser at planting and, in some cases, instead of spraying, therefore treatments this cabbage trial program will include weekly spray regimes compared to the current 'best practice' treatment of twice-weekly spraying in the first two to five weeks after transplanting, the use of a broadcast fertiliser application at planting in combination with spraying or as a replacement for the spray treatments to test the benefits from spraying with regard to both yield and nutrient leaching. With huge increases in fertiliser costs during 2008, recent trials also tested the use of lower cost NPK fertilisers such as Turf Special® with good results so this will also be tested on cabbage.

Method

The bay for this trial had been recently planted to iceberg lettuce which had been harvested on 10 November 2008. Soil tests before the previous trial had shown good levels of soil phosphorus and potassium so only 150 kg/ha Hi-Trace® was applied one week before planting, followed by a spray of magnesium sulphate at 300 kg/ha (30 kg/ha Mg) one day prior to planting.

Seedlings for the trial (cultivar 'Beverley Hills') were bought in from a specialist nursery and planted on 22 January 2009. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting, Dacthal® (6 kg/ha) was applied and followed with 6 mm irrigation. The remaining crop irrigation was scheduled as follows:

- Weeks 1 and 2 at 1.0 times EPan and no more than 4 mm in any one irrigation
- Weeks 3 to 6 at 1.2 times EPan and no more than 6 mm in any one irrigation
- Weeks 7 and 8 at 1.4 times EPan and no more than 8 mm in any one irrigation
- Subsequent weeks at 1.5 times EPan and no more than 8 mm in any one irrigation.

Lysimeters under selected treatments were pumped out weekly, volumes recorded and nitrate measured. Rain gauges in the plots with lysimeters were also recorded weekly at the time of pumping.

Fertiliser treatments

Treatments applied in this trial included:

- weekly versus twice-weekly spray treatments to determine whether one spray at twice the rate could replace twice-weekly spraying in the first two to three weeks of seedling growth in the field
- granular broadcast fertiliser options as substitutes for spraying in Phase 1, potentially reducing labour costs for fertiliser application and slowing the rate of nutrient leaching
- Turf Special as a lower cost alternative to Nitrophoska Blue Special in Phases 1 and 2.

A solution of magnesium sulphate at 300 kg/ha plus borax and water at 15 g/L was sprayed over the crop at row closure. Table 3.2 details the fertiliser treatments applied.

Table 3.2 **Schedule of treatments applied to summer planting of a cabbage crop. Row closure was between days 21 and 28. All quantities are in kg/ha of nitrogen (as contained in the product)**

Treatment	At planting	Day number																Total		
		0	3	7	10	14	17	21	28	35	42	49	55	56	62	63	75 (Harvest)	N	P	K
1	nil	S1	S1	S1	S1	S1	S1	Nitro5	S3	S3	S3	S3	S3	S3	S3	S3		499	26	116
2	nil	S1	S1	S1	S1	S1	S1	Nitro5	S5	S5	S5	S5	S5	S5	S5	S5		503	26	116
3	Nitro2	S2		S2		S2		Nitro5	S3	S3	S3	S3	S3	S3	S3	S3		523	36	144
4	Nitro2	S2		S2		S2		Nitro5	S5	S5	S5	S5	S5	S5	S5	S5		527	36	144
5	Nitro2	S1	S1	S1	S1	S1	S1	Nitro5	S3	S3	S3	S3	S3	S3	S3	S3		523	36	144
6	Nitro2	S1	S1	S1	S1	S1	S1	Nitro5	S5	S5	S5	S5	S5	S5	S5	S5		527	36	144
7	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	S3	S3	S3	S3	S3	S3	S3	S3		500	57	155
8	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	S5	S5	S5	S5	S5	S5	S5	S5		504	57	155
9	Nitro2		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	S3	S3	S3	S3	S3	S3	S3	S3		512	62	169
10	Nitro2	S1	S1	S1	S1	Nitro5		Nitro5	S3	S3	S3	S3	S3	S3	S3	S3		559	62	200
11	Turf1		Turf1	Turf1	Turf1	Turf1	Turf1	Turf5	S4	S4	S4	S4	S4	S4	S4	S4		513	20	311
12	Turf1		Turf1	Turf1	Turf1	Turf1	Turf1	Turf5	S6	S6	S6	S6	S6	S6	S6	S6		516	20	311

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N:7.5K)
S2 = Spray 40 g/L urea + 40 g/L KNO_3 at1000 L/ha (24N:15K) wash off after closure
S3 = Spray 50 g/L urea at 2000 L/ha (46 N: 0K) wash off after closure
S4 = Spray 40 g/L urea + 40 g/L KNO_3 at 2000 L/ha (47.2 N:30.4K) wash off after closure
S5 = Spray 150 g/L calcium nitrate 2000 L/ha (46.5 N:0K) wash off after closure
S6 = Spray 120 g/L calcium nitrate + 40 g/L KNO_3 at 2000 L/ha (46.5 N: 30.4K) wash off after closure
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro5 = Nitrophoska Blue Special 500 kg/ha (60N)
Turf 1 = Turf Special 100 kg/ha (12N)
Turf 5 = Turf Special 500 kg/ha (60N)

□ = Lysimeter under this plot
□ = Broadcast application
□ = Banded application
□ = Fertigated application

Results

The crop grew more rapidly than expected so the second banding had to be dropped and replaced with a fertigation. Treatment 10 which had the earlier banding of Nitrophoska Blue Special was visibly superior to all other treatments by week 3 (Figure 3.1). At about the eighth week some purpling was becoming evident on the outer leaves. This was thought to be nitrogen deficiency, possibly arising from the lesser amount of applied nitrogen resulting from dropping one banding. To remedy this fertigation was doubled for a two-week period, by fertigating on two consecutive days for two weeks. This seemed successful as the purpling disappeared.

Figure 3.1 **At four weeks T10 (upper right) appeared ahead of several other treatments. Bottom left photo compares T10 on the left with T1. Bottom right photo compares T2 (left) with T8 (right)**

During this latter period infection by *Sclerotinia* was observed in the crop and Rovral® was applied to prevent further spread. It seemed more prevalent in some treatments. The crop was harvested on 7 April when 32 heads were cut from each plot, trimmed and weighed. Defects such as *Sclerotinia* infection were recorded. The first replicate harvested was also cut open and rated for tip burn but none was found.

Analysis of variance using Genstat was performed on two sets of data. The first set included all harvested plants and plants infected by *Sclerotina*,. The second set assumed the incidence of *Sclerotinia* was treatment-related and infected plants were excluded from the marketable yield.

Data set 1 (Sclerotinia *affected plants included*)

Analysis of variance using Genstat showed significant differences between treatments (p< 0.001). Treatment 10, which had the earlier banding and received the most nitrogen (Figure 3.2), was significantly better than all others.

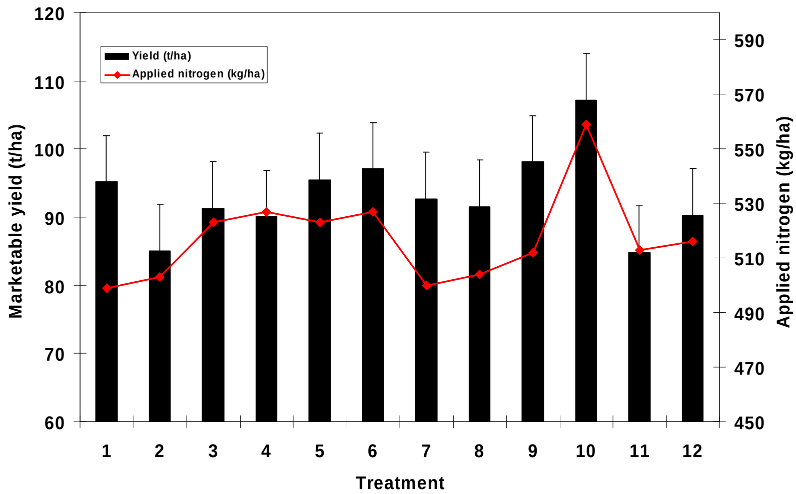

Figure 3.2 **Comparison of marketable yield from summer cabbage crop subjected to 12 fertiliser regimes with *Sclerotinia* affected plants included**

Data set 2 (Sclerotinia *plants excluded*)

Analysis of variance using Genstat showed significant differences between treatments (p< 0.019). Treatments 2 and 11 were significantly worse than all others as shown in Figure 3.3.

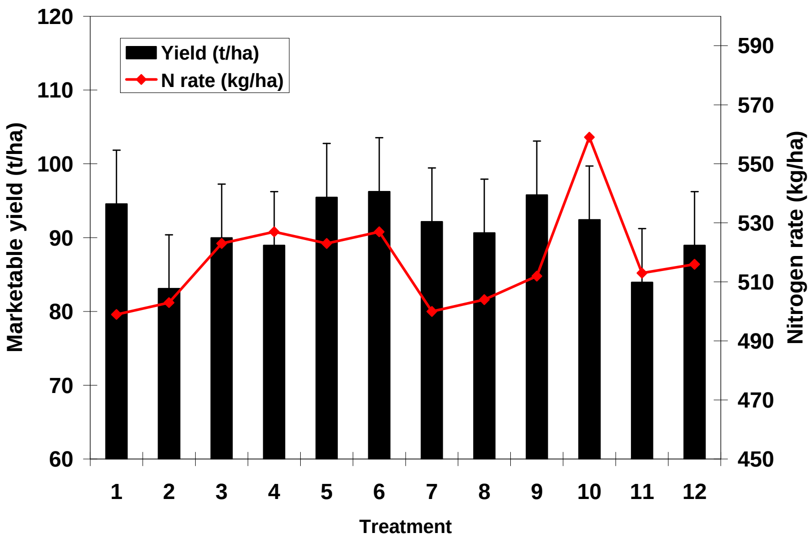

Figure 3.3 **Comparison of marketable yields from summer cabbage crop subjected to 12 fertiliser regimes and with *Sclerotinia* infected plants removed**

Overall, both sets of data showed that there was no yield or quality advantage in fertigation with calcium nitrate after row closure. Both Turf Special treatments performed poorly and therefore this option cannot be recommended. There does seem to be a correlation between the amount of nitrogen supplied and marketable yield but the incidence of Sclerotinia in treatment 10 is of concern. Table 3.3 shows the counts for this disease and it can be seen that three of the four replicates of treatment 10, which had the earlier banding of Nitrophoska Blue Special had a much higher incidence of the disease.

Table 3.3 **Number of cabbage plants infected with *Sclerotinia* by treatment and replicate**

Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Total
1	1				**1**
2		1	2		**3**
3			1	1	**2**
4			2		**2**
5					
6	1	1			**2**
7			1		**1**
8			1		**1**
9		3			**3**
10	5	7	1	4	**17**
11	1				**1**
12	1	2			**3**
Total	**9**	**14**	**8**	**5**	**36**

The unanswered question is whether this incidence of *Sclerotinia* was a treatment effect and if so, whether the rate of nitrogen was detrimental in itself or the earlier banding had some kind of adverse effect? It seems unlikely that the act of banding would have been harmful to the plants even at an early stage as the fertiliser was placed well between the plant rows. Perhaps earlier row closure with this treatment may have created an environment which favoured sclerotinia.

Leaching data

The amount of nitrogen leached was similar for all treatments (202-269 kg/ha) shown in Figure 3.4. Only 1.8 mm of rainfall was recorded during the trial and all leaching was the result of irrigation. Most leaching occurred during Phase 2 (banding).

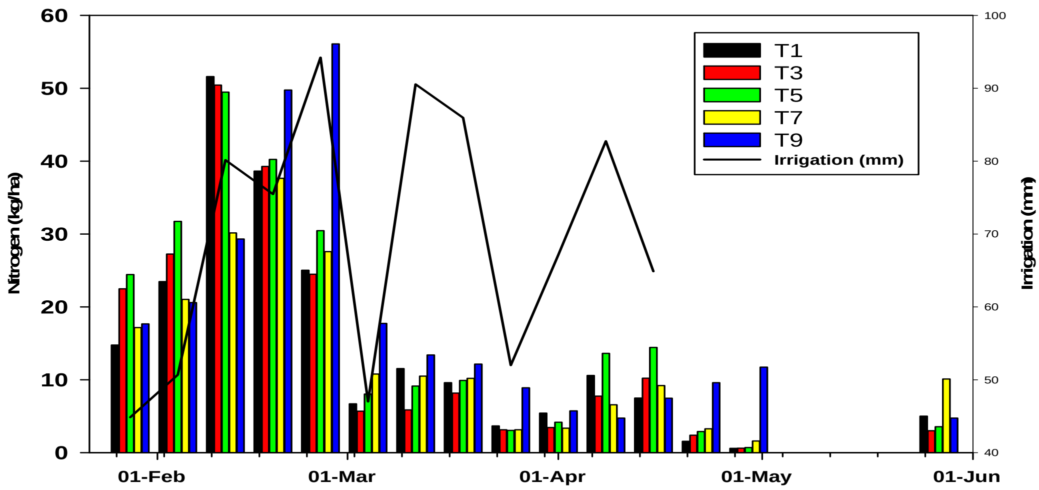

Figure 3.4 **Nitrogen leaching and irrigation plus rainfall for the cabbage trial**

Conclusion

In this trial, marketable yields of about 95 t/ha of summer cabbage were achieved with 500-510 kg/ha nitrogen. Calcium nitrate conferred no additional benefit to cabbage over the use of urea and there was no additional response to potassium after row closure. Turf Special did not appear to be a realistic alternative to Nitrophoska Blue Special. Beyond that, either spray or broadcast applications of nitrogen in the first three weeks of a summer cabbage crop were satisfactory, followed by banding until row closure and finishing fertigation using urea only.

It remains unclear whether the combination of hot weather and high nitrogen predisposed the plants to *Sclerotinia* in Treatment 10. The N rate for Treatment 10 was similar to treatments 5 (no *Sclerotinia*) and 6 (two plants over all replicates) and it is hard to imagine an extra 30 kg/ha of nitrogen having that much impact, especially when potassium levels were relatively high. Either early banding or earlier row closure may have been the cause.

Winter 2009

Introduction

The aims of this trial were primarily to refine rates and timing of nitrogen application for cabbage under winter conditions. Treatments to compare earlier banding at week 3 rather than week 4 were included. A range of nitrogen rates was tested in Phase 3 and nitrogen source was evaluated to see if winter conditions had a detrimental effect on the availability of urea. Other treatments looked at the requirements for potassium in Phase 3.

Method

The bay for this trial had recently grown a celery crop which was harvested on 15 April. Since this bay had been in continuous rotation for some time and had a reasonable fertiliser history, we only applied 300 kg/ha of magnesium sulphate on the day before planting. Seedlings for the trial (cultivar 'Beverley Hills') were bought in from a specialist nursery and planted on 28 May 2009. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting, Dacthal® (6 kg/ha) was applied and followed with 6 mm irrigation. The remaining crop irrigation was scheduled as follows:

- Weeks 1 and 2 at 1.0 times EPan and no more than 4 mm in any one irrigation
- Weeks 3 to 6 at 1.2 times EPan and no more than 6 mm in any one irrigation
- Weeks 7 and 8 at 1.4 times EPan and no more than 8 mm in any one irrigation
- Subsequent weeks at 1.5 times EPan and no more than 8 mm in any one irrigation.

Lysimeters under selected treatments were pumped out weekly, volumes recorded and nitrate measured. Rain gauges in the plots with lysimeters were also recorded weekly at the time of pumping.

Fertiliser treatments

The 12 fertiliser treatments in this trial are presented in Table 3.4.

Table 3.4 **Schedule of treatments applied to a winter planting of cabbage where row closure was between days 21 and 28. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	Day number																		Total		
	At planting	3	7	10	14	17	21	24	28	35	42	49	56	63	70	77	84	91	98 (Hvst)	N	P	K
1	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S9	S9	S9	S9	S9	S9	S9	S9		572	88	239
2	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S4	S4	S4	S4	S4	S4	S4	S4		580	88	239
3	Nitro2	S1	S1	S1	S1	S1	Nitro4		Nitro4	Nitro4	S2	S2	S2	S2	S2	S2	S2	S2		606	73	477
4	Nitro2	S1	S1	S1	S1	S1	Nitro4		Nitro4	Nitro4	S3	S3	S3	S3	S3	S3	S3	S3		604	73	477
5	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S7	S7	S7	S7	S7	S7	S7	S7		412	99	267
6	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S5	S5	S5	S5	S5	S5	S5	S5		532	99	267
7	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S4	S4	S4	S4	S4	S4	S4	S4		604	99	267
8	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S8	S8	S8	S8	S8	S8	S8	S8		412	99	387
9	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S6	S6	S6	S6	S6	S6	S6	S6		532	99	449
10	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S3	S3	S3	S3	S3	S3	S3	S3		604	99	510
11	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S7	S7	S7	S7	S7	S7	S7	S7		388	88	239
12	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S5	S5	S5	S5	S5	S5	S5	S5		508	88	239

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N:7.5K) do not wash off
S2 = Spray 40 g/L urea + 40g/L KNO_3 at 2000 L/ha (47.2N:30.4K) and wash off
S3 = Spray 85 g/L sulphate of ammonia + 40g/L KNO_3 at 2000 L/ha (46.1-0-30.4) and wash off
S4 = Spray 110 g/L sulphate of ammonia at 2000 L/ha (46.2 N: 0K) and wash off
S5 = Spray 90 g/L sulphate of ammonia at 2000 L/ha (38N:0K) and wash off
S6 = Spray 70 g/L sulphate of ammonia plus 30 g/L KNO_3 at 2000 L/ha (38-0-23) and wash off
S7 = Spray 55 g/L sulphate of ammonia at 2000 L/ha (23.1 N:0K) and wash off
S8 = Spray 40 g sulphate of ammonia plus 20 g KNO_3 at 2000 L/ha (22.4-0-15.2) and wash off
S9 = Spray 55 g/L urea at 2000 L/ha (46N:0K) and wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (24N)

= Lysimeter under this treatment
= Broadcast application
= Banded application
= Fertigated application

Results

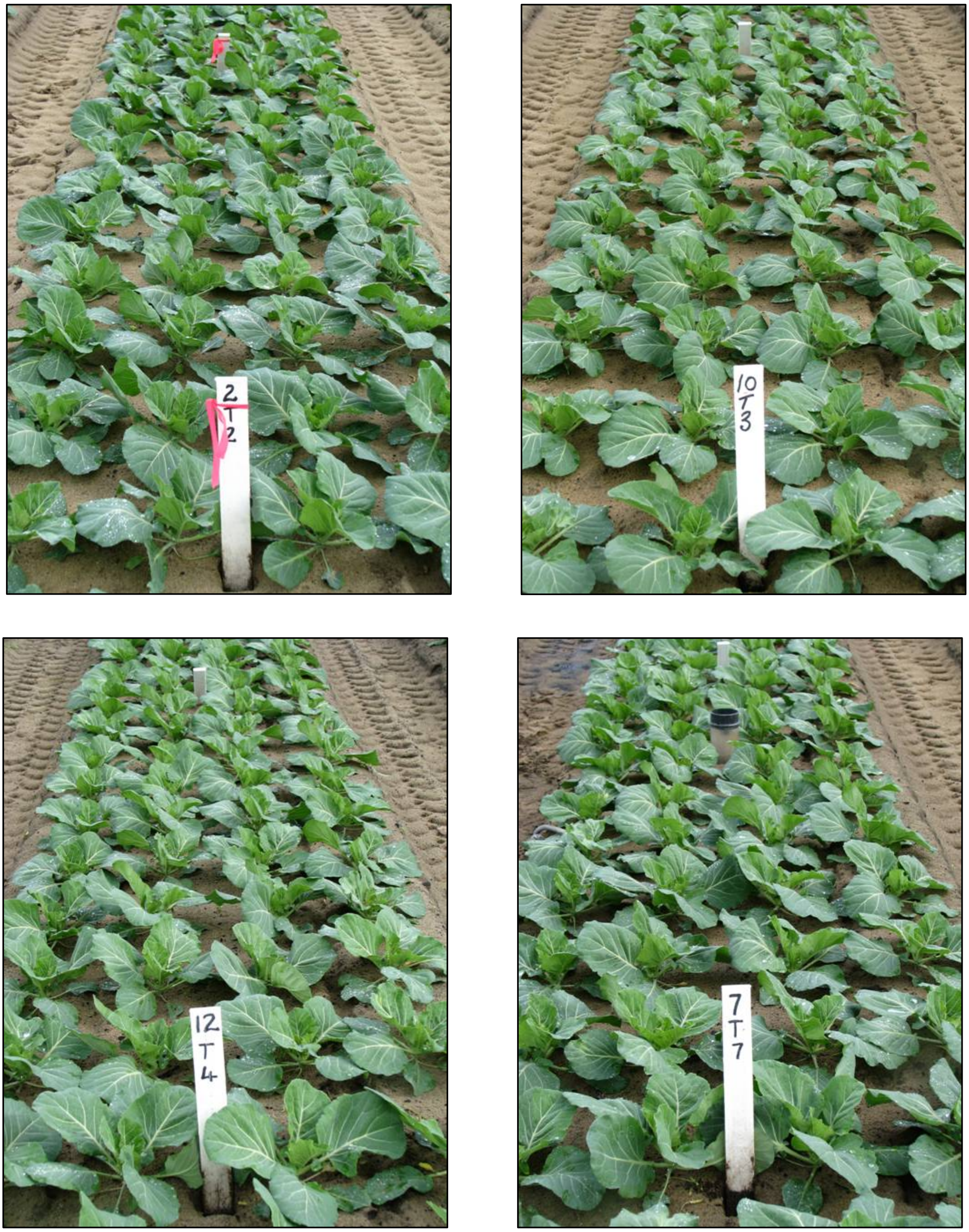

Figure 3.5 **A very even crop on 1 July 2009 (34 days after transplanting). All treatments had received the same broadcast granular NPK fertiliser regime except T3 (top right) and T4 (bottom left) which both received spray applications in Phase 1**

The crop initially grew well and all treatments appeared fairly even (Figure 3.5) but after day 34 the north facing row began to overtake the other three. Consequently, the decision was made to harvest the crop in two sections. The north facing row was harvested on 8 September (103 days from transplanting) and the remaning three rows on 17 September (112 days from transplanting). A total of 32 plants were harvested per plot and all heads were cut and trimmed and individual head weights were recorded. There was a lot of purpling and at harvest all heads were rated for that character on a scale of 1 to 3 as shown in Figure 3.6.

The heads from one replicate were cut in half to check for internal defects but all heads were healthy and no bolting was seen.

Analysis of variance using Genstat showed that for the first harvest treatments 1, 3, 4, 9 and 10 were all significantly better than the rest. For the total harvest this reduced to treatments 1 ,4, 9 and 10.

Figure 3.6 **Purpling was graded at harvest from 0 (left) = none to 1 (centre) = slight and 3 (right) = severe**

There was a strong correlation between yield and total nitrogen applied as seen in Figure 3.7. Nitrogen source also appeared to affect yield with nitrogen supplied as ammonium sulphate consistently giving lower yields than nitrogen supplied from the combination of ammonium sulphate and potassium nitrate or urea, i.e. treatment 2 yielded less than treatment 1, T5 less than T8, T7 less than T10 and T6 less than T9. An exception to this was treatment 3 where nitrogen supplied from the combination of urea and potassium nitrate performed poorly relative to other treatments using potassium nitrate. Whether this was a response to source of nitrogen or additional potassium is not clear but T1, one of the best performing treatments, received the least amount of potassium.

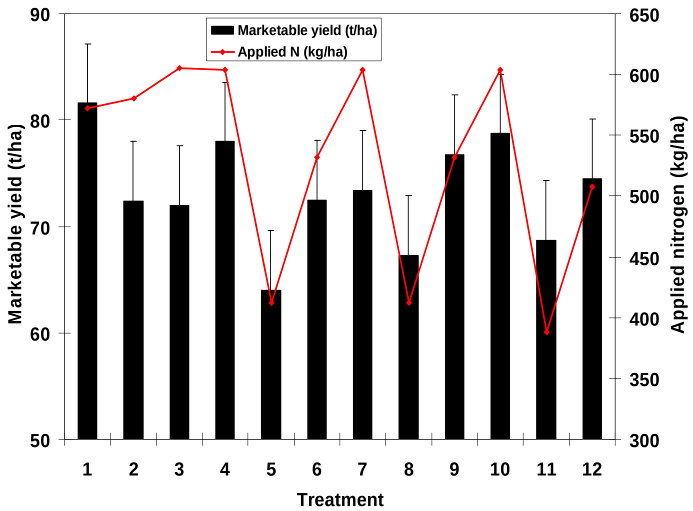

Figure 3.7 **Comparison of mean head weight of cabbage (both harvests) grown in winter and subjected to a range of fertiliser regimes**

There was no difference in treatments receiving spray application of fertiliser versus broadcast NPK during Phase 1 (T4 versus T10) and no additional benefit in applying a heavy banding of 400 kg/ha of NPK at 21 days, (T5 versus T11 and T6 versus T12).

Leaching data

Figure 3.8 shows the high correlation between rainfall events and leaching. The trial had lysimeters installed under treatment 7 only so no comparisonof fertiliser regimes with respect to nitrate leaching could be made. About 208 kg/ha nitrogen, about one third of the 604 kg/ha of nitrogen applied to the crop, was leached as nitrate.

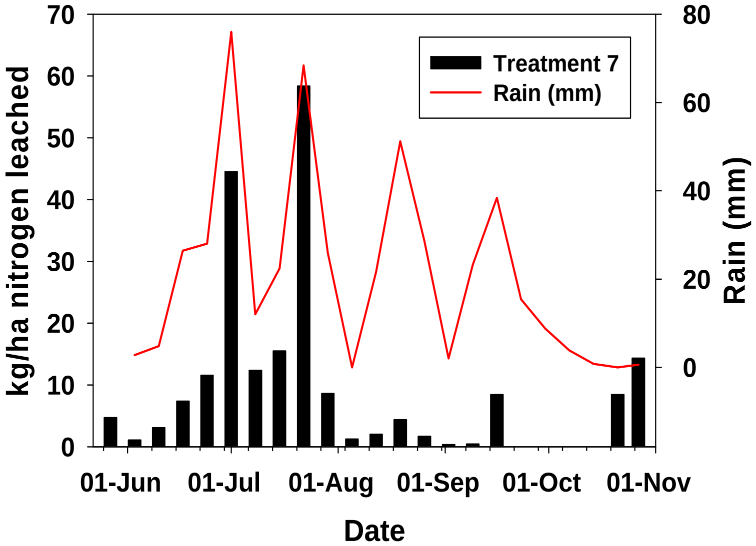

Figure 3.8 **Nitrogen leaching and weekly rainfall during the trial**

Conclusion

A winter crop of cabbage with a marketable yield of around 80 t/ha can be grown using 600 kg nitrogen. Either spray or broadcast fertiliser can be used in Phase 1 and when urea is used, no potassium is required after row closure in Phase 3. Urea appears to be a good source of nitrogen even during winter. Sulphate of ammonia after row closure did not perform as well as urea unless supplemented with potassium.

Summer 2009–10

Introduction

Cabbage was planted following a spring celery crop to investigate two aspects to nitrogen application - first whether increasing the rate of nitrogen produced better yields, and second whether we might be able to further reduce leaching without affecting plant growth by better matching nitrogen application rates with the plant growth curve.

The reason for increasing the rate of nitrogen overall was that growth towards the end of all previous cabbage crops appeared to slow dramatically, suggesting that yield might be reduced by lack of nitrogen. A literature search produced a German paper that had explored nitrogen nutrition of white cabbage at several locations on various soil types including sands, and at a range of times of the year. The rates of nitrogen and the yields achieved together with the uptake figures quoted seemed to indicate we could usefully apply more nitrogen (Fink and Feller 1998).

In addition, we:

- compared weekly applications of broadcast granular NPK fertiliser with twice-weekly applications (same amount of NPK per week)
- tested if the rate of banding could be decreased below 500 kg/ha
- replaced banding with fertigation in two treatments following concerns that the first banding could be adversely affecting plant growth (pictures of roots clearly showed that after the first banding root growth appeared to move from directly under the band)
- used two fertigation treatments with additional potassium to confirm previous experiences indicating potassium applied post-row closure is unnecessary.

Method

Prior to this planting the bed was fumigated with metham sodium as a precaution due to levels of *Sclerotinia* in the previous two crops (celery and cabbage). No base dressings were applied to the soil except for a spray of magnesium sulphate at 300 kg/ha (30 kg/ha Mg) the day before planting.

Seedlings for the trial (cultivar 'Beverley Hills') were bought in from a specialist nursery and planted on 29 October 2009. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants giving a total of 32 plants per plot (63,492 plants/ha).

Immediately after transplanting, Dacthal® (6 kg/ha) was applied and followed with 6 mm irrigation. The remaining crop irrigation was scheduled as follows:

- Weeks 1 and 2 at 1.0 times EPan and no more than 4 mm in any one irrigation
- Weeks 3 to 6 at 1.2 times EPan and no more than 6 mm in any one irrigation
- Weeks 7 and 8 at 1.4 times EPan and no more than 8 mm in any one irrigation
- Subsequent weeks at 1.5 times EPan and no more than 8 mm in any one irrigation.

Lysimeters under selected treatments were pumped out weekly, volumes recorded and nitrate measured. Rain gauges in the plots with lysimeters were also recorded weekly at the time of pumping.

Soil and petiole sampling

Soil samples were taken weekly for all plots with lysimeters. Eight cores were taken from each plot at 0-15 cm and at 15-30 cm depths. Cores were taken in line with plant rows to avoid picking up fertiliser granules from the banding, but otherwise sampling was random over the plot. The cores from each depth were bulked to provide two samples for each of the 15 plots. These samples were taken back to the laboratory for nitrate analysis. Nitrate was determined using Merckoquant® test strips and an R.Q. Flex® meter after 50:50 v/v aqueous extraction (USDA, 1999).

Petioles were sampled fortnightly commencing 10 December. Six petioles were taken from the end of each plot so as not to disadvantage the heads. These were refrigerated for transport back to the laboratory and sap was extracted, diluted as required and analysed for nitrate and potassium using Merckoquant® test strips and an R.Q. Flex® meter. Generally a 1:10 dilution was required to obtain a reading within the range of the strips.

Fertiliser treatments

A solution of magnesium sulphate at 300 kg/ha plus borax and water at 15 g/L was sprayed over the crop at row closure.

Table 3.6 details the treatments applied.

Table 3.6 **Schedule of treatments applied to summer planting of cabbage crop. Row closure was between days 28 and 35. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	At planting	Day number												
		4	7	11	14	18	21	25	28	35	42	49	56	63
1	Nitro2		Nitro2		Nitro2		NK36.8		NK36.8	N50.6	N50.6	N50.6	N60	N60
2	Nitro2		Nitro2		Nitro2		Nitro3		NK36.8	N50.6	N50.6	N50.6	N60	N60
3	Nitro2		Nitro2		Nitro2		Nitro3		Nitro3	N50.6	N50.6	N50.6	N60	N60
4	Nitro2		Nitro2		Nitro3		Nitro4		Nitro4	N50.6	N50.6	N50.6	N60	N60
5	Nitro2	S1	S1	S1	S1	S1	S1		Nitro5	N50.6	N50.6	N50.6	N50.6	N50.6
6	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1		Nitro5	N50.6	N50.6	N50.6	N50.6	N50.6
7	Nitro2		Nitro2		Nitro3		Nitro4		NK50.6	NK50.6	NK50.6	NK60	NK60	NK60
8	Nitro2		Nitro2		Nitro2		Nitro3		NK36.8	NK50.6	NK50.6	NK50.6	NK60	NK60
9	Nitro2		Nitro2		Nitro3		Nitro4		Nitro4	N50.6	N50.6	N60	N60	N60
10	Nitro2		Nitro2		Nitro2		Nitro2		Nitro5	N50.6	N50.6	N50.6	N50.6	N50.6
11	Nitro2	Nitro1	Nitro1	Nitro1.5	Nitro1.5	Nitro2	Nitro2		Nitro4	N50.6	N50.6	N50.6	N60	N60
12	Nitro2		Nitro2		Nitro3		Nitro4		Nitro4	N50.6	N50.6	N50.6	N60	N60

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N:7.5K) do not wash off
NK36.8 = Spray urea at 24.3 g/L + KNO_3 55.7 g/L at 2000 L/ha and wash off
N50.6 = Spray urea at 55 g/L at 2000 L/ha and wash off
NK50.6 = Spray urea at 43 g/L plus KNO_3 at 43 g/L and wash off
N60 = Spray urea at 65 g/L at 2000 L /ha and wash off
N73.6 = Spray urea at 80 g/L at 2000 L/ha and wash off
NK60 = Spray urea at 51 g/L + KNO_3 51 g/L at 2000 L /ha and wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro1.5 = Nitrophoska Blue Special 150 kg/ha (18N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro3 = Nitrophoska Blue Special 300 kg/ha (36N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)
Nitro5 = Nitrophoska Blue Special 500 kg/ha (60N)

= Lysimeter buried under this plot
= Broadcast application
= Banded application
= Fertigated application

Table 3.6 **continued.**

Treat-ment	Day number				Total		
	63	70	77	83 (Harvest)	N	P	K
1	N60	N60	N60		537	31	169
2	N60	N60	N60		535	62	169
3	N60	N60	N60		536	47	169
4	N60	N60	N60		571	78	211
5	N50.6	N50.6	N50.6		510	36	144
6	N50.6	N50.6	N50.6		510	68	183
7	NK60	NK60	NK60		538	62	271
8	NK60	NK60	NK60		525	73	257
9	N60	N73.6	N73.6		608	78	211
10	N50.6	N50.6	N50.6		510	68	183
11	N60	N60	N60		571	78	211
12	N60	N60	N60		571	68	183

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N: 7.5K) do not wash off
NK36.8 = Spray urea at 24.3 g/L + KNO_3 55.7g/L at 2000 L/ha and wash off
N50.6= Spray urea at 55 g/L at 2000 L/ha and wash off.
NK50.6 = Spray urea at 43 g/L plus KNO_3 at 43 g/L and wash off
N60 = Spray urea at 65 g/L at 2000 L/ha and wash off
N73.6 = Spray urea at 80 g/L at 2000 L/ha and wash off'
NK60 = Spray urea at 51 g/L + KNO_3 51 g/L at 2000 L /ha wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro1.5 = Nitrophoska Blue Special 150 kg/ha (18N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro3 = Nitrophoska Blue Special 300 kg/ha (36N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)
Nitro5 = Nitrophoska Blue Special 500 kg/ha (60N)

= Lysimeter buried under this plot
= Broadcast application
= Banded application
= Fertigated application

Results

This crop grew more evenly than the winter crop, possibly due to warmer weather and more light in the south-facing rows. A serious diamondback moth infestation almost caused the trial to be abandoned. Figure 3.9 shows the growth and the damage caused by the moths 27 days after transplanting (25 November).

Figure 3.9 **At 27 days it was hard to see any real differences between treatments**

The crop was harvested in one pass on 20 January when 32 heads were cut from each plot, trimmed to bald heads and weighed individually. There was a slight incidence of sclerotinia unrelated to any treatment effect.

Analysis of variance using Genstat showed treatments 9, 11 and 12 to be significantly better than all others but the margin was small (Figure 3.11). As in previous trials, the best treatments all received the highest rate of nitrogen (570-608 kg/ha). Despite fears of an adverse effect from banding at 21 days, this was not proven. Treatments 1, 2 and 3 all produced similar yields. Treatment 12 which had an earlier banding was also one of the best. There appeared to be a slight advantage to using a granular NPK fertiliser in Phase 1 (T6 versus T5). Again there was no additional benefit to applying potassium in Phase 3.

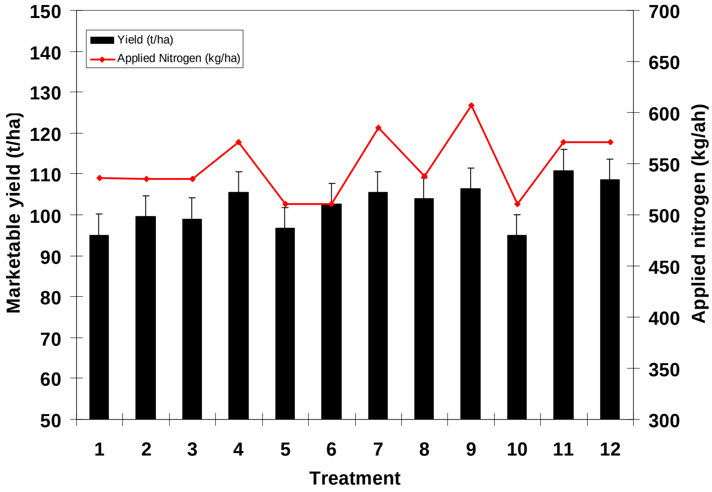

Figure 3.11 **Comparison of yields in a summer cabbage crop subjected to a range of fertiliser regimes**

Leaching data

A peak in nitrate leaching occurred during Phase 2 (Figure 3.12). Overall, the crop leached between 150 and 182 kg N/ha. T5 and T9 leached the lowest amount of N (150 kg) but T5 had 100 kg less applied than T9. The only difference was that T9 had a stepped rate and T5 was our usual regime.

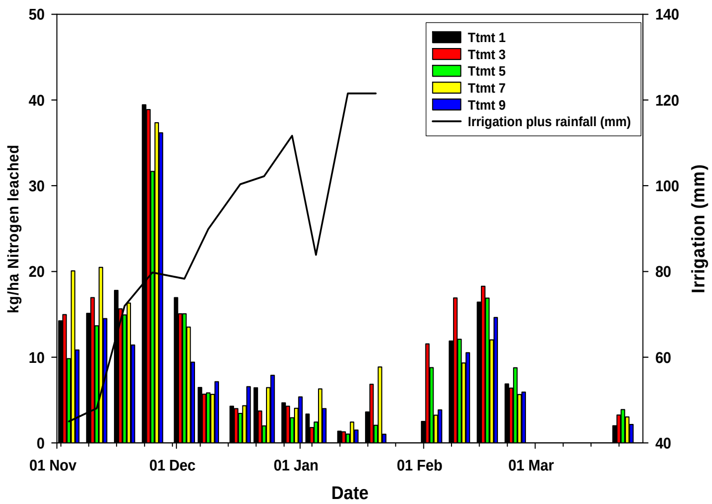

Figure 3.12 **Nitrate leaching (kg N/ha) graphed with applied irrigation (mm) for a summer cabbage crop**

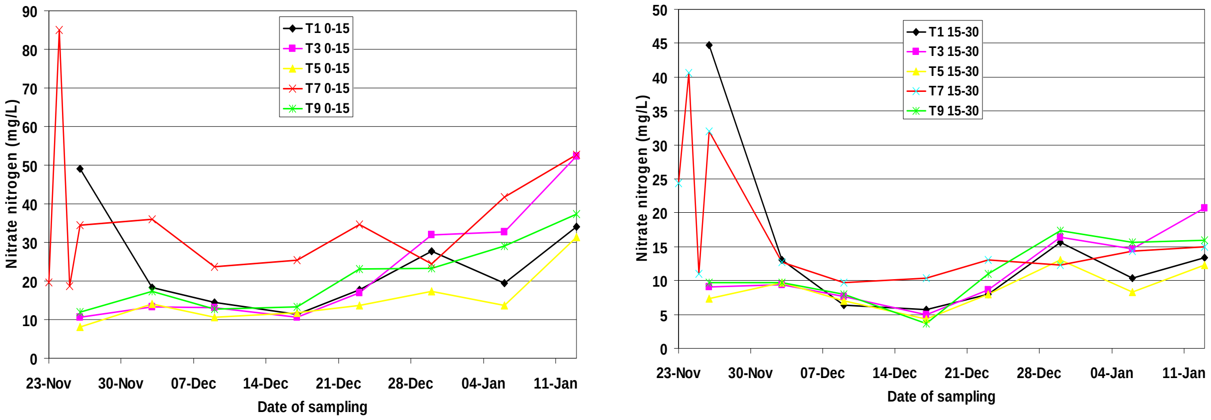

Figure 3.13 **Variation in soil nitrate levels over time in selected treatments of a summer cabbage crop**

Soil and petiole sampling

Soil nitrate levels were measured weekly in the plots with lysimeters. Levels fluctuated over time but the higher levels tended to be found in the plots receiving more nitrogen such as T9 and were generally in the range 10-40 mg/L in the top 0-15 cm and 5-15 mg/L at 15-30 cm (Figure 3.13).

Plant sap levels of nitrogen and potassium also varied widely. Nitrate nitrogen was much lower than previous crops and was generally in the range of 5-600 mg/L while potassium was similar to previous crops and ranged between 3.2 and 4.9 per cent.

Conclusion

Marketable yield between 100 and 110 t/ha in a summer cabbage crop can be achieved using around 570 kg/ha nitrogen. A stepped rate of nitrogen application may reduce leaching but further trials would be needed to see if this reduction is repeatable and significant. Early banding (week 3) was not detrimental to the crop. There was no response to additional potassium applied after row closure.

4. CELERY

Summer 2006-07

Background

Celery is a crop that is widely transplanted in the field from 'tray-grown' seedlings produced by specialist nurseries in Australia. In Western Australia it is almost exclusively grown this way in commercial practice, and it is grown year-round on sandy soils of the Swan Coastal Plain, up to 200 km north and south of Perth.

The crop is often grown in rotation with crops such as lettuce and broccoli. Traditional nutrition practice for these crops is to use poultry manure as a broadcast treatment before planting and/or banding between rows after planting. Mineral fertilisers are also routinely applied as topdressings, and fertigation is widely used.

The potential benefits of the '3Phase' technique are reduced leaching of fertiliser into groundwater from lower fertiliser application rates and better placement of fertiliser than achieved by current commercial practices. This is particularly so soon after transplanting when the plant has a poorly developed root system and low fertiliser demand.

In Horticulture Australia Project VG04018 celery was planted in late May and subjected to one of five spray treatments (S1 to S5) commencing one day after planting. The treatments were applied twice-weekly for a total of 14 days (four applications in total).

S1 No spray
S2 40 kg/ha potassium nitrate (20.8 kg/ha nitrogen in total, 60.8 kg potassium in total)
S3 11.3 kg/ha urea only (20.8 kg/ha N in total)
S4 11.3 kg/ha urea plus 40 kg/ha potassium nitrate (41.6 kg/ha nitrogen, 60.8 kg potassium in total)
S5 22.5 kg/ha urea plus 20 kg/ha potassium nitrate (51.8 kg/ha nitrogen, 30.4 kg potassium in total).

These were followed by a series of one of four banding treatments as detailed in Table 4.1. The prilled or granular fertilisers were banded into a shallow furrow equidistant between the pairs of rows of celery commencing 14 days after planting.

Table 4.1 **Topdressing treatments (B1–B4) applied to celery (kg/ha)**

Banding treatment	B1		B2	B3		B4	
Day no.	KN	High AN	Nitrophoska Perfekt®	KN	U	KN	Medium AN
14	400		550	400		400	
21		200	550		150		150
28		200	550		150		150
35		200	550		150		150
42	500		550	500		400	
49		200	550		150		150

At day 56, all treatments also received a top up spray of 300 kg/ha potassium nitrate plus 50 kg/ha ammonium nitrate boom-sprayed and immediately watered in over all plots as a simulated fertigation (56-0-114).

Significantly better yields were obtained with both S4 and S5. S5 was cheaper but S4 was a safer option. B3 proved to be the cheapest and most effective topdressing treatment. No additional positive yield effects could be shown from topdressing phosphorus and potassium fertiliser in the period to row closure, as evidenced by the lack of any additional yield response from the Nitrophoska Perfekt® treatment (B2).

The yields produced in this trial were acceptable but not optimal and it was clear that further work was needed to evaluate options for additional fertiliser application after row closure in order to maximise yields. This was the emphasis of the next celery trial in 2006-07.

Method

Seedlings (cultivar LV2459 'Big Ben') for the trial were bought in from a specialist nursery and planted on 13 December 2006. The site had recently been planted to iceberg lettuce fertilised with 2500 kg/ha of double superphosphate, 150 kg/ha of Hi-Trace® and 200 kg/ha K-Mag® as a base dressing. Prior to this crop, only 200 kg/ha K-Mag® was applied over all plots except for Treatment 1. The seedlings were treated with a pre-plant drench of potassium nitrate at 40 g/L at 500 mL per tray (100 cells) and planted within one hour. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants. There were 28 plants per plot.

Immediately after transplanting Gesagard® (prometryn 500 g/L) was applied at 2.2 kg/ha for weed control and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Ten different fertiliser regimes were applied to the celery crop as shown in Table 4.2. In addition to these treatments, an application of magnesium sulphate at 300 kg/ha plus borax at 15 g/L was sprayed over the crop at row closure.

Table 4.2 **Schedule of treatments applied to winter celery. Row closure is between days 35 and 42. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	Pre-plant	Day number																			
		1	4	7	10	14	17	21	24	28	35	42	49	56	63	70	77	84	91	96 Harvest	Total N (kg/ha)
1	CM			48		48		48		48	48	42.55	42.5	42.5	42.5	42.5	42.5	42.5	42.5		580
2						66		66		66	66			66			66				396
3		S1	S1	S1	S1	66		66		66	66										316
4		S1	S1	S1	S1	S1	S1	66		66	66										276
5		S1	S1	S1	S1	66		66		66	66			66			66				448
6		S1	S1	S1	S1	S1	S1	66		66	66			66			66				408
7		S1	S1	S1	S1	66		66		66	66	66		66		66		66			580
8		S1	S1	S1	S1	S1	S1	66		66	66	66		66		66		66			540
9		S1	S1	S1	S1	S1	S1	S1	S1	66	66	66		66		66		66			500
10		S1	S1	S1	S1	66		66		66	66	33	33	33	33	33	33	33	33		580

Note: In the weeks where there was a changeover from spraying to banding, the final spray was applied on Tuesday and banding commenced on Thursday of the same week.

S1 = 22.5 kg/ha urea plus 20 kg/ha potassium nitrate (24.6 kg/ha N per week) in 1000 L water sprayed without wash off.

(pink) = Conditioned poultry manure (CM) broadcast at 50 cubic metres per hectare
(yellow) = Nitrophoska Blue Special® (12-5.2-14) banded between the outer pairs of rows (rate of nitrogen per hectare shown)
(light green) = Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen per hectare shown)
(green) = Lysimeter buried under this treatment

Results

The crop grew well with obvious visual differences between the unsprayed and spray treatments evident as early as one week after planting (Figure 4.1). Over time, as the remaining treatments were applied, these differences became less obvious (Figure 4.2), but at harvest, the unsprayed treatment was still visibly smaller than all the sprayed treatments. Plant growth within plots was generally uneven in this trial with plants in the centre two rows generally more vigorous than those on the outside although the reverse was true for treatment 2 (Figure 4.3).

A problem with the boom-spray occurred while applying the herbicide. Some plots at the eastern end of replicate four were overdosed with Gesagard™ causing some plant deaths. This was taken into account when analysing results.

The following photos show differences between spray treatments over time.

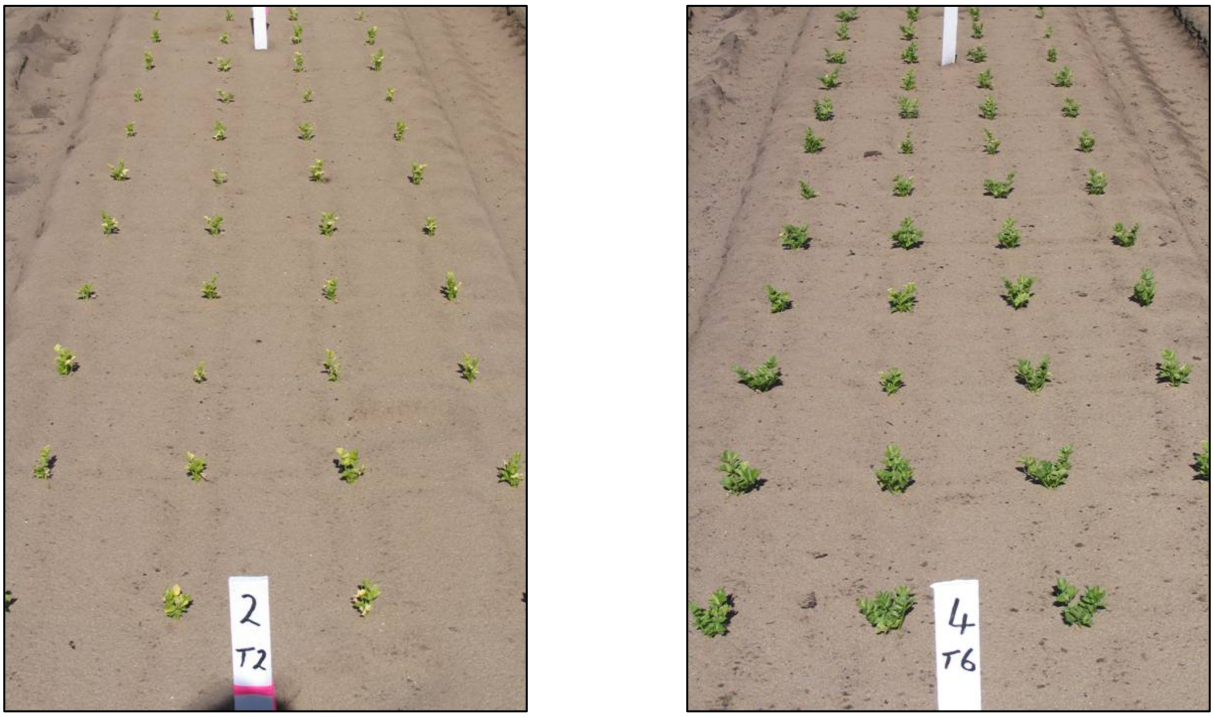

Figure 4.1 **Spray applications affected growth within two weeks after planting; T2 (left) had no sprays, T6 (right) had four applications of potassium nitrate and low biuret urea.**

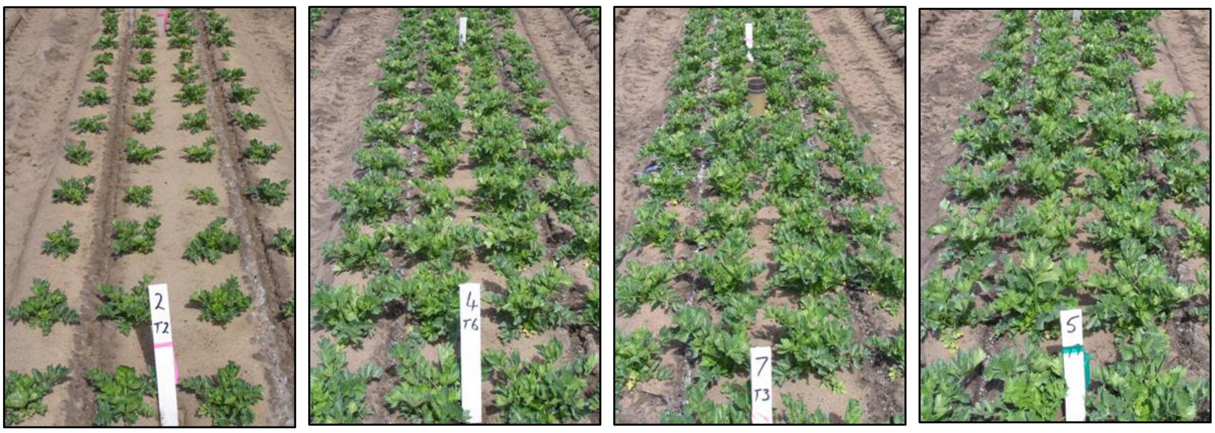

Figure 4.2 **The enduring effects of spraying were still visible one week after the completion of banding (day 43). From left to right: Treatment T2 was unsprayed; T3 had four sprays of potassium nitrate plus low biuret urea; T6 received six sprays; and T9 eight sprays.**

Figure 4.3 **Most treatments showed a difference in plant size between inner and outer rows as illustrated by T8 (centre and right) at 71 days after planting. Treatment T2 (left) was the exception with inner rows less vigorous than outer rows.**

Because of within-plot variation, the centre two rows were harvested separately to the outer two rows. This enabled us to determine if there was a relationship between treatments and unevenness.

The crop was harvested over two days, on 19-20 March 2007 (96, 97 days after planting). The first harvest consisted of 14 plants from the two inner rows and the second another 14 plants from the two outer rows. Plants were trimmed to marketable size in the field and then trimmed to length in the shed prior to weighing. Plants were weighed individually and any defects recorded.

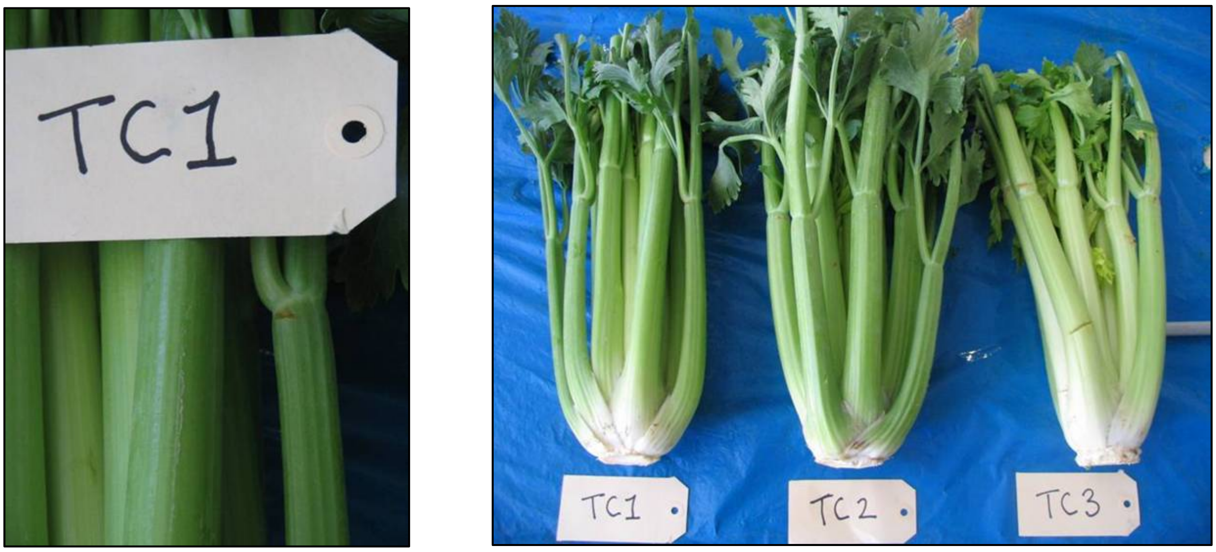

Figure 4.4 **Stem cracking was present in some treatments. The left photo shows the defect close-up. Examples of the grading system used are shown in the right photo. Left to right grades 1–3, 1 being the least severe, 3 the worst.**

Replicate four of T5 and T10 were eliminated from the analysis because of herbicide effects. Analysis of variance showed the only difference was the yield from treatment 2 was significantly different from the rest ($p < 0.001$). However the quantity of nitrogen supplied in each of these treatment ranged from 276 to 580 kg/ha.

Figure 4.5 depicts the relative yields from each treatment compared with the rate of applied nitrogen. T2, which had no spray treatments prior to banding, performed significantly worse ($p < 0.001$).

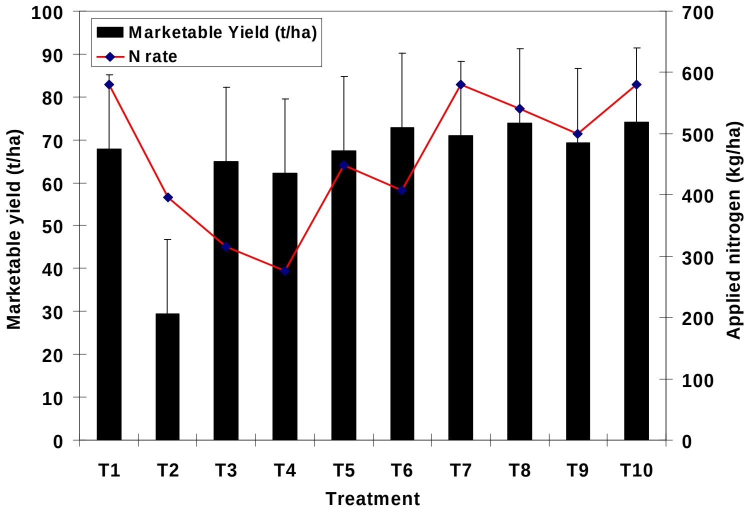

Figure 4.5 **Marketable yield of celery subjected to a range of fertiliser treatments**

The relative value of four sprays versus six sprays (T4, T8) is not clear from this trial. Of the three paired treatments, two showed a slight increase with six sprays and one a slight decrease. None of these differences was significant.

The value of fertigation after row closure is also uncertain. There were no significant differences but a number of treatments showed a slight yet consistent trend towards better yields with more frequent applications of nitrogen post-row closure.

Leaching data

Only one lysimeter was installed under treatment 3 of this crop. It collected the equivalent of 265 kg/ha of nitrogen as leachate from this crop.

Figure 4.6 shows the relationship between rainfall during the trial and nitrate leaching below the crop. The spike in nitrate from the pumping on 24 April was the result of a combination of nitrogen in crop residue and a substantial (49 mm) fall of rain on 16 April.

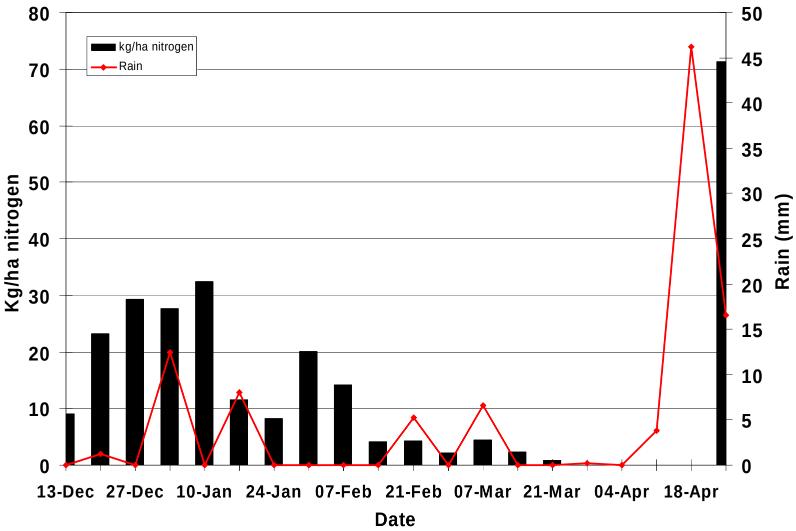

Figure 4.6 **Nitrogen leaching and weekly rainfall during the trial**

Conclusion

A marketable yield of around 70 t/ha of summer-planted celery can be achieved using as little as 400 kg/ha nitrogen and a regime comprising a combination of fertiliser sprays to establish the crop in Phase 1 followed by banding in Phase 2 to row closure and fertigated nitrogen from row closure to harvest (Phase 3) on infertile sandy soil with no previous vegetable cropping history. The final yield did not always rise with increasing rate of nitrogen applied, but was influenced more by the presence and duration of early nitrogen applications and the frequency of applications beyond row closure. Yields increased with at least six establishment sprays in the first 21 days after planting and there was a trend for higher yields with weekly applications of nitrogen after row closure. This contrasts with previous lettuce research that showed four sprays to be sufficient in summer and no requirement for applications after row closure.

This trial was marred by a lack of size uniformity between inner and outer rows of ‘four-row’ beds. The causes of this problem need to be investigated in future trials.

Further work with summer celery should look at combining three to four weeks of spraying initially, followed by banding with Nitrophoska Blue Special until row closure, followed by weekly applications of nitrogen sprayed or fertigated until harvest. The method of applying establishment sprays needs to be investigated to ensure uniformity of inner and outer rows on beds.

Winter 2007

Introduction

This autumn crop was expected to be of longer duration and so further clarification of nitrogen rates and timing was the aim of this trial. Treatments emphasised the length of Phase 1 and the use of a range of nitrogen rates in Phase 3.

Method

This crop was preceded by a broccoli crop which was harvested between 11 and 18 April. Poultry manure (see Table 4.3 for the analysis) was applied at and incorporated into all treatment one plots a week prior to planting at 70 m^3/ha.

Table 4.3 **Fresh poultry manure analysis results**

Moisture content (%)	Nitrogen (% dry weight)	Phosphorus (ICP) (% dry weight)	Potassium (ICP) (% dry weight)	Ammonium nitrogen (% dry weight)	Nitrate nitrogen (% dry weight)	Potassium (HCO_3) (mg/kg)
50.4	4	1.47	1.49	0.65	< 0.01	15400

The remaining treatment plots received only 150 kg/ha of Hi-Trace® as a base dressing. Seedlings (cultivar 'Big Ben') were bought in from a specialist nursery and planted on 5 July 2007. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants. No pre-plant drench was applied. There were 28 plants per plot.

Immediately after transplanting, Gesagard® (prometryn 500 g/L) was applied at 2.2 kg/ha for weed control and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Ten different fertiliser regimes were applied to the celery crop as shown in Table 4.4. In addition, an overall application of magnesium sulphate at 300 kg/ha plus borax at 15 g/L was sprayed over the crop at row closure.

Table 4.4 **Schedule of treatments applied to a winter celery crop. Row closure (#) is between days 42 and 49. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat-ment	**Pre-plant**	**Day number**																					
		1	**4**	**7**	**10**	**14**	**17**	**21**	**24**	**28**	**35**	**42#**	**49**	**56**	**63**	**70**	**77**	**84**	**91**	**98**	**105**	**110 (Harvest)**	**Total N (kg/ha)**
1	PM (70 m^3/ha)			40		40		PM (15 m^3/ha)		40	40	40	40	40	40	40	40	40	40	40	40		560.0
2		S1	S1	S1	S1	86		86		86	86	86											477.2
3		S1	S1	S1	S1	102		102		102	102	102											557.0
4		S1	S1	S1	S1	S1	S1	102	102	102	102	102											478.8
5		S1	S1	S1	S1	S1	S1	27.7		27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7	27.7		430.9
6		S1	S1	S1	S1	S1	S1	S1	S1	S1	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2		560.2
7		S1	S1	S1	S1	S1	S1	S1	S1	S1	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4		430.4
8		S1	S1	S1	S1	S1	S1	31.3		31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3		477.7
9		S1	S1	S1	S1	36.6		36.6		36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6		559.6
10		S1	S1	S1	S1	S1	S1	S1	S1	S1	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7		477.7

In the weeks where there was a changeover from spraying to banding, the final spray was applied on Tuesday and banding commenced on Thursday of the same week.

S1 = 22.5 kg/ha low biuret urea plus 20 kg/ha potassium nitrate (12.8 kg/ha N per application)sprayed without wash off
PM = Fresh poultry manure broadcast at the rate shown
= Nitrophoska Blue Special® (12-5.2-14) banded between outer pairs of rows (rate of nitrogen per hectare shown)
= Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen per hectare shown)
= Lysimeters under these plots

.

Results

Figure 4.7 shows crop growth after 34 days. Growth of treatment 1, the grower control was more even and superior to other treatments. Growth of treatments 2 and 3 which had received two bandings by then was inferior. This suggests that development at that stage was not sufficient to utilise the banded fertiliser. Treatment 6 which had been sprayed up to that stage was slightly greener but just as uneven.

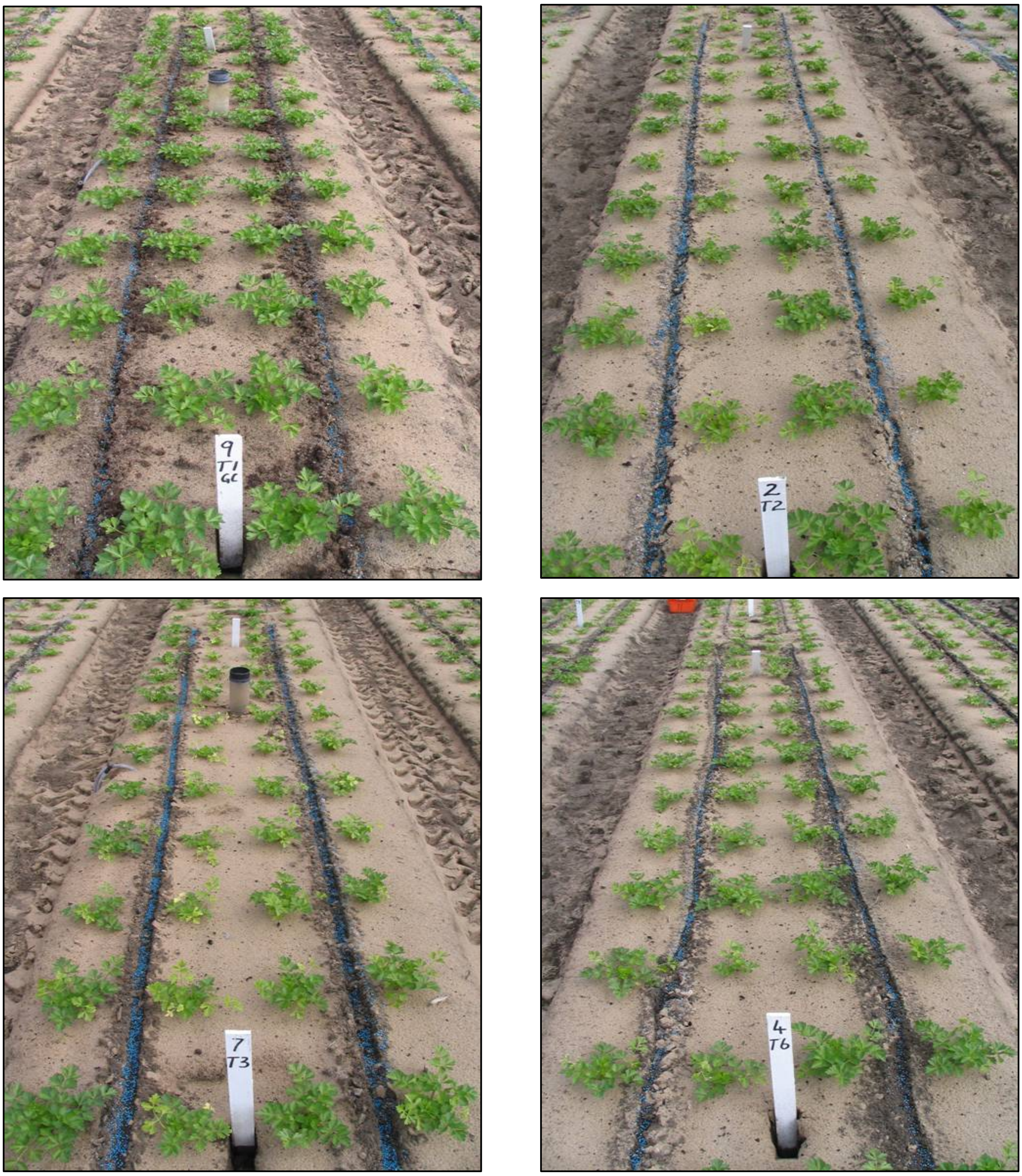

Figure 4.7 **(clockwise from upper left. Growth of celery in treatments T1, T2, T3 and T6 as at 8 August, 34 days after transplanting**

These differences persevered throughout the trial and Figure 4.8 shows the same treatment plots at 75 days.

The crop was harvested on 23 October 2007 (110 days). Plants were trimmed to marketable size in the field and then trimmed further to length in the shed prior to weighing. Plants were weighed individually and any defects recorded.

Data were analysed in Genstat. using ANOVA. Mean head size was greatest for treatment 1, the grower control. When marketable yields, using either 1.0 or 1.2 kg as the minimum market weight were calculated, results were similar, with treatment 1 still significantly better than all other treatments (see Figure 4.9).

Figure 4.8 **Treatments T1, T2, T3 and T6 (clockwise from upper left) on 19 September 2007, 76 days after transplanting**

Excluding treatment 1, using a minimum marketable weight threshold of 1.0 kg, treatments 6, 7, 8, 9 and 10 were all not significantly different from each other whereas for a minimum marketable weight threshold of 1.2 kg, treatments 6, 8, 9 and 10 were not significantly different.

Treatments 2, 3 and 4, which did not receive additional nitrogen after row closure, yielded significantly less that all other treatments. This was despite receiving similar total nitrogen to treatments 6, 8, 9 and 10.

There was an indication that eight spray applications in the first 21 days, rather than four, increased yield. For example, T6, which received a similar rate of nitrogen to T9 but had eight sprays instead of four, yielded 5 t/ha more.

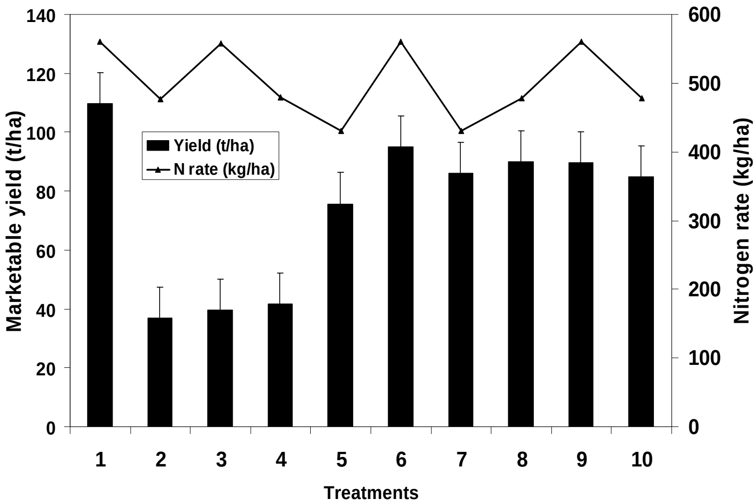

Figure 4.9 **Comparison of marketable yield of celery grown using a range of fertiliser treatments**

Conclusion

The significant result from this trial was the confirmation that celery requires fertiliser application after row closure.

The duration of spray treatments during Phase 1 had little effect on final yield. Longer spray durations reduced overall fertiliser application rates but need to be balanced against the additional labour requirements for the spray operations. Extending the length of Phase 1 by spraying for 28 days was associated with improved uniformity of the marketable product as shown in Table 4.5. Treatments 2, 3 and 4 which had no fertiliser application post-row closure were the most uneven. Each had a coefficient of variation more than double that of the other treatments (see Table 4.5).

Table 4.5 **Comparison of variation between treatments in the autumn celery trial**

Treatment	1	2	3	4	5	6	7	8	9	10
Mean head weight (g)	1729.5	578.5	623.8	655.5	1192.3	1495.8	1355.0	1416.8	1413.5	1338.3
Coefficient of variation (%)	18.1	38.1	43.5	37.8	18.4	15.8	13.9	16.2	19.3	15.8

While treatment 1, the grower control, performed better than all other treatments it must be remembered that it effectively had more nitrogen than the other treatments. The nitrogen component of the chicken manure was not factored into the initial calculations. The 85 m^3 of manure used contained more than 600 kg nitrogen. Even if a significant proportion was leached, it still suggests the superior performance was due to additional nitrogen and treatments 6, 7, 8 and 9 were actually much more fertiliser-efficient than treatment 1.

The final yields of celery exceeded those of the previous trial by about 10 t/ha and this was achieved using similar or slightly higher rates of nitrogen.

Summer 2009

Background

In this trial emphasis was placed on ways to further reduce costs of fertiliser and labour. A revised Phase 1 spray treatment in which the twice-weekly spray was replaced with a single spray at twice the rate was evaluated. We also looked at granular broadcast fertilisers as substitutes for spraying in Phase 1, potentially reducing labour costs for application and slowing the rate of nutrient leaching. Several treatments which used a low rate of broadcast granular NPK fertiliser at planting time to try and increase yields in the spray treatments were also included. At the time fertiliser costs had risen steeply and two treatments utilised Turf Special® in Phases 1 and 2 as a cheaper alternative to Nitrophoska Blue Special®.

Method

The trial bay had been recently planted to broccoli which was harvested between 28 November and 4 December. Soil tests at the beginning of the previous trial had shown good levels of phosphorus and potassium so no pre-plant fertilisers were applied apart from a spray of magnesium sulphate at 300 kg/ha (30 kg/ha Mg) the day before planting.

Seedlings for the trial (cultivar 'Tango') were bought in from a specialist nursery and planted on 22 January 2009. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting Dacthal® (6 kg/ha) was applied and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

The 12 fertiliser treatments in this trial are shown in Table 4.6. In addition, an overall application of magnesium sulphate at 300 kg/ha plus borax at 15 g/L was sprayed over the crop at row closure.

Table 4.6 **Schedule of treatments applied to summer celery. Row closure was between days 42 and 49. All quantities are in kg/ha of nitrogen (as contained in the product)**

Treat-ment	**At plant-ing**	**Day number**																	**Total**		
		0	**3**	**7**	**10**	**14**	**17**	**21**	**24**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**83 (Harvest)**	**N**	**P**	**K**
1		S1	S1	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	S4	S4	S4	S4	S4		510.4	78	424.3
2		S1	S1	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	S3	S3	S3	S3	S3		504.4	78	272.3
3	Nitro2	S2		S2		S2		S2		Nitro5	Nitro5	Nitro5	S4	S4	S4	S4	S4		534.4	88.4	452.5
4	Nitro2	S2		S2		S2		S2		Nitro5	Nitro5	Nitro5	S3	S3	S3	S3	S3		528.4	88.4	300.5
5	Nitro2	S1	S1	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	S4	S4	S4	S4	S4		534	88	453
6	Nitro2	S1	S1	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	S3	S3	S3	S3	S3		528.4	88.4	300.5
7	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	Nitro5	Nitro5	S4	S4	S4	S4	S4		512	114.4	462.2
8	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	Nitro5	Nitro5	S3	S3	S3	S3	S3		506	114.4	310.2
9	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	Nitro5	Nitro5	S6	S6	S6	S6	S6		514	114.4	462.2
10	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	Nitro5	Nitro5	S5	S5	S5	S5	S5		508.5	114.4	310.2
11	Turf1		Turf1	Turf1	Turf1	Turf1	Turf1	Turf1	Turf1	Turf5	Turf5	Turf5	S4	S4	S4	S4	S4		518.9	41.4	294.6
12	Turf1		Turf1	Turf1	Turf1	Turf1	Turf1	Turf1	Turf1	Turf5	Turf5	Turf5	S3	S3	S3	S3	S3		512.9	41.4	142.6

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N:7.5K) without wash off
S2 = Spray 40 g/L urea + 40g/L KNO_3 at 1000 L/ha (24N:15K) without wash off
S3 = Spray 50 g/L urea at 2000 L/ha (46 N:0K) wash off after row closure
S4 = Spray 40 g/L urea + 40g/L KNO_3 at 2000 L/ha (46.5-0-30.4) wash off after row closure
S5 = Spray 150 g/L calcium nitrate 2000 L/ha (46.5 N:0K) wash off after row closure
S6 = Spray 120 g/L calcium nitrate + 40 g/L KNO_3 at 2000 L/ha (46.5-0-30.4) wash off after row closure
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro5 = Nitrophoska Blue Special 500 kg/ha (60N)

Turf 1 = broadcast Turf Special 100 kg/ha (12N)
Turf 5 = banded Turf Special 500 kg/ha (60N)

□ = Lysimeter buried under these plots
□ = Broadcast application
□ = Banded application
□ = Fertigated application

Results

The celery seedlings varied in size so were graded at planting to keep the worst in the buffers as much as possible. Early growth was good and by week 4 there were already marked differences between treatments 1 and 2 and the rest of the crop as shown in Figure 4.10. Treatments 1 and 2 which had no broadcast granular NPK at planting time were noticeably behind the other treatments.

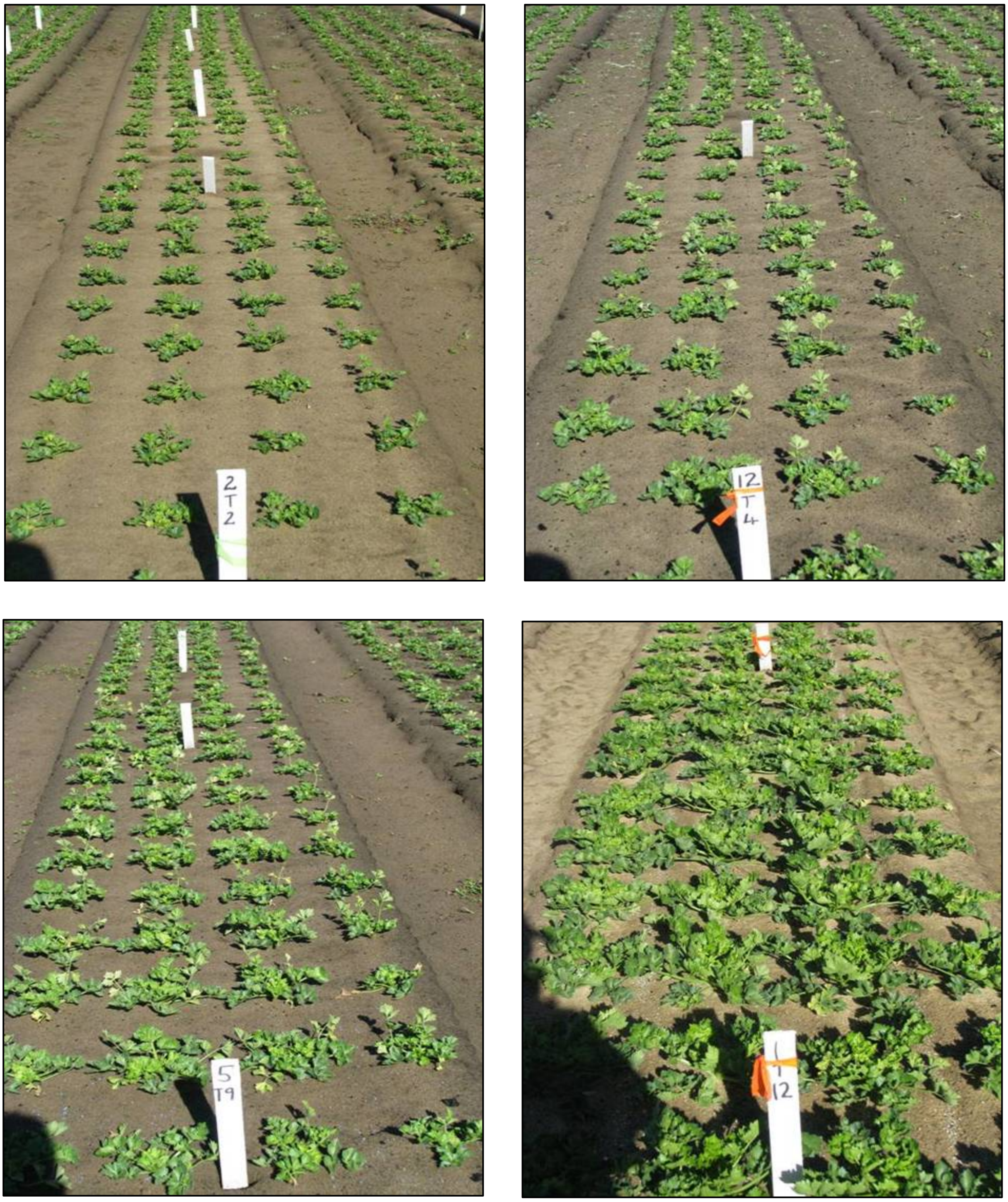

Figure 4.10 **Comparison of celery treatments at 27 days after transplanting. Clockwise from top left: T2 (no pre-plant broadcast fertiliser), T4 (twice-weekly sprays), T12 (twice-weekly Turf Special) and T9 (twice-weekly Nitrophoska Blue Special)**

Treatments 3 and 4 which received only one weekly spray application were slightly behind the twice-weekly spray treatment. Turf Special was performing better than Nitrophoska Blue Special at the early stages but appeared to fall behind the Nitrophoska Blue Special® treatments as the crop progressed.

The crop was harvested on 15 April (83 days after transplanting). Thirty-two plants from each plot were harvested and trimmed of surplus stalks in the field. Once in the shed they were weighed individually and then trimmed to a marketable length and weighed again. Any defects were recorded. A very small amount of *Septoria* leaf spot was noted and some caterpillar damage but nothing related to the treatment.

Analysis of variance using Genstat was performed on both the trimmed and untrimmed data sets. A similar result was obtained for both sets. Treatments 5 to 10 inclusive were all not significantly different from each other (see Figure 4.11). Treatments 1 and 2 which had no granular NPK fertiliser broadcast on the day of planting, remained inferior throughout the trial and were significantly poorer in yield than the six best treatments. Comparison of treatments 1, 3, 5, 7 and 11 (with potassium in Phase 3 fertigation) and treatments 2, 4, 6, 8 and 12 (no potassium in Phase 3 fertigation) showed there was no response to added potassium at that time. This also showed that nitrogen only (as urea or calcium nitrate) needed to be applied beyond row closure as long as sufficient potassium is supplied in Phases 1 and 2. Both Turf Special treatments proved inferior to those with Nitrophoska Blue Special despite receiving comparable amounts of nitrogen – it is likely the low phosphorus content may have been the cause (41.4 kg/ha versus at least double that for other treatments).

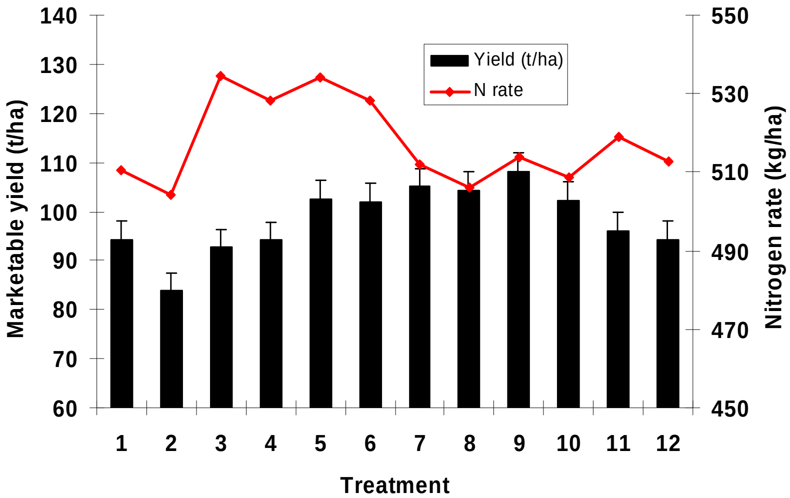

Figure 4.11 **Marketable yield of celery subjected to a range of fertiliser regimes (T1-12) and graphed against applied nitrogen (kg/ha)**

Leaching data

Only one set of lysimeters was installed in this bay. These were placed under treatment 7 which was one that received weekly sprays in Phase 1. Across the three replicates, a range of 249-280 kg N/ha was leached over the duration of the crop. Figure 4.12 shows the bulk of this occurred when irrigation rates were high during the banding period (Phase 2). A few weeks later during March ,when irrigation rates were also high leaching was much lower. Clearly the fertiliser applied at that time was being used more efficiently by the crop whereas in February a substantial amount of the banded fertiliser was bypassing the root zone.

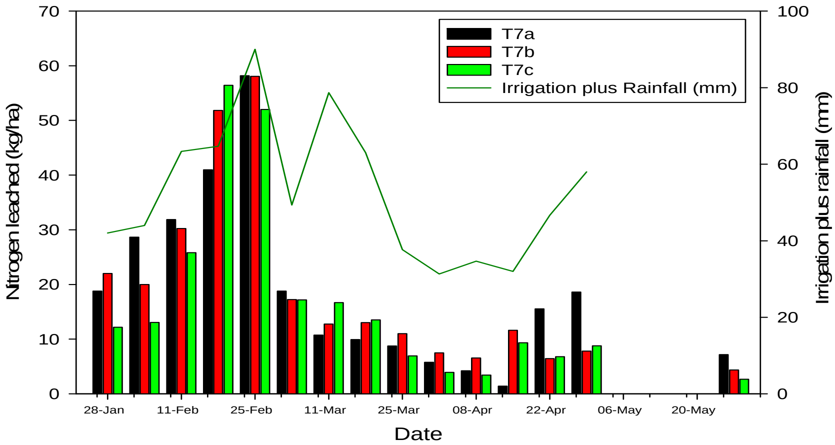

Figure 4.12 **Leaching of nitrogen from treatment 7 in relation to applied irrigation and rainfall during the summer celery trial (note the crop was harvested on 15 April)**

Conclusion

A broadcast application of NPK granular fertiliser at planting followed by twice-weekly spray or broadcast granular NPK applications of fertiliser in Phase 1, banding of granular NPK fertiliser at 500 kg/ha in Phase 2 and then fertigation with urea in Phase 3 to apply a total amount of 500-530 kg/ha nitrogen is a cost efficient way of producing a high quality summer celery crop. Yields of over 100 t/ha were achieved, more than in both previous trials.

Future work needs to concentrate on reducing the amount of fertiliser leaching during the banding phase and evaluating weekly as opposed to twice-weekly applications of granular NPK fertiliser in Phase 1.

Winter 2009

Introduction

In this trial a pre-plant broadcast application of granular NPK fertiliser was adopted as standard practice, as were twice-weekly applications of fertiliser in Phase 1. As this was a winter trial and the prospects for rain and hence leaching, were high, the emphasis was on the use of granular NPK fertiliser in that phase and only two spray treatments were used. In an effort to reduce leaching in Phase 2 the banding rate was reduced to 400 kg/ha instead of 500 kg/ha. Two start dates for banding were trialled—28 and 35 days. The major aim of the trial was to investigate a range of options for Phase 3 and to try and overcome a poor finish for the crop. A range of nitrogen rates with and without potassium was used as well as some treatments with sulphate of ammonia as the source of nitrogen instead of urea, to compare the efficacy of the two fertilisers over the winter period.

Method

The bay for this trial had been recently planted to cabbage which was harvested on 7 April. Soil tests at the beginning of the previous trial had shown good levels of soil phosphorus and potassium so no pre-plant fertilisers were applied apart from a spray of magnesium sulphate at 300 kg/ha (30 kg/ha Mg) the day before planting.

Seedlings for the trial (cultivar 'Tango') were bought in from a specialist nursery and planted on 28 May 2009. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting, Dacthal® (6 kg/ha) was applied and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Ten different fertiliser regimes were applied to the celery crop as shown in Table 4.7. In addition to those treatments, an overall application of magnesium sulphate at 300 kg/ha plus borax at 15 g/L was sprayed over the crop at row closure.

Soil and petiole sampling

In this trial we decided to monitor soil nitrate levels and sap nitrate and potassium in selected treatments. Treatments 4, 7 and 11 were used for the soil and treatments 2, 6, 8, 9 and 10 for the petioles.

Weekly soil sampling was done immediately after fertiliser application. Eight cores were taken from each plot at 0-15 cm depth and at 15-30 cm. Each core was taken in line with plant rows to avoid picking up fertiliser granules from the banding, but otherwise sampling was random over the plot. Cores from each depth were bulked to provide two samples for each of the 12 plots. These samples were taken back to the laboratory for nitrate analysis. Nitrate was determined using Merckoquant® test strips and a R.Q. Flex® meter after 50:50 v/v aqueous extraction (USDA 1999)

Petioles were sampled fortnightly commencing 10 December. Six petioles were taken from the end of each plot so as not to disadvantage the heads for harvesting. These were refrigerated for transport back to the lab and sap was extracted and analysed for nitrate and potassium using Merckoquant® test strips and an R.Q. Flex® meter. Generally a 1:10 dilution was required to obtain a reading within the range of the strips.

Table 4.7 **Schedule of treatments applied to winter celery. Row closure was between days 42 and 49. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat-ment	At planting	Day number																			
		3	7	10	14	17	21	24	28	32	35	42	49	56	63	70	77	84	91	98	105	Harvest
1	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S9	S9	S9	S9	S9	S9	S9	S9	S9	
2	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S4	S4	S4	S4	S4	S4	S4	S4	S4	
3	Nitro2	S1	S1	S1	S1	S1	S1	S1	Nitro4		Nitro4	Nitro4	S2	S2	S2	S2	S2	S2	S2	S2	S2	
4	Nitro2	S1	S1	S1	S1	S1	S1	S1	Nitro4		Nitro4	Nitro4	S3	S3	S3	S3	S3	S3	S3	S3	S3	
5	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S7	S7	S7	S7	S7	S7	S7	S7	S7	
6	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S5	S5	S5	S5	S5	S5	S5	S5	S5	
7	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S4	S4	S4	S4	S4	S4	S4	S4	S4	
8	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S8	S8	S8	S8	S8	S8	S8	S8	S8	
9	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S6	S6	S6	S6	S6	S6	S6	S6	S6	
10	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4		Nitro4	Nitro4	S3	S3	S3	S3	S3	S3	S3	S3	S3	
11	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S7	S7	S7	S7	S7	S7	S7	S7	S7	
12	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	S5	S5	S5	S5	S5	S5	S5	S5	S5	

S1 = Spray 20 g/L potassium nitrate + 20 g/L urea at 1000 L/ha (12N:7.5K) without wash off
S2 = Spray 40 g/L urea + 40 g/L KNO_3 at 2000 L/ha (47.2N:30.4K) and wash off
S3 = Spray 85 g/L sulphate of ammonia + 40 g/L KNO_3 at 2000 L/ha (46.1N:30.4K) and wash off
S4 = Spray 110 g/L sulphate of ammonia at 2000 L/ha (46.2N:0K) and wash off
S5 = Spray 90 g/L sulphate of ammonia at 2000 L/ha (38N:0K) and wash off
S6 = Spray 70 g/L sulphate of ammonia plus 30 g/L KNO_3 at 2000 L/ha (38N:23K) and wash off
S7 = Spray 55 g/L sulphate of ammonia at 2000 L/ha (23.1N: 0K) wash off
S8 = Spray 40 g sulphate of ammonia plus 20 g KNO_3 at 2000 L/ha (22.4N:15.2K) and wash off
S9 = Spray 55 g/L urea at 2000 L/ha (46N:0K) and wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)

□ = Lysimeter buried under these plots
□ = Broadcast application
□ = Banded application
□ = Fertigated application

Results

The crop grew slowly and no real treatment differences were evident until late in the trial. This was not unexpected as the only difference between treatments until Phase 3 was in treatments 3 and 4 during Phase 1 where fertiliser was sprayed rather than broadcast (Figures 3.13 and 3.14).

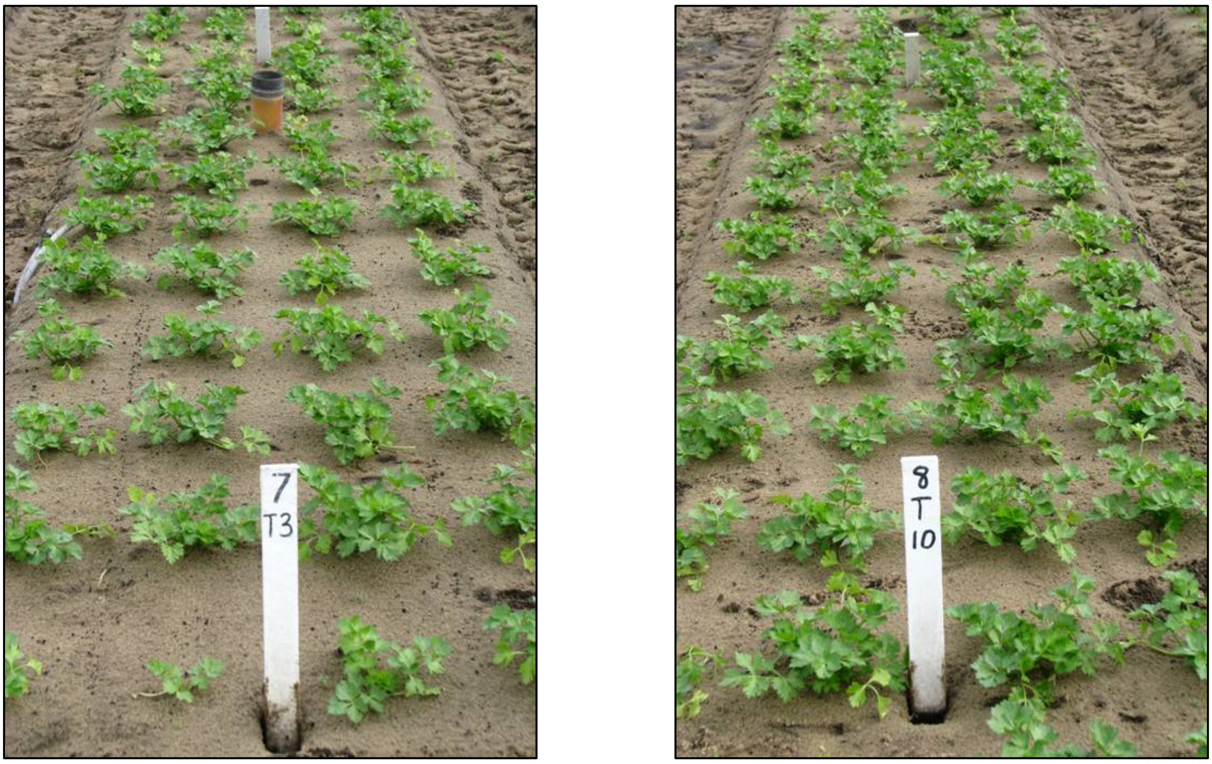

Figure 4.13 **Treatments 3 (left) and 10 (right) compared at 34 days after transplanting when fertiliser applications were the same for most treatments**

Figures 4.14 **Despite appearances, treatment 4 (left) proved to be significantly better than treatment 5 (right) by the end of the trial**

The crop was harvested on 14 September. Thirty-two plants from each plot were harvested and trimmed of surplus stalks in the field. In the shed, they were weighed individually and then trimmed to a marketable length and weighed again. Any defects were noted.

Analysis of variance using Genstat gave the same results for both trimmed and untrimmed heads. Treatments 1, 3, 4, 8, 9 and 10 yielded best.

There was a high incidence of infection by *Sclerotinia* at harvest but analysis of variance showed it was not related to treatment.

Sulphate of ammonia by itself in Phase 3 appeared to have an adverse effect on growth. For example, treatment 1 which had a high rate of urea in Phase 3 produced a higher yield than treatment 2 which had the same amount of nitrogen in Phase 3 supplied as sulphate of ammonia (see Figure 4.15). However, in treatments 3 and 4, when sulphate of ammonia was supplemented with potassium nitrate, this effect disappeared.

There was no response to potassium in Phase 3.

Comparison of treatments 2 and 7, 5 and 11, or 6 and 12 suggests there is no yield difference between banding at 28 or 35 days.

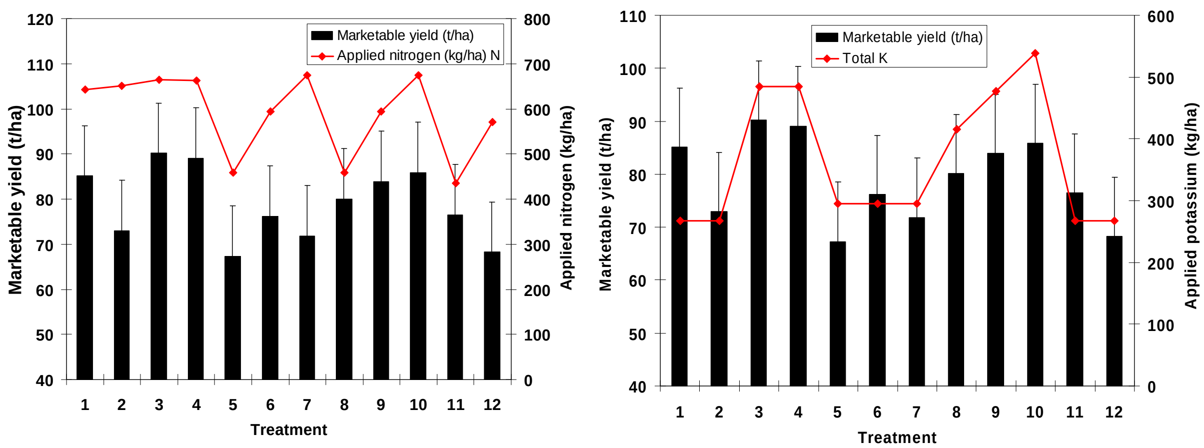

Figure 4.15 **Comparison of response of a winter celery crop to a range of selected fertiliser regimes and graphed against applied nitrogen (left) and potassium (right)**

Soil nitrate

Figure 4.16 shows the trends of three treatments over time. For all treatments soil nitrate levels generally decreased. Nitrate levels for T4 were higher after the start of fertigation (Phase 3). This was undoubtedly because T4 contained both ammonium sulphate and potassium nitrate i.e. both forms of nitrogen in the fertigation. Soil nitrate levels in T7 remained lower due to the time required to convert ammonium to nitrate or nitrogen loss from volatilisation. T11 had the lowest levels of nitrogen in Phase 3.

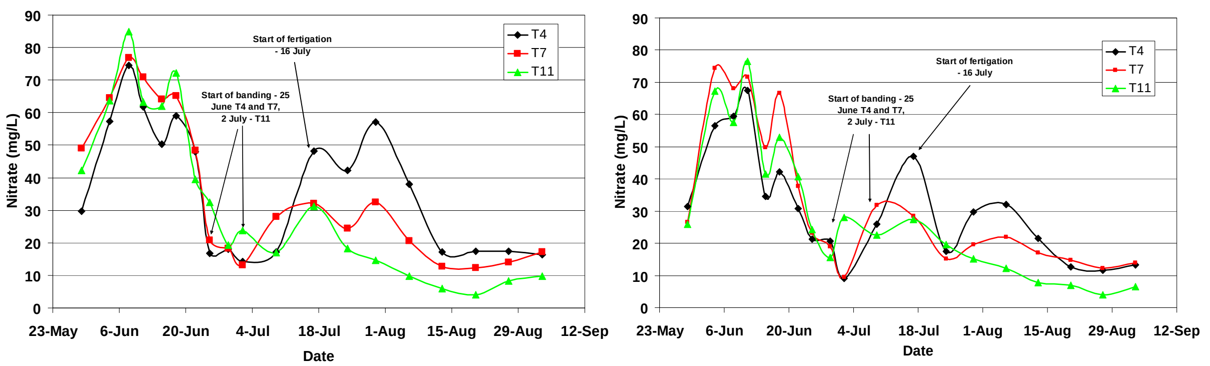

Figure 4.16 **Trends in soil nitrate under three selected fertiliser regimes in a winter celery crop at 0–15 cm (left) and 15–30 cm (right)**

Petioles

Nitrogen levels in the petioles varied widely between treatments as shown in Figure 4.17. T10 which received both ammonium sulphate and potassium nitrate during fertigation (Phase 3) consistently showed the highest nitrogen levels. T2 had the same amounts of nitrogen applied as ammonium sulphate only and its sap nitrate levels were always 600-900 mg/L less. T8 received the least nitrogen in the fertigation and this seemed to be reflected in the rapidly dropping sap nitrate levels in the latter stages.

There was little variation in sap potassium levels between treatments.

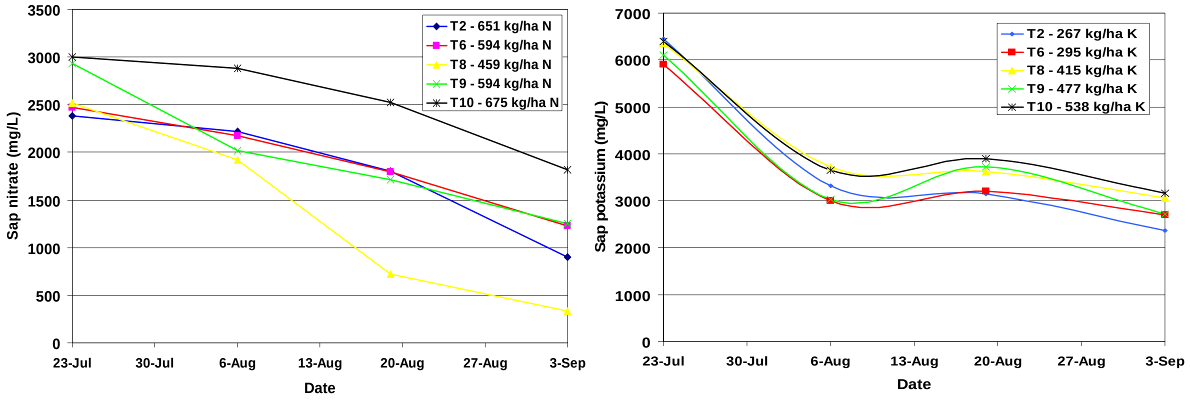

Figure 4.17 **Comparison of trends in celery sap nitrogen and potassium levels between selected treatments**

Leaching data

Over the entire trial, the quantity of nitrogen leached ranged from 223 to 296 kg/ha. Because this trial was conducted during the winter months it was expected that rainfall events might affect leaching. Figure 4.18 shows the high level of correlation between rain and nitrate leaching.

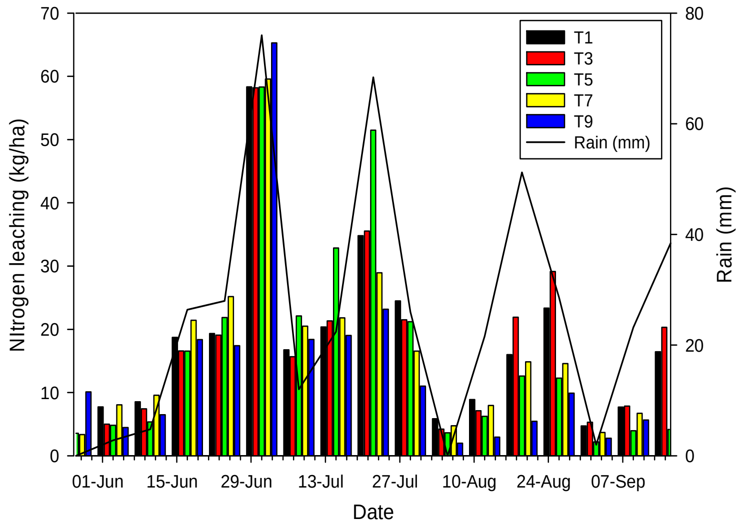

Figure 4.18 **Nitrogen leaching and weekly rainfall during the trial**

Conclusion

Table 4.8 summarises the treatment results with the highest yielding options shaded in grey. Nitrogen ranged from 459 to 665 kg/ha, however the cost difference between treatments is a reflection of nitrogen source rather than nitrogen rate. Urea is still by far the cheapest option, however, both urea treatments also leached the most nitrogen.

According to the literature, celery has no preference for nitrogen form (Santamaria et al. 1999) but it does seem likely that over winter, the slower conversion of the ammonium in ammonium sulphate to nitrate is having an adverse effect on crop growth. This seems to be supported by the fact that all treatments that combined potassium nitrate with sulphate of ammonia in Phase 3 performed better despite similar amounts of nitrogen being present—due to the more readily available nitrate rather than the additional potassium. This hypothesis is also supported by a comparison of treatments 1 and 3 which were not significantly different despite treatment 3 containing substantially more potassium. Urea alone gave good results at relatively low cost when fertigated in Phase 3 (treatment 1) confirming the result from the preceding summer trial.

Table 4.8 **Summary of applied fertiliser and costs for each treatment applied to a winter celery trial**

Treatment	**Total nutrient applied in kg/ha**			**Total cost of fertiliser applied $/ha**
	Nitrogen	**Phosphorus**	**Potassium**	
1	642	99	267	**2903**
2	651	99	267	**2962**
3	665	73	484	**4318**
4	663	73	484	**4394**
5	459	109	295	**2843**
6	594	109	295	**3070**
7	675	109	295	**3199**
8	459	109	415	**3602**
9	594	109	477	**4225**
10	675	109	538	**4750**
11	435	99	267	**2369**
12	570	99	267	**2596**

Summer 2009-10

Introduction

Concerns about leaching of nitrate from celery trials especially during banding led us to try modifying the pattern of application to better match crop growth. Previous trials prioritised a simple recipe to assist with grower adoption but this may not be the best way to reduce leaching. A review of the literature enabled us to formulate a stepped pattern of nitrogen applications that better matched the slow initial growth of celery.

In addition, earlier trials had not examined the use of weekly granular NPK applications and this was incorporated into some of the treatments.

Two treatments replaced the first banding with fertigation due to concerns expressed that the first banding could be having adverse effects on plant growth. Photographs of roots beneath a celery crop (Figure 4.19) clearly showed that after the first banding there was an apparent movement of root growth away from directly under the band.

Figure 4.19 **Rooting pattern under a celery crop 43 days after transplanting and shortly after the first banded application of granular NPK fertiliser**

Method

This trial bay was previously planted to cabbage harvested on 8 and 17 September. No pre-plant fertilisers were applied apart from a spray of magnesium sulphate at 300 kg/ha (30 kg/ha Mg) the day before planting.

Seedlings for the trial (cultivar 'Tango') were bought in from a specialist nursery and planted on 22 October 2009. Seedlings were planted at four rows per bed with 300 mm between rows and 420 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting Dacthal® (6 kg/ha) was applied and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 21 with applications not exceeding 4 mm per irrigation
- 1.25 times EPan from day 22 to day 42 with applications not exceeding 6 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Twelve different fertiliser regimes were applied to the celery crop as shown in Table 4.9. In addition to those treatments, an overall application of magnesium sulphate at 300 kg/ha plus borax at 15 g/L was sprayed over the crop at row closure.

Petiole sampling

Sap nitrate and potassium were monitored in selected treatments (T1, T3, T6 and T9).

Petioles were sampled fortnightly commencing 9 December. Six petioles were taken from the end of each plot so as not to disadvantage the heads for harvesting. These were refrigerated for transport back to the laboratory and sap was extracted, diluted as required, and analysed for nitrate and potassium. Generally a 1:10 dilution was required to obtain a reading within the range of the strips.

Table 4.9 **Schedule of treatments applied to summer celery. Row closure was between days 42 and 49. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

	Day number											
Date	**22 Oct**	**26 Oct**	**29 Oct**	**2 Nov**	**5 Nov**	**9 Nov**	**12 Nov**		**19 Nov**		**26 Nov**	**3 Dec**
Treatment	**At planting**	**4**	**7**	**11**	**14**	**18**	**21**	**25**	**28**	**32**	**35**	**42**
1	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1		Nitro4	Nitro4
2	Nitro1		Nitro1		Nitro1		Nitro1		Nitro2		Nitro3	Nitro3
3	Nitro1		Nitro1		Nitro1		Nitro1		Nitro2		Nitro2.5	Nitro2.5
4	Nitro1		Nitro1		Nitro1		Nitro1		Nitro2		Nitro2.5	Nitro2.5
5	Nitro1		Nitro2		Nitro2		Nitro2		Nitro2		Nitro3	Nitro3
6	Nitro1		Nitro1		Nitro1		Nitro1		Nitro2		Nitro2.5	Nitro2.5
7	Nitro1	S0.5	S0.5	S0.5	S0.5	S0.5	S0.5	S1	S1	S1	Nitro3	Nitro3
8	Nitro1	Nitro0.5	Nitro0.5	Nitro0.5	Nitro0.5	Nitro0.5	Nitro0.5	Nitro1	Nitro1		Nitro3	Nitro3
9	Nitro1	S0.5	S0.5	S0.5	S0.5	S0.5	S0.5	S1	S1	S1	Nitro2.5	Nitro2.5
10	Nitro2		Nitro2		Nitro2		Nitro2		Nitro2		Nitro4	Nitro4
11	Nitro1	S1	S1	S1	S1	S1	S1	S1	S1	S1	Nitro3	Nitro3
12	Nitro1	S0.5	S0.5	S0.5	S0.5	S0.5	S0.5	S1	S1	S1	Nitro2.5	Nitro2.5

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12 N: 7.5K) without wash off
S0.5 = Spray 10 g/L urea + 10 g/L KNO_3 at 1000 L/ha (8.97 N: 5.7K) without wash off
N50 = Spray 55 g/L urea (50.6 N) at 2000 L/ha and wash off
NK50 = Spray 43 g/L urea + KNO_3 43 g/L at 2000 L/ha and wash off
N41.4 = Spray 45 g/L urea at 2000 L/ha and wash off
NK41.4 = Spray 35g/L urea + KNO_3 35 g/L at 2000 L/ha and wash off
Nitro0.5 = Nitrophoska Blue Special 50 kg/ha (6N)
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro2.5 = Nitrophoska Blue Special 250 kg/ha (30N)
Nitro3 = Nitrophoska Blue Special 300 kg/ha (36N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)

= Lysimeter
= Broadcast application
= Banded application
= Fertigated application

Table 4.9 continued

Date	10 Dec	17 Dec	24 Dec	31 Dec	7 Jan	Total		
Treatment	49	56	63	70	Harvest	N	P	K
1	N50.6	N50.6	N50.6	N50.6		419.0	93.6	383.7
2	N41.4	N41.4	N50.6	N50.6		340.1	67.6	301.9
3	N41.4	N41.4	N50.6	N50.6		328.1	62.4	287.8
4	N41.4	N41.4	N50.6	N50.6		328.1	62.4	287.8
5	N50.6	N50.6	N50.6	N50.6		383.0	78.0	211.5
6	NK41.4	NK41.4	NK50.6	NK50.6		346.4	62.4	299.9
7	N41.4	N41.4	N50.6	N50.6		339.5	36.4	262.6
8	N41.4	N41.4	N50.6	N50.6		328.1	62.4	287.8
9	N41.4	N41.4	N41.4	N41.4		308.6	31.2	236.3
10	N50.6	N50.6	N50.6	N50.6		419.0	93.6	383.7
11	N41.4	N41.4	N50.6	N50.6		376.1	36.4	284.8
12	N41.4	N41.4	N50.6	N50.6		321.6	31.2	244.7

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N: 7.5K) without wash off
S0.5 = Spray 10 g/L KNO_3 + 10g/L urea at 1000 L/ha (8.97N: 5.7K) without wash off
N50 = Spray 55 g/L urea (50.6N) at 2000 L/ha and wash off
NK50 = Spray urea 43 g/L + KNO_3 43 g/L at 2000 L/ha and wash off
N41.4 = Spray urea 45 g/L at 2000 L/ha and wash off
NK41.4 = Spray urea 35 g/L + KNO_3 35 g/L at 2000 L/ha and wash off
Nitro0.5 = Nitrophoska Blue Special 50 kg/ha (6N)
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro2.5 = Nitrophoska Blue Special 250 kg/ha (30N)
Nitro3 = Nitrophoska Blue Special 300 kg/ha (36N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)

= Lysimeter buried under this plot
= Broadcast application
= Banded application
= Fertigated application

Results

The transplants were very uneven and it was apparent they were collated from two or three separate sowings. As much as possible they were graded so that the worst plants were kept to the buffers.

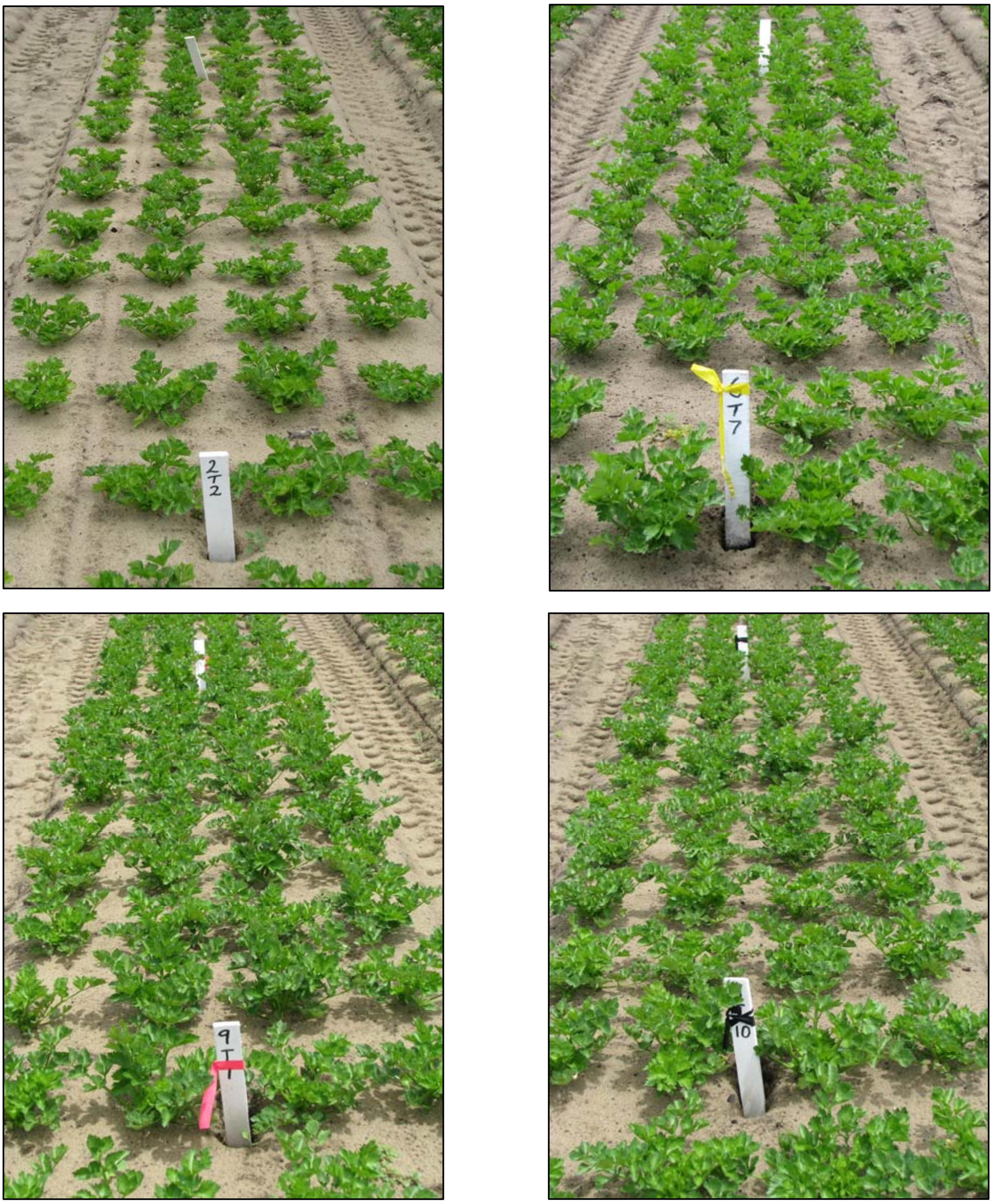

Figure 4.20 **T2 (top left) which had the lowest rates of broadcast Nitrophoska compared to T7 (top right) which had moderate rates of nitrogen applied as twice weekly spray treatments. T1 (bottom left) and T10 both had the highest rates of nitrogen, T1 applied twice weekly and T10 applied weekly. Photographs on 25 November, 34 days after transplanting**

Some differences appeared between treatments within the first four to six weeks (Figure 4.20). These differences seemed to disappear as the trial progressed and by harvest it was hard to see any major difference between the treatments. Despite a slow start, in the last few weeks the crop made rapid progress and was harvested about three weeks ahead of schedule on 7 January (77 days). Thirty-two plants from each plot were harvested and trimmed of surplus stalks in the field. Once in the shed they were weighed individually and then trimmed to a marketable length and weighed again. Any defects were noted.

There was a minor incidence of sclerotina, not related to treatment. Analysis of variance using Genstat, of both trimmmed and untrimmed heads, showed that treatments 1 and 10 were significantly better in both cases (Figure 4.21). Both treatments received the highest amount of nitrogen (419 kg/ha) overall, 200 kg/ha rather than 100 kg/ha of broadcast NPK granular fertiliser at planting and the highest rate of banding in Phase 2. Phase 3 had a flat rate of nitrogen and no additional potassium.

Comparison of treatments 3 and 4 showed a slight benefit to broadcasting instead of banding in Phase 2.

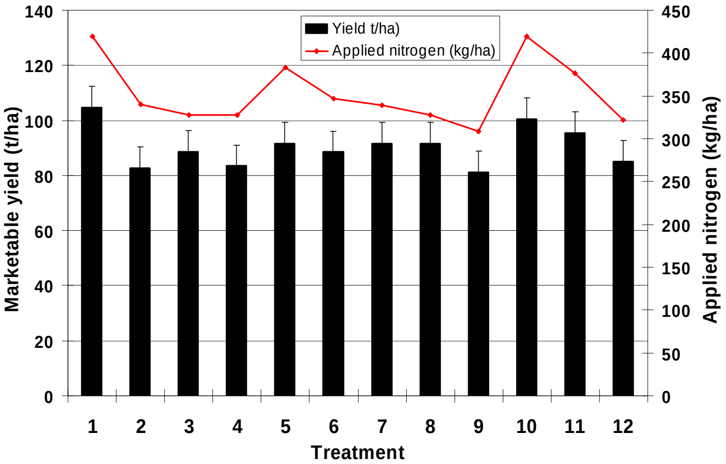

Figure 4.21 **Comparison of marketable yield in a summer celery crop subjected to a range of fertiliser regimes**

The higher yield of treatment 1 compared to treatment 10 (not significant) suggests twice-weekly applications of fertiliser in Phase 1 could be better than weekly applications. Treatment 8 gave significantly higher yields than treatment 4 and this was probably also due to the fact that it had twice weekly rather than weekly application of Nitrophoska in Phase 2.

Leaching data

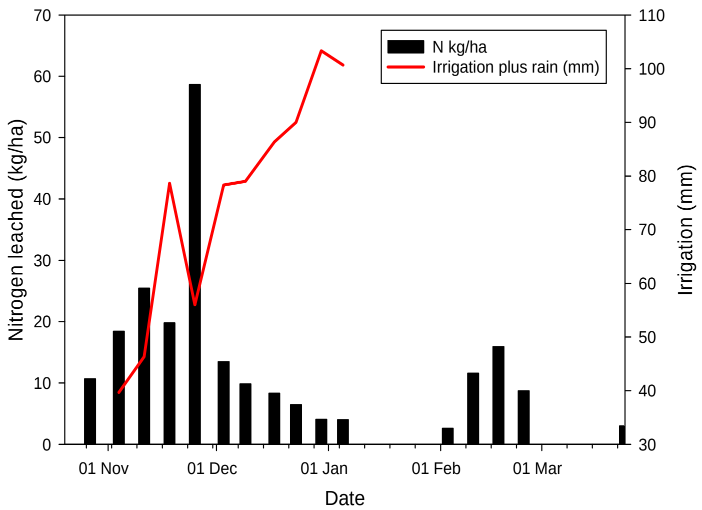

Figure 4.22 **Leaching of nitrogen under treatment 3 graphed with applied irrigation plus rainfall**

Nitrate leaching recorded from treatment 3 peaked in the week ending the 25 November as shown in Figure 4.22. This coincided with the start of banding for most treatments (including treatment 3 which had the lysimeter) and some significant rain events – 10.2 mm on 18 November and 26.8 mm on 19 November. A total of 221 kg/ha of nitrogen was leached from this trial.

Petiole sampling

Sap levels of nitrate nitrogen were quite low in this trial. Starting at around 1000 mg/L they dropped to between 200 and 400 mg/L (in treatment 1) by the end of the trial. Potassium levels started at around 5.5 per cent and dropped to 3.5 per cent.

Conclusion

This crop of celery achieved similar yields to the previous year's summer crop on much less nitrogen, i.e. 100-104 t/ha applying 420 kg of nitrogen compared to 100-108 t/ha applying 500-530 kg/ha of N. In both years the better treatments had granular NPK fertiliser broadcast in Phase 1. This may be applied weekly or twice-weekly to achieve similar results. The omission of banding in Phase 2 and switching straight from broadcasting to fertigation seems a viable option, but highest yields were achieved in treatments where Nitrophoska was banded at a flat rate on days 35 and 42, which was consistent with results from earlier celery trials. This result suggested that the apparent lack of celery roots directly underneath fertiliser bands, thought to be caused by localised fertiliser toxicity, did not adversely affect final yields. There appears to be little benefit in applying additional potassium in Phase 3 and fertigation with urea only is recommended.

5. COS LETTUCE

Summer 2007

Introduction

Cos lettuce is widely transplanted in the field from 'tray-grown' seedlings produced by specialist nurseries in Australia. In Western Australia it is almost exclusively grown this way in commercial practice, and is grown year-round on sandy soils of the Swan Coastal Plain, up to 200 km north and south of Perth.

Cos is often rotated with crops such as celery and broccoli. Traditional practice has been to broadcast poultry manure before planting and/or banding between rows after planting. Mineral fertilisers are also routinely applied as topdressings on these crops, and fertigation is widely used.

The potential benefits of the '3Phase' technique are reduced leaching of fertiliser into groundwater from lower fertiliser applications and better placement than achieved by current commercial practices. This is particularly the case soon after transplanting when the plant has a poorly developed root system and low fertiliser demand.

In Horticulture Australia Project VG04018, Cos lettuce was planted both as a summer and a winter crop. Half the seedling trays were drenched with 40 g/litre potassium nitrate at 500 mL/tray (100 cells) within one hour of planting. Then in each case, plants were subjected to one of five spray treatments (S1 to S5) commencing one day after planting. The treatments were applied twice-weekly for a total of 14 days for the summer crop and 21 days for the winter crop (four or six applications in total).

S1 No spray

S2 40 kg/ha potassium nitrate (KN) only (31.2 kg/ha nitrogen and 91.2 kg/ha potassium in total)

S3 11.3 kg/ha urea (U) only (31.2 kg/ha N in total)

S4 11.3 kg/ha urea plus 40 kg/ha potassium nitrate (62.4 kg/ha nitrogen and 91.2 kg/ha potassium in total)

S5 22.5 kg/ha urea plus 20 kg/ha potassium nitrate (77.7 kg/ha nitrogen, 45.6 kg potassium in total)

This was followed by a series of one of four topdressing treatments as detailed in Tables 5.1 and 5.2. The prilled fertiliser treatments were banded into a shallow furrow between pairs of rows of lettuce commencing 18 days after transplanting and ending at row closure. The liquid fertiliser, Spurt-N® was dissolved in one litre of water per square metre of bed area and spread over the foliage with a watering can. This treatment was immediately washed from the foliage with 2 L/m^2 water, using the same method. The crop also received a foliar spray of borax at 10 g/L at mid growth as a preventive measure for boron deficiency.

Table 5.1 **Topdressing treatments (B1–B4) applied to winter Cos lettuce (kg/ha).**

Topdressing treatment	B1		B2	B3		B4	
Days after planting	**KN**	**AN**	**Nitrophoska Blue Special®**	**KN**	**U**	**KN**	**Spurt-N®**
18	400		550	400		400	
28		200	550		150		200
33		200	550		150		200
39		200	550		150		200
48	500		550	500		500	

Table 5.2 **Topdressing treatments (B1–B4) applied to summer Cos lettuce (kg/ha)**

Topdressing treatment	B1		B2	B3		B4	
Day no.	**KN**	**AN**	**Nitrophoska Blue Special®**	**KN**	**U**	**KN**	**Spurt-N® (kg/ha)**
14	400		550	400		400	
21		200	550		150		200
26	500		550	500		500	

In neither trial was there a clear benefit from the pre-plant drench. S5 applied the highest rate of early nitrogen and was the best treatment in winter but in summer S2 was the recommended option. While no different in terms of yield to S4 or S5, the high incidence of tip burn with the latter two treatments in summer was a concern. B4 proved to be the best topdressing treatment for a winter crop but in summer there was no difference between any of the treatments. B1 is recommended, again to minimise the risk of tip burn together with the lower cost.

This trial aimed to further this work by refining the rate of nitrogen required to grow a crop of Cos lettuce in summer. Other treatments evaluated the optimum length of Phase 1. All treatments were compared with a grower control using conditioned manure as a pre-plant application combined with side dressings of granular NPK fertiliser. The reasons for choosing a granular NPK treatment for this trial instead of the B1 treatment from the previous work was that the price of potassium nitrate had become too expensive and NPK granular fertilisers at fixed rates of application simplified programs, making adoption by growers easier.

Method

Seedlings for the trial (cultivar 'Maximus') were bought in from a specialist nursery and planted on 6 December 2007. The seedling trays were drenched with 40 g/litre potassium nitrate at 500 mL/tray (100 cells) within one hour of planting for all the treatments except for Treatment 1, the grower control. As this crop followed on from a broccoli crop which had a base dressing of double superphosphate and trace elements, only 200 kg/ha K-Mag® was applied as a base dressing. Seedlings were planted at four rows per bed with 300 mm between rows and 300 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting, Kerb® was applied at 3 kg/ha and followed with 6 mm of irrigation.

Figure 5.1 **Planting Cos lettuce at Medina Research Station, 6 December 2007**

The trial was irrigated as follows:

- 1.0 times EPan from days 0 to day 7 with applications not exceeding 3 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Ten different fertiliser regimes were applied to the Cos lettuce crop as detailed in Table 5.3.

Table 5.3 **Schedule of treatments applied to Cos lettuce. Row closure was between days 28 and 35. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat ment	**Pre-plant**	**Day number**												
		0	**3**	**7**	**10**	**14**	**17**	**21**	**24**	**28**	**32**	**35**		**Total N**
1	CM (50 m/ha)			60		60		43		43		43		**250**
2	Seedling drench					66		66		66				**198**
3	Seedling drench	S1	S1	S1	S1	66		66		66				**250**
4	Seedling drench	S1	S1	S1	S1	S1	S1	66		66				**210**
5	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	66				**171**
6	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	66		66		**236**
7	Seedling drench	S1	S1	S1	S1	49.5		49.5		49.5		49.5		**250**
8	Seedling drench	S1	S1	S1	S1	S1	S1	44		44		44		**210**
9	Seedling drench	S1	S1	S1	S1	S1	S1	33		33		33		**178**
10	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1			66		**171**

Note: In the weeks where there is a changeover from spraying to banding, the final spray is applied on Tuesday and banding commences on Thursday of the same week.

S1 = 22.5 g/L low biuret urea plus 20 g/L potassium nitrate in 1000 L/ha water sprayed without wash off (13.11N/kg/ha/spray)

= Nitrophoska Blue Special banded between pairs of rows (Rate of N in kg/ha shown)

= Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen in kg/ha shown)

CM = Conditioned poultry manure

= Lysimeter buried under this treatment

Results

All treatments established and grew rapidly in the first two weeks after planting due to warm weather. Differences between spray treatments were obvious 14 days after planting (Figure 5.2), with T2, the nil spray treatment appearing smaller and nitrogen deficient compared to all other treatments.

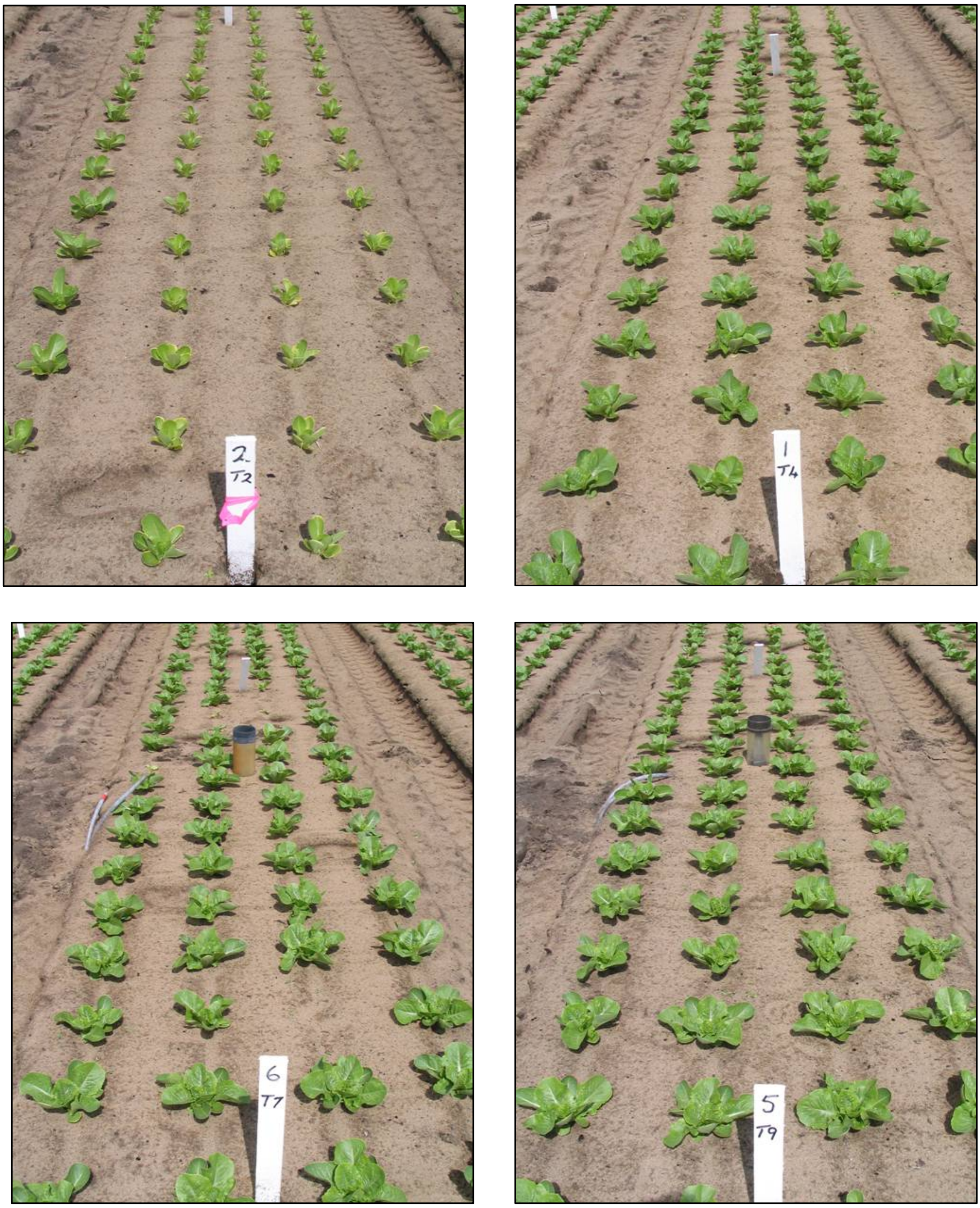

Figure 5.2 **After only 14 days treatment 2 which received no spray lagged behind all other treatments**

Figure 5.3 shows the quality of the crop a week before harvest. The crop was harvested on 15 January (37 days after planting). A total of 32 plants was cut from each plot, outer leaves removed and individually weighed.

Analysis of variance using Genstat showed that treatments 3 and 7 performed significantly better than all others (Figure 5.4). Treatment 1 was similar to treatments 3 or 8. Results correlated well with the amounts of nitrogen applied—the top treatments all receiving 250 kg/ha nitrogen.

Figure 5. 3 **Example of two of the best treatments, T3 (left) and T7(right) the week before harvest**

Marginal leaf scorch was a feature of some treatments (Figure 5.6). T4 was the worst with almost 90 per cent of plants affected but T5 and T3 were also bad (70 and 51 per cent respectively). These treatments did not receive any topdressing after row closure. The treatments that had least scorch were the grower control (T1) and T7 Both of these treatments had received fertiliser until harvest and also received the highest rate of nitrogen (250 kg/ha). However, these were not significantly different to T8, T9 and T10.

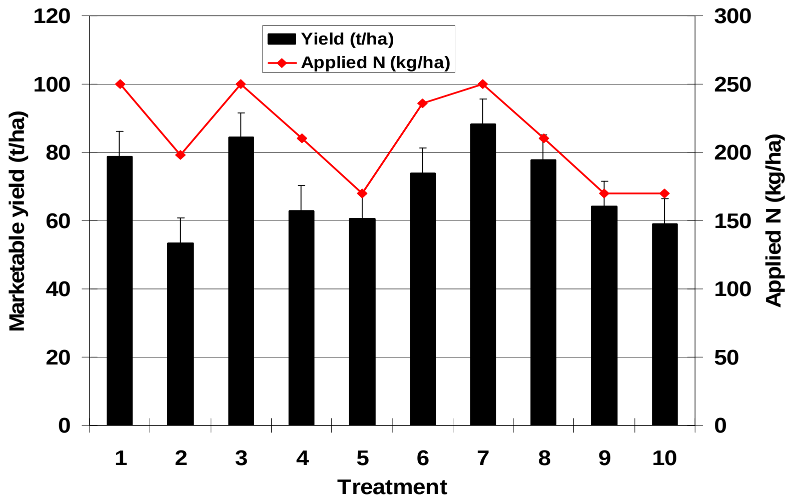

Figure 5.4 **Marketable yield (t/ha) for a summer Cos lettuce crop subjected to a range of fertiliser treatments**

The need for fertiliser application beyond row closure was not proven. T3 received the same amount of nitrogen in total as T7 but T3 had no nitrogen after row closure and yielded almost as much. Treatment 2 which received no fertiliser in the first two weeks was the worst treatment but not significantly different to T5 and T10, both of which received the lowest rate of nitrogen.

Leaching data

Figure 5.5 shows the pattern of nitrate leached from the crop. Leaching from treatment 1, the grower control which was fertilised with conditioned poultry manure, was greater than other treatments and totalled just over 500 kg. The best yielding treatments, 3 and 7, leached 118 and 86 kg or 47 per cent and 34 per cent of nitrogen applied respectively. The lower leaching of treatment 7 suggests a better matching of fertiliser application to growth rate in that treatment.

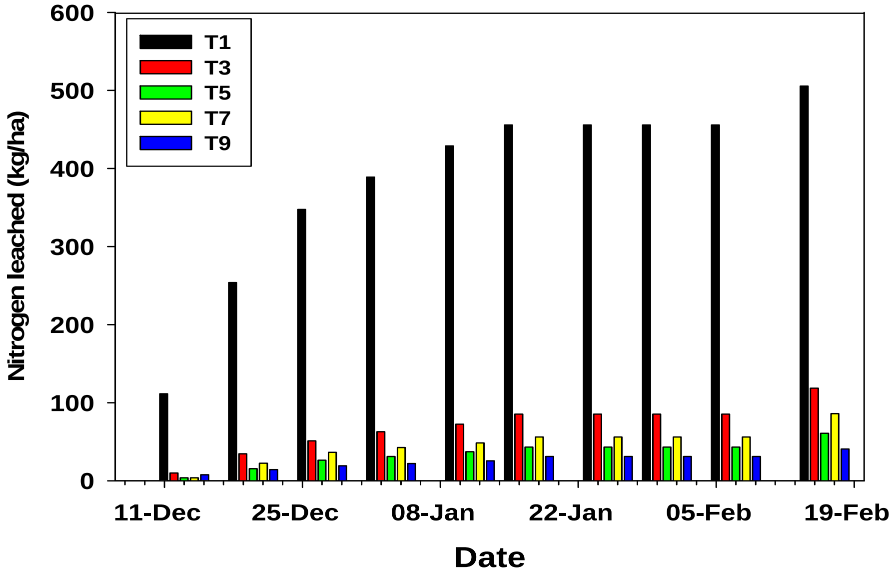

Figure 5.5 **Leaching of nitrogen from a summer Cos lettuce trial for selected treatments**

Figure 5.6 **Example of Cos lettuce from this trial at harvest showing T7 (left) without and T4 (right) with the tipburn problem**

Conclusion

Yields of summer grown Cos lettuce exceeding 80 t/ha can be obtained using as little as 250 kg/ha nitrogen. The need for fertiliser application beyond row closure was not proven. Efforts to reduce nitrogen application by extending the period of spray treatment were unsuccessful. Stepped application rates to better reflect the crop's own growth curve may be able to minimise nitrate leaching.

6. ICEBERG LETTUCE

Spring 2006

Introduction

Iceberg lettuce is widely grown from 'tray-grown' seedlings produced by specialist nurseries in Australia. In Western Australia it is almost exclusively grown this way commercially, year-round on sandy soils of the Swan Coastal Plain, up to 200 km north and south of Perth. Iceberg lettuce is also grown on sandy loam soils in summer in the lower south-west of the State in districts such as Manjimup.

Lettuce is often rotated with crops such as broccoli and celery. Standard nutritional practice has been to use poultry manure as a broadcast treatment before planting and/or banding between rows after planting. Mineral fertilisers are also routinely applied as topdressings and fertigation is widely used. Prior to the recently completed Horticulture Australia Project VG04018, no research had been done to test seedling drenches or fertiliser sprays as establishment treatments for iceberg lettuce.

The potential benefits of our nutritional program, now called '3Phase', are reduced leaching of fertiliser into groundwater from lower application rates and better placement than achieved by current commercial practices. This is particularly so soon after transplanting when the plant has a poorly developed root system and low fertiliser demand.

In the previous project, two trials involved iceberg lettuce, one planted in August and one in December, both using the same range of treatments. Five spray treatments were trialled, each applied in the first 21 days after transplanting. The spray treatments (S1 to S5) were:

S1 No spray

S2 40 kg/ha potassium nitrate only (31.2 kg/ha nitrogen and 91.2 kg/ha potassium in total)

S3 11.3 kg/ha urea only (31.2 kg/ha N in total)

S4 11.3 kg/ha urea plus 40 kg/ha potassium nitrate (62.4 kg/ha nitrogen and 91.2 kg/ha potassium in total)

S5 22.5 kg/ha urea plus 20 kg/ha potassium nitrate (77.7 kg/ha nitrogen, 45.6 kg/ha potassium in total).

These were followed by a series of one of four topdressing treatments as detailed in Table 6.1. The prilled fertiliser treatments were banded into a shallow furrow between pairs of lettuce rows commencing 18 days after transplanting and ending at row closure. The liquid fertiliser Spurt-N® was dissolved in one litre of water per square metre of bed area and spread over the foliage with a watering can. This treatment was immediately washed from the foliage with 2 litres of water per square metre, using the same method.

Table 6.1 **Topdressing treatments (B1-B4) applied to iceberg lettuce (kg/ha)**

Banding treatment	B1		B2	B3		B4	
Days from planting	**KN**	**AN**	**Nitrophoska Blue Special®**	**KN**	**U**	**KN**	**Spurt-N®**
18	400		550	400		400	
28		200	550		150		200
33		200	550		150		200
39		200	550		150		200
48	500		550	500		500	

In both cases the best yields were obtained using a spray treatment consisting of 11.3 kg/ha urea plus 40 kg/ha potassium nitrate four times in the first two weeks after planting then topdressing with Spurt-N® or ammonium nitrate at 200 kg/ha per week to row closure. In summer, there was a benefit from the pre-plant seedling drench.

For the winter crop, Nitrophoska Blue Special® combined with the pre-plant seedling drench produced equivalent yields, but at a higher product cost than the other banding treatments.

After consideration of those results it was decided that future trials needed to test two principal theories:

- whether further economies in fertiliser could be obtained from extending the period of spray treatment
- whether there was any benefit from extending fertiliser application beyond row closure.

Method

The site used was new, with no immediate fertiliser history so a comprehensive base dressing regime was required. Poultry manure was applied and incorporated into all treatment 1 plots a week prior to planting at 70 m^3/ha. The remaining treatment plots received 2500 kg/ha of double superphosphate broadcast, 150 kg/ha of Hi-Trace® and 200 kg/ha K-Mag® over all plots except for treatment 1.

Seedlings for the trial (cultivar 'Silverado') were bought in from a specialist nursery and planted on 31 August 2006. All seedling trays were drenched with 40 g/litre potassium nitrate at 500 mL/tray (100 cells) within one hour of planting except for treatment 1, the grower control. Seedlings were planted at four rows per bed with 300 mm between rows and 300 mm between plants giving a total of 32 plants per plot.

Immediately after transplanting Kerb® was applied at 3 kg/ha and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 7 with applications not exceeding 3 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

The treatments compared a grower control using conditioned manure and banded granular NPK fertiliser with spray treatments in the first two to five weeks followed by banding and then either fertigation or nil fertiliser after row closure. Both the banding and fertigation treatments used a range of nitrogen rates. The total rates of nitrogen applied to the lettuce varied from 196 to 314 kg/ha. Table 6.2 details the fertiliser treatments applied.

Table 6.2 **Schedule of treatments applied to a spring iceberg lettuce crop. Row closure was between days 35 and 42. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	Pre-plant	Day number													
		0	3	7	10	14	17	21	24	28	32	35	42	49	53	Total N
1	CM (70 m^3/ha) applied one week before planting			46.8		55.5		CM (15 m^3/ha)		55.5		52.2	52.2	52.2		314.4 plus CM
2	Seedling drench					65.6		65.6		65.6		65.6				262.4
3	Seedling drench	S1	S1	S1	S1	65.6		65.6		65.6		65.6				314.4
4	Seedling drench	S1	S1	S1	S1	S1	S1	65.6		65.6		65.6				275
5	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	65.6		65.6				235
6	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	65.6				195.6
7	Seedling drench	S1	S1	S1	S1	46.9		46.9		46.9		40.6	40.6	40.6		314
8	Seedling drench	S1	S1	S1	S1	S1	S1	32.8		32.8		43.7	43.7	43.7		275
9	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	26.2		35	35	35		236
10	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	21.9	21.9	21.9		195.6

Note: In the weeks where there was a changeover from spraying to banding, the final spray was applied on Tuesday and banding commenced on Thursday of the same week.

S1 = 22.5 g/L low biuret urea plus 20 g/L potassium nitrate in 1000 L/ha water sprayed without wash off

= Nitrophoska banded between pairs of rows (Rate of nitrogen in kg/ha shown)

= Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen per hectare shown)

CM = Conditioned manure

Results

Figure 6.1 **Comparison of T2, T3 and T7 (left to right) shows that after only 14 days, plants lacking the Phase 1 spray treatment were already noticeably behind other treatments.**

The crop grew well and was relatively even apart from treatment 2 (Figure 6.1). Rain fell frequently during the trial (Figure 6.2) and may have impacted on the spray treatments which were applied over the first 14 to 35 days depending on the treatment. Figure 6.3 shows how reduced growth as a result of omitting the spray treatment in Phase 1 lasts throughout the life of the crop.

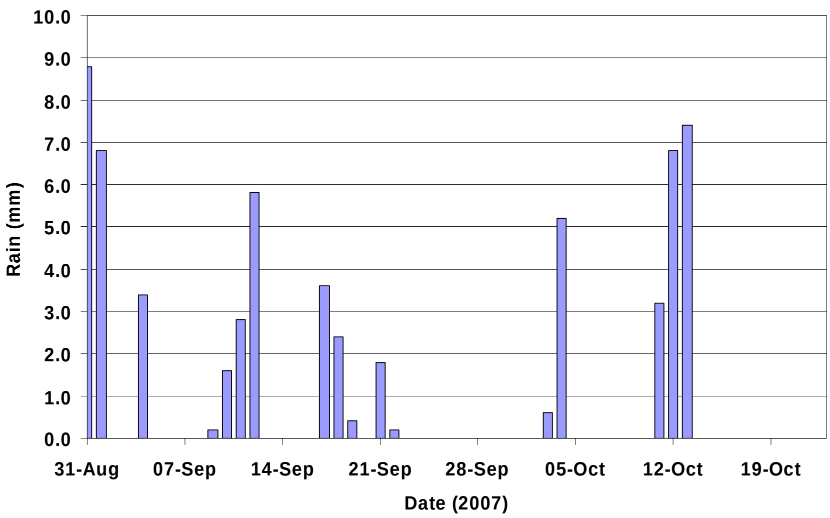

Figure 6.2 **Rain events during the spring iceberg lettuce crop (31 August to 23 October)**

Figure 6.3 **Spring iceberg lettuce at 43 days (10 days prior to harvest) where T2 (left) is still behind T3 (centre and T7 (right)**

The crop was harvested on 23 October, 53 days after transplanting. Heads were picked as for processing with the head plus one wrapper leaf. Each head was weighed separately and the data analysed using Genstat.

Treatment 2 which had no spray treatment had by far the slowest growth despite receiving one of the highest rates of nitrogen overall (Figure 6.4). The other treatments that performed poorly were the two that had five weeks of spray treatments and hence the lowest rate of applied nitrogen (195.6 kg). The remaining treatments all performed equally well despite applied nitrogen ranging from 235 to 314 kg.

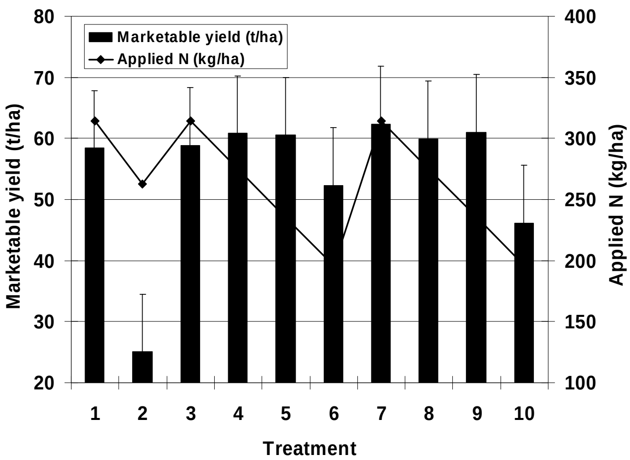

Figure 6.4 **Comparison of marketable yield from a spring lettuce crop grown using a range of fertiliser treatments**

There appears to be no benefit of nitrogen applied post-row closure. Treatments 3 and 7 received identical rates of nitrogen overall but treatment 3 received all of that nitrogen before row closure. This pattern was repeated for treatments 4 and 8 and also treatments 5 and 9. There was no significant difference in yield between any of those treatments.

Conclusion

The use of spray treatments in the early stages of growth has been shown to produce at least equivalent crop yields to those gained by the use of pre-plant applications of conditioned poultry manure.

An iceberg lettuce crop may be grown in winter on as little as 236 kg of nitrogen. Significant economies in fertiliser application rates may be made by applying twice-weekly spray treatments in the first four weeks of growth at no detriment to crop marketable yield. There is no apparent benefit of applying nitrogen after row closure.

Autumn-winter 2007

Introduction

The aim of this trial was to refine the rates of nitrogen required for a winter crop of iceberg lettuce and to determine whether nitrogen applications are needed after row closure during this time of year when maturity times are much longer than in summer.

Method

The bay used was previously planted to celery which was harvested on 19 March 2007. Levels of phosphorus and potassium were assumed to be adequate and so the only base dressing applied prior this trial was 150 kg/ha Hi-Trace®.

Seedlings (cultivar 'Silverado') were bought in from a specialist nursery and planted on 26 April 2007. The seedling trays were drenched with 40 g/L potassium nitrate at 500 mL/tray (100 cells) within one hour of planting with the exception of treatment 1, the grower control.

Seedlings were planted by hand in the field at three rows per bed with 300 mm between rows and 300 mm between plants (88,888 plants/hectare). There were 36 plants per plot. Each plot was equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting, Kerb® was applied by boom-spray for weed control at 3 kg/ha and this was followed with 3 mm irrigation.

Fertiliser treatments

The treatments compared a grower control using conditioned manure and banded granular NPK fertiliser with spray treatments in the first two to three weeks followed by banding and then either fertigation or nil fertiliser after row closure. Both the banding and fertigation treatments used a range of nitrogen rates. The total rates of nitrogen applied to the lettuce varied from 239 to 401 kg/ha.

Table 6.3 outlines the fertiliser treatments applied.

Results

Crop growth was comparatively even except for treatments 1 and 9 (See Figure 6.5).

Apart from a significant fall of rain 12 days into the trial, most rain fell in the latter stages during fertigation (Figure 6.6). It is hard to tell what impact this may have had because at that stage there may have still been significant leaching resulting from the previous celery crop. The leachate collected 8 and 15 days after the trial commenced was equivalent to 71 and 20 kg nitrogen/ha respectively.

An infestation of lettuce aphid became apparent later in the crop and at harvest insects were present in the heads (see Figure 6.7).

The crop was harvested on 6 July, 71 days after planting. Heads were picked for processing with one wrapper leaf. Each head was weighed separately and the data analysed using analysis of variance.

Table 6.3 **Schedule of treatments applied to an autumn iceberg lettuce crop. Row closure is between days 35 and 42. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat-ment	Pre-plant	Day number														
		0	3	7	10	14	17	21	24	28	35	42	49	56	63 Harvest	Total N
1	CM (25 m^3/ha) applied one week before planting			50		50		50		50	50	50	50	50		400
2	Seedling drench	S1	S1	S1	S1	S1	S1	36		36	36	36	36	36		287
3	Seedling drench	S1	S1	S1	S1	S1	S1	72		72	72					287
4	Seedling drench	S1	S1	S1	S1	S1	S1	55		55	55	55	55	55		401
5	Seedling drench	S1	S1	S1	S1	S1	S1	84		84	84					323
6	Seedling drench	S1	S1	S1	S1	S1	S1	42		42	42	42	42	42		323
7	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	72	72					238
8	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	29	29	29	29	29		239
9	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	120	120					334.
10	Seedling drench	S1	S1	S1	S1	S1	S1	S1	S1	48	48	48	48	48		334

Note: In the weeks where there was a changeover from spraying to banding, the final spray is applied on Tuesday and banding commences on Thursday of the same week.
S1 = 22.5 g/L low biuret urea plus 20 g/L potassium nitrate in 1000 L/ha water sprayed without wash off
= Nitrophoska Blue Special banded between pairs of row (Nitrogen rate shown in kg/ha)
= Spurt-N® (32-0-0) sprayed and washed in with irrigation (rate of nitrogen per hectare shown)
CM = Conditioned manure
= Lysimeter buried under this treatment

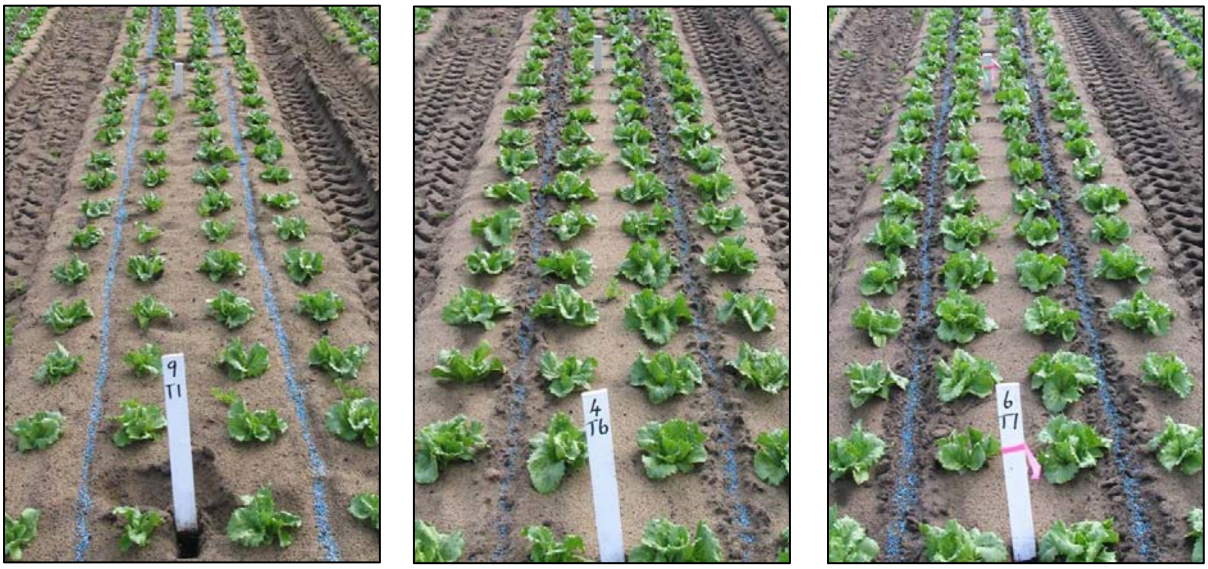

Figure 6.5 **Response of iceberg lettuce to four fertiliser treatments on 23 May, 27 days after transplanting**

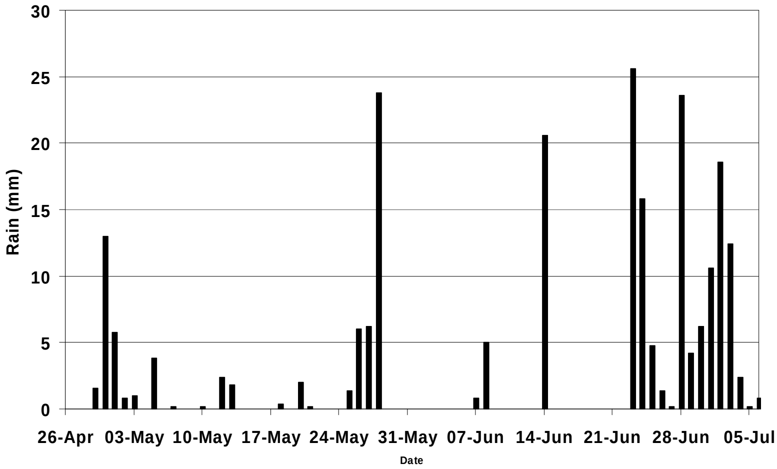

Figure 6.6 **Rainfall during the trial**

Figure 6.7 **Examples of damage from currant lettuce aphid**

Only treatments 1 and 9 were found to be significantly lower in head weight and total weight per plot than all other treatments (Figure 6.7).

The conditioned manure sample used for the pre-plant application was analysed and the results are presented in Table 6.4. The nitrogen levels proved to be extremely low and would have contributed almost nothing to the growth of the crop. All spray treatments performed significantly better.

The impact of little or no pre-plant nitrogen outweighed the fact that the total nitrogen level supplied to the crop was one of the highest, identical to that of treatment 4.

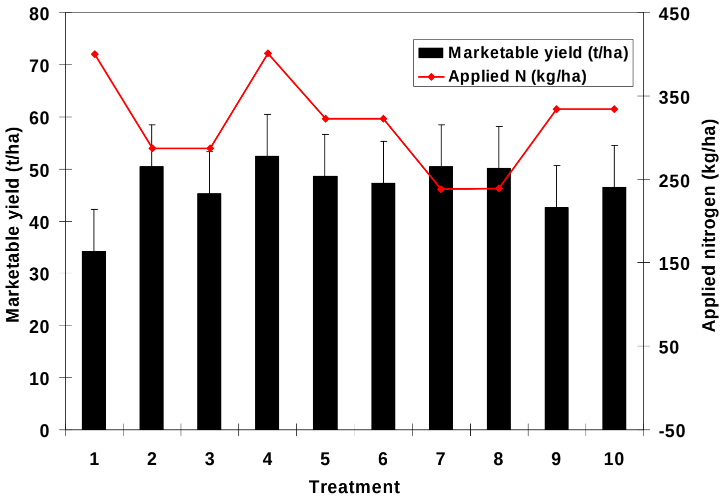

Figure 6.7 **Comparison of marketable yield from a winter lettuce crop grown using a range of fertiliser treatments**

Table 6.4 **Analysis of conditioned poultry manure used in the spring iceberg lettuce trial**

Water content (%) as received	Phosphorus (ICP % (dry basis)	Potassium (ICP) % (dry basis)	Ammonia nitrogen % (dry basis)	Nitrate nitrogen % (dry basis)	Potassium (bicarbonate extraction) mg/kg	Total nitrogen % (dry basis)
61.3	0.83	1.14	0.02	0.14	10700	2.25

The reason for treatment 9 performing poorly is not clear. The yield was very close to being significantly different and so may be simply a result of the variation between replicates in the trial. It performed nearer the average in replicate 3.

It does appear as though fertigation post-row closure at this time of year is unnecessary. There were no significant differences between treatments 3 and 4, 5 and 6, or 7 and 8 even though they have similar amounts of nitrogen overall. The advantage or not, of spraying for the first three weeks and hence earlier banding versus spraying for the first four weeks, is also not clear. Treatments 6 and 10 received similar amounts of applied nitrogen (323 and 334 kg/ha) but their yields were virtually identical.

Conclusion

This trial verified the result from the previous winter crop showing that iceberg lettuce can be successfully grown using only 238 kg/ha nitrogen. The use of four weeks of spray treatments compared with three weeks offers cost efficiencies for growers without yield loss.

Again, the need for fertigation after row closure has been shown to be unnecessary. This is an advantage in commercial cropping situations because it reduces the risk of overspray onto surrounding crops or bare ground where it is not needed and therefore wasted.

Summer 2008

Introduction

This trial concentrated on the timing and rates of nitrogen application, particularly in the first two weeks after transplanting. A granular NPK fertiliser was used in some treatments instead of the sprays. Our seedling drench was retained in one treatment as a control (treatment 12). Weekly or twice-weekly applications were trialled as well as some treatments with urea only in that initial two-week period. In an effort to reduce both costs and leaching during the banding period, two rates of banding (60 or 75 kg/ha/week of N) were evaluated.

Method

Prior to planting some strategic soil sampling was done to determine the need for any pre-plant fertilisers. Ten soil samples (0-15 cm) were taken at random from each plot and bulked across replicates. Results of this testing are shown in Table 6.5.

Table 6.5 **Soil test results prior to summer iceberg crop**

Treatment no.	Nitrate N (mg/kg)	Ammonium N (mg/kg)	Total N (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)
T1	1.92	3.14	0.02	104.9	22.30
T2	1.47	3.29	0.01	116.0	31.30
T3	1.05	2.05	0.01	134.7	26.85
T4	1.12	1.64	0.01	117.4	24.67
T5	1.15	3.07	0.01	86.2	19.21
T6	1.48	2.25	0.01	88.9	12.42
T7	0.89	1.88	0.01	90.7	13.38
T8	1.09	1.75	0.01	103.5	45.32
T9	1.57	1.64	0.01	92.9	14.19
T10	1.12	3.01	0.01	103.2	17.76

Soil test results showed reasonable levels of potassium and phosphorus, so only a top-up application of 1000 kg/ha superphosphate was applied together with 150 kg/ha of Hi-Trace® and 200 kg/ha of K-Mag® one week prior to planting. Seedlings for the trial (cultivar 'Silverado') were bought in from a specialist nursery and planted on 21 February 2008 at four rows per bed with 300 mm between rows and 300 mm between plants. Each trial plot consisted of 32 plants and was equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting, Kerb® was applied at 3 kg/ha and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 7 with applications not exceeding 3 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Table 6.6 details the fertiliser treatments.

Table 6.6 **Schedule of treatments applied to summer iceberg lettuce crop in 2008. Row closure was between days 21 and 28. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	Pre-plant	Day number									
		0	3	7	10	14	21	28	35	42 Harvest	Total N
1	none	S2		S2		Nitro3	Nitro3	Nitro3			**227**
2	none	S3		S3		Nitro3	Nitro3	Nitro3			**227**
3	none	S1	S1	S1	S1	Nitro3	Nitro3	Nitro3			**227**
4	none	S1	S1	S1	S1	S4	Nitro3	Nitro3			**197**
5	none	S4		S4		S4	Nitro3	Nitro3			**199**
6	none	S1	S1	S1	S1	S5	Nitro3	Nitro3			**214**
7	none	Nitro1	Nitro1	Nitro1	Nitro1	Nitro3	Nitro3	Nitro3			**228**
8	Nitro2			Nitro2		Nitro3	Nitro3	Nitro3			**228**
9	none	S1	S1	S1	S1	S4	S4	S4	S4		**167**
10	none	S4		S4		S4	S4	S4	S4		**180**
11	none	S6		S6		S6	S6	S6	S6		**186**
12	none	S1	S1	S1	S1	S6	S6	S6	S6		**171**

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N) without wash off
S2 = Spray 20 g/L KNO_3 + 20 g/L urea at 2000 L/ha (24N) without wash off
S3 = Spray 50 g/L urea at 1000 L/ha (23N) without wash off
S4 = Spray 80 g/L KNO_3 + 10 g/L urea at 2000 L/ha (30N) and wash off
S5 = Spray 50 g/L urea at 2000 L/ha (46N) and wash off
S6 = Spray 120 g /L KNO_3 at 2000 L/ha (31N) and wash off

Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro3 = banded Nitrophoska Blue Special 500 kg/ha (60N)
(green) = Lysimeter buried under these plots
(blue) = Broadcast application
(yellow) = Banded application

Results

Some marginal scorching was apparent in some of the treatments within one week after planting (Figure 6.8). No scorching was noted on any of the broadcast granular fertiliser treatments, nor from S4 (80 g/L KNO_3 plus 10 g/L urea at 2000 L/ha) or S6 (120 g/L KNO_3 at 2000 L/ha) spray treatments (Figure 6.9), however the S1, S2 and S3 spray treatments which all contained at least 20 g/L of urea caused marginal scorch. Despite this damage, the crop subsequently grew well and by harvest those leaves scorched by the spray treatments were not part of the marketable head and therefore inconsequential.

Figure 6.8 **Treatments such as T2 (left) and T11 (right) showed signs of marginal scorching within a week of transplanting**

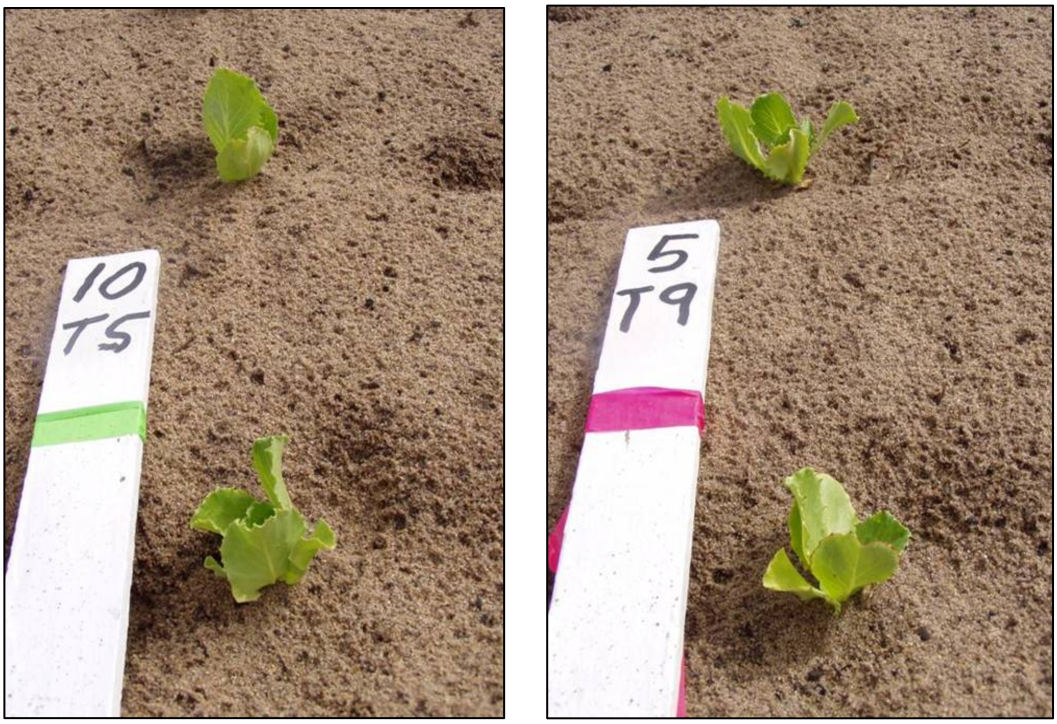

Figure 6.9 **Treatments 5 (left) and 9 (right) showed no signs of burning from their sprays**

Growth of the crop as a whole appeared to be uneven as early as seven days after planting. The unevenness was random. In some plots, growth at the western end tended to be better, but in other plots, the two centre rows were larger. In other plots outer rows either on both sides or one side only was better (Figure 6.10). It was not confined to either spray or granular fertiliser treatments. This unevenness prevailed throughout the trial. Ratings of each plot in the first weeks recorded this effect and were used to plan strategic soil sampling at the end of the trial to see if a cause could be determined.

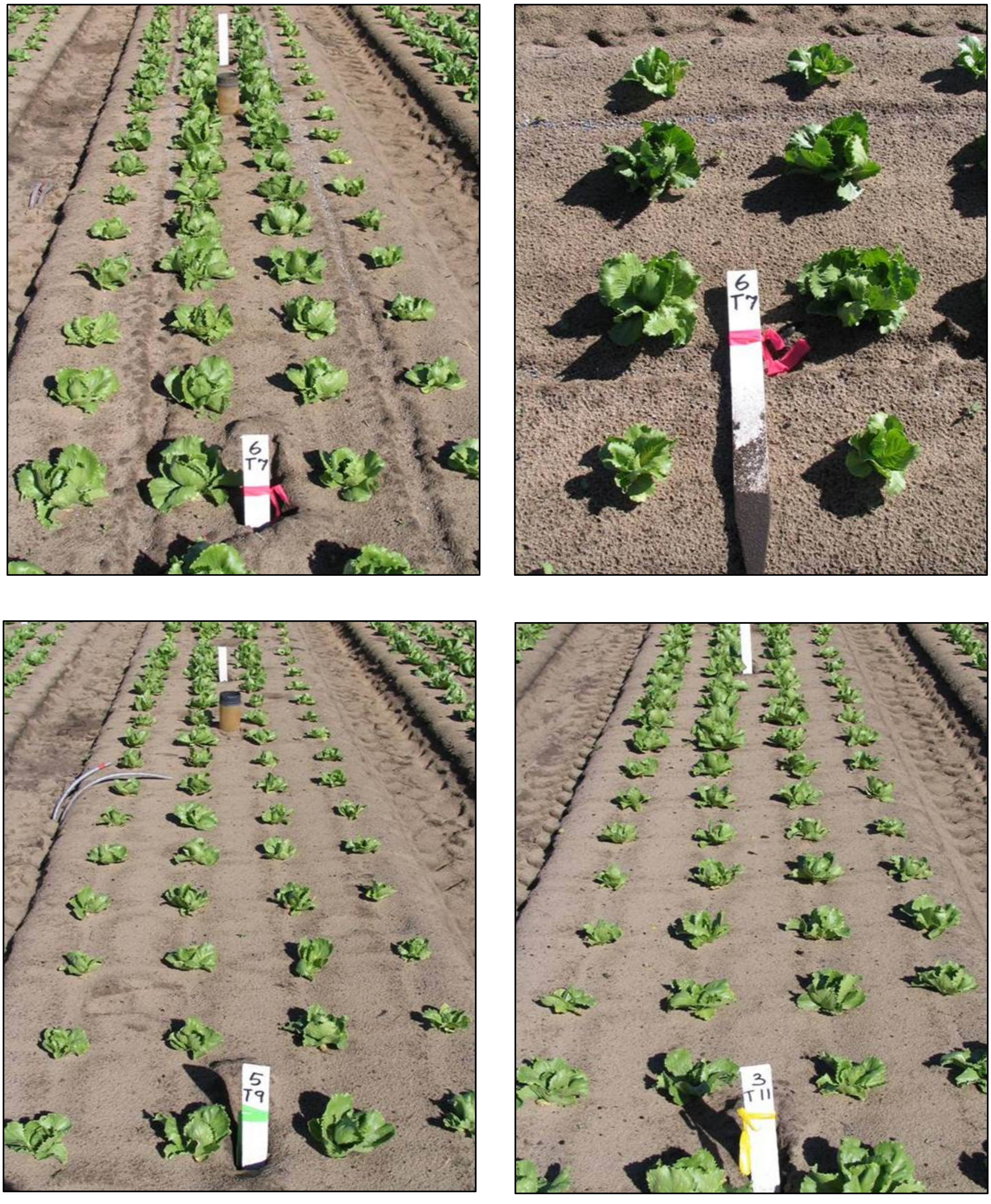

Figure 6.10 **Examples of unevenness in the summer lettuce crop at 50 days after transplanting**

The crop was harvested on 3 April, 42 days after transplanting. Timing of harvest was difficult due to the uneven growth. Many plants were not going to produce marketable heads so it was decided to harvest when the majority of 'good' heads were ready. This date proved to be a little early for many treatments but on close examination, seed head development was already starting on the more advanced plants so further delay would have been inadvisable. Some very hot days early in the trial may have caused this problem.

Heads were picked as for processing with one wrapper leaf. Each head was weighed separately and the data analysed using analysis of variance.

Due to the extreme variation within plots there was a very high least significant difference and only four treatments proved to be significantly worse than the others – treatments 6, 9, 10 and 11 (Figure 6.11).

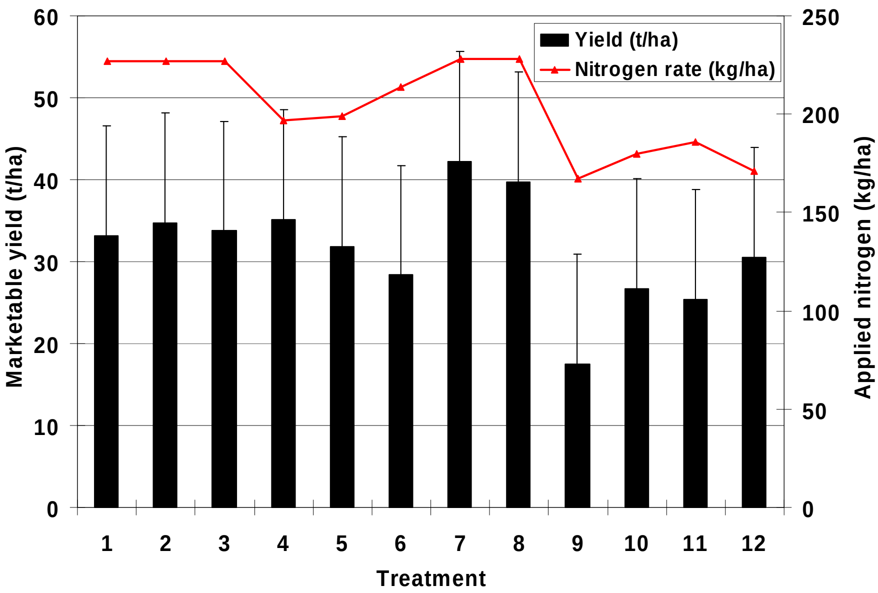

Figure 6.11 **Yield of summer grown iceberg lettuce subjected to a range of fertiliser treatments**

Most of the better treatments were given the higher rate of nitrogen i.e. 227 or 228 kg/ha. Treatments 7 and 8 both received Nitrophoska Blue Special prior to row closure. None of the treatments sprayed in the first weeks after transplanting performed as well as those two treatments but the differences were not significant. The three worst treatments had the lowest rates of N. The results for treatment 12 did not fit the general pattern of response and could not be explained. The urea component of the sprays after 14 days may have had an adverse effect on growth in treatments 9 and 10.

Treatment 6 also received a spray with a high rate of urea on day 14.

Analysis of variance showed that treatments 9, 10, 11 and 12 all had less internal variation than the rest. While the result was not significant there was a definite trend and it is interesting to note that those treatments were all sprayed, not banded, after row closure. One of the most variable treatments was banded from transplanting, however treatment 6 which was sprayed until row closure was equally variable. No one factor can be attributed to the within-plot variation from a treatment perspective.

The results of soil sampling (0-15 cm) for organic carbon showed a range of 0.2–1.29 per cent with the majority of readings in the range of 0.4–0.5 per cent (Figure 6.11). There was no apparent correlation between soil carbon and plant growth. Soil potassium levels varied greatly from 25 to 133 mg/kg with most readings between 40 and 80 mg/kg. Soil phosphorus varied from 98 to 189 mg/kg with most values between 160 and 180 mg/kg. Again, there was little correlation between these values and plant growth.

This trial had two extra treatments compared to previous trials in 2006–07 (12 compared with 10). The extra plots were added at the western end of the site. Plots in the western end generally appeared to be more even than the rest. It was considered that this could be due to a differential pattern of incorporation of crop residues at the end of the series of trials, or might be due to relative flatness.

Areas of internal buffers were grown between each plot within the replicate rows. To try and prevent uneven quantities of crop residue from being incorporated after each trial we had harvested all of these plants and removed them prior to rotary hoeing, except for the last celery trial, so it is possible the distribution of crop residues within the beds could be uneven. Soil sampling and testing for organic carbon was not able to substantiate this.

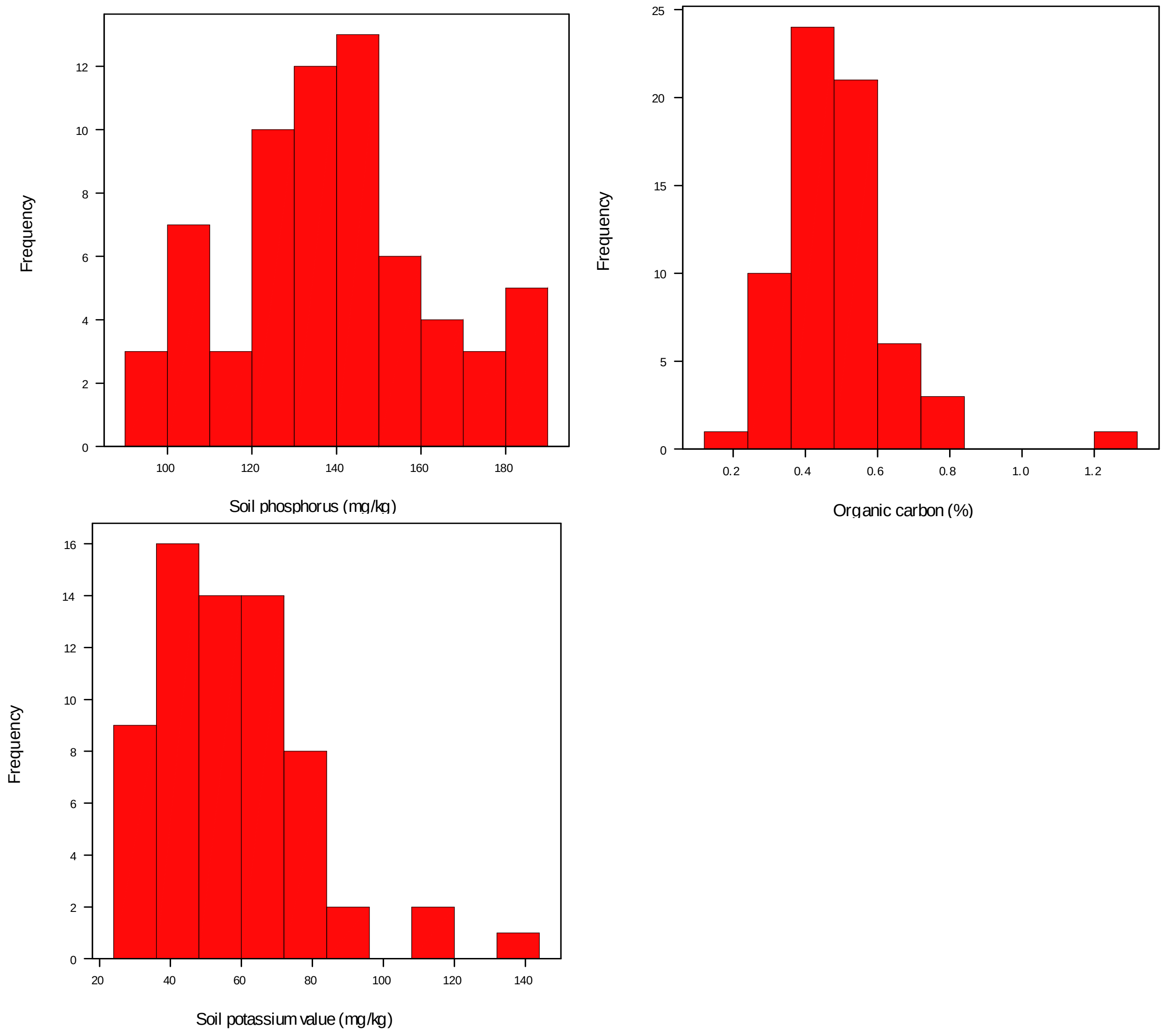

Figure 6.12 **Frequency histograms of soil test results from 17 April 2008 for phosphorus (left), organic carbon (right) and potassium (bottom)**

Some consideration, early in the trial, was given to the possibility of herbicide damage but on close examination of the site it did not appear that this was likely due to the random nature of the growth effects.

In some plots the banded fertiliser was closer to one row than the other. This may have caused some of the unevenness but did not explain the east-west variation and the unevenness in plots that appeared prior to banding.

The most likely reason for the unevenness is that over-irrigation just after planting may have leached more nitrogen than desirable and that combined with some wear in the sprinkler nozzles. The fact that the two treatments that received Nitrophoska Blue Special® prior to row closure performed best adds weight to that argument since the nitrogen is likely to be slightly less available in that compound than a straight spray.

Conclusion

A summer lettuce crop can be grown successfully with 228 kg/ha nitrogen. The use of a granular NPK fertiliser in Phase 1 appears to give superior results to the spray treatments in this case.

WINTER 2008

Introduction

Treatment changes applied in this trial included:

- a weekly spray treatment at double the rate of the twice-weekly spray treatment to see if it was equally effective to reduce labour costs
- a weekly and twice-weekly broadcast granular NPK treatment to compare with the spray treatment for possible increased efficacy and reduced leaching in rainy periods
- treatment with broadcast di-ammonium phosphate to compare with the broadcast granular NPK fertiliser to try and reduce costs
- two treatments using a stronger spray to replace the first banding with granular NPK fertiliser to try and increase crop uniformity
- use of fertigation with supplemental potassium instead of nitrogen only in the post-row closure period compared with a single treatment with no fertigation after row closure.

Method

This iceberg trial was planted in a bay which has been used in continuous rotation since August 2006 for this series of trials. However, there was a substantial gap immediately prior to this trial. The previous trial on the site was iceberg lettuce from May to July 2007 so the site was fallow for almost 12 months. We applied a comprehensive base dressing consisting of 2500 kg/ha of double superphosphate broadcast, 150 kg/ha of Hi-Trace® and 200 kg/ha K-Mag® was applied to all plots and rotary hoed in one week before planting.

The variety used for this trial was 'Titanic' planted on 11 June, 2008. Seedlings were planted at four rows per bed with 300 mm between rows and 350 mm between plants. Each trial plot consisted of 32 plants and was equally spaced along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting Kerb® was applied at 3 kg/ha and followed with 6 mm irrigation. The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 7 with applications not exceeding 3 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Table 6.7 details the treatment schedule.

Table 6.7 **Schedule of treatments applied to winter iceberg lettuce crop. Row closure was between days 49 and 56. All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treat -ment	At planting	Day number																
		0	**3**	**7**	**10**	**14**	**17**	**21**	**24**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**Total N**
1	Nil	S2		S2		S2		S2		S5	Nitro3	Nitro3	Nitro3	F5	F6	F5		388
2	Nil	S2		S2		S2		S2		Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		401
3	Nil	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		403
4	Nil	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro3	Nitro3	Nitro3		F6			334
5	Nitro2	S2		S2		S2		S2		Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		425
6	Nitro2	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		427
7	Nitro2	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		428
8	Nitro2		Nitro2		Nitro2		Nitro2		Nitro2	Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		428
9	Nitro2	S2		S2		S2		S2		S5	Nitro3	Nitro3	Nitro3	F5	F6	F5		412
10	DAP2	S2		S2		S2		S2		Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		424
11	DAP2		DAP2		DAP2		DAP2		DAP2	Nitro4	Nitro3	Nitro3	Nitro3	F5	F6	F5		421
12	Nil	S1	S1	S1	S1	S1	S1	S1	S1	Nitro4	Nitro3	Nitro3	Nitro3					299

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N) without wash off
S2 = Spray 45 g/L urea + 20g/L KNO_3 at 1000 L/ha (23N) without wash off
S5 = Spray 45 g/L urea + 20g/L KNO_3 at 2000 L/ha (46N) without wash off
F5 = Fertigate by boom-spray 100 kg (76 L)/ha Spurt N (32N) and wash off
F6 = Fertigate by boom-spray 100 kg (76 L)/ha Spurt N (32N) plus 200 L/ha Spurt KS (60K) and wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro3 = Nitrophoska Blue Special 400 kg/ha (48N)
Nitro4 = Nitrophoska Blue Special 500 kg/ha (60N)
DAP2 = broadcast DAP 130 kg/ha (23N)

(green) = Lysimeter
(blue) = Broadcast application
(yellow) = Banded application
(light cyan) = Fertigated application
(teal) = Fertigated application

Results

The crop initially grew well but by day 32 plants in treatments 10 and 11 which were both scheduled to receive broadcast di-ammonium phosphate in the first four weeks had severe chlorosis with marginal necrosis on the older leaves (Figure 6.13). This began to subside with the start of banding and by day 70 most symptoms had disappeared.

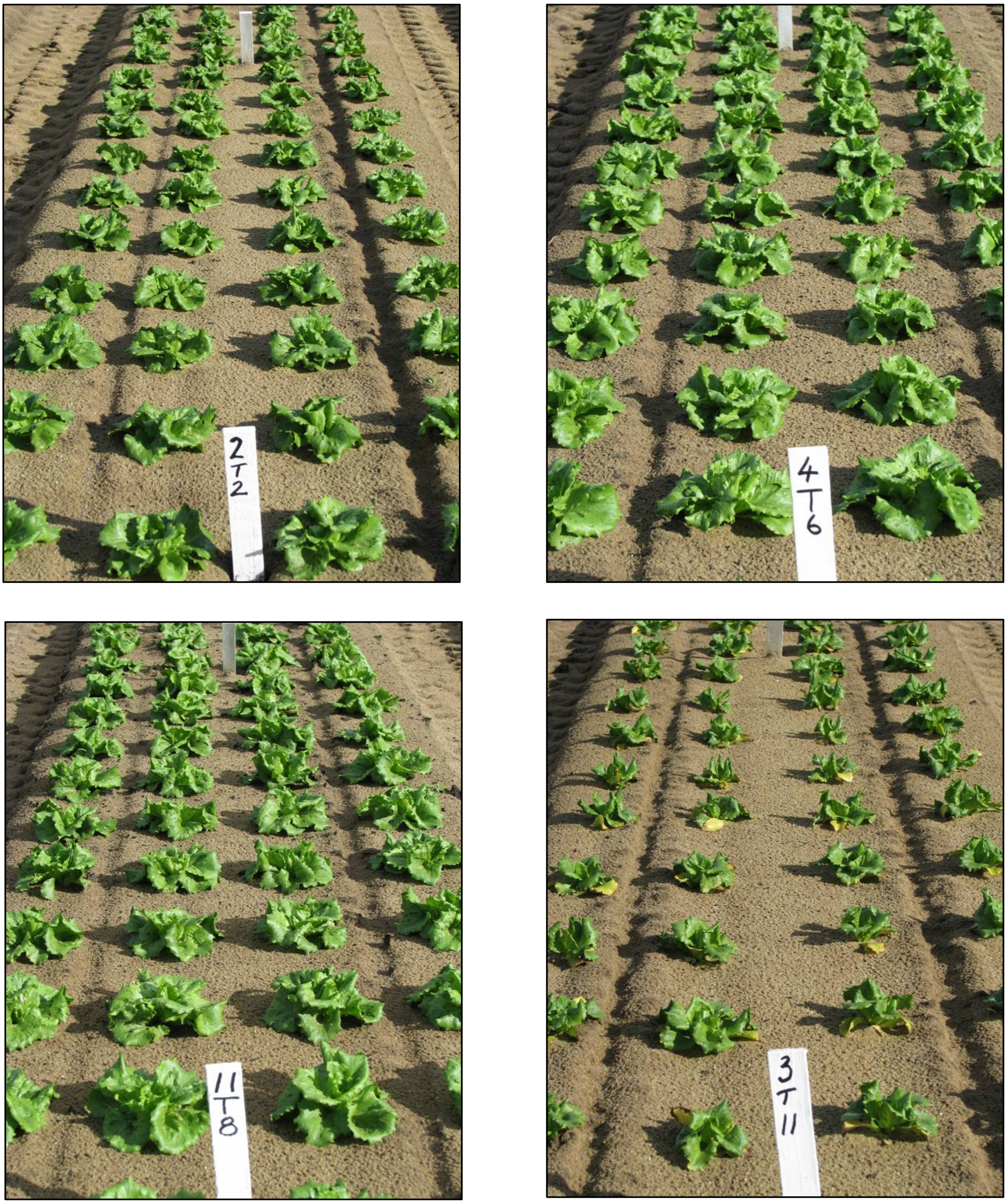

Figure 6.13 **Growth of a winter lettuce crop at 32 days. Treatment 11 (lower right) shows severe chlorosis, T8 (lower left) received granular NPK and appears ahead at this stage as does T6 (top right) which received a broadcast pre-plant application of NPK granular fertiliser unlike T2 (top left)**

By day 56 signs of big vein were clearly apparent (see Figure 6.14 left). Despite being winter the incidence of *Sclerotinia* remained low. One or two patches of dry leaf spot (*Xanthomonas campestris*) and seen in Figure 6.14 (right) established in the buffer plots and then started to spread into the plots during the heavy rain in July/August. Figure 6.15 shows the pattern of rainfall during the trial. Some heavy falls during Phase 1 may have contributed to leaching of those spray applications. There were also some large rain events during Phase 3. Crop growth was quite uneven within and between replicates.

Figure 6.14 **Big vein (left) and dry leaf spot (right) in the winter iceberg lettuce crop**

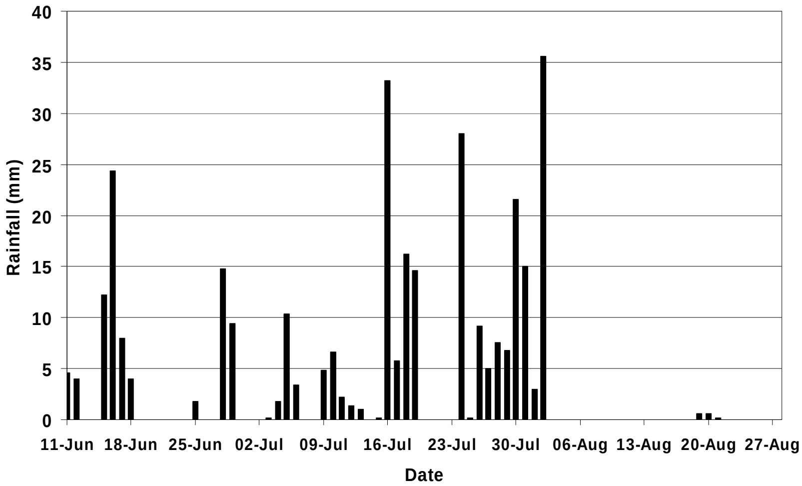

Figure 6.15 **Rainfall during the trial**

The crop was harvested on 28 August, 78 days after planting. It was harvested as for processing with one wrapper leaf only. Twenty-eight plants were harvested per plot. There was considerable variation between replicates of some treatments, up to 250 g difference between the best and worst plots, however analysis of the variability within plots showed all plots were equally variable. Table 6.8 shows the range of treatment rankings between replicates. For example, treatments 4 and 8 were both close to the worst in one replicate but had the best performer in others.

Table 6.8 **Variability in plot weights within and between replicates with replicates sorted in descending order of head weights according to treatment**

Treatment	Rep 1 Plot weight (g)	Treatment	Rep 2 Plot weight (g)	Treatment	Rep 3 Plot weight (g)	Treatment	Rep 4 Plot weight (g)
8	16,270	1	16,056	4	16,373	4	14,712
5	15,689	7	15,596	6	15,570	8	13,993
9	14,470	12	14,816	5	14,957	1	13,919
10	14,435	6	14,761	12	14,687	5	13,649
6	14,393	9	14,758	7	13,704	6	13,275
3	13,239	5	14,211	9	13,574	7	12,535
1	12,366	3	13,029	1	13,371	3	12,170
7	11,425	4	12,669	2	13,302	9	12,117
12	10,991	10	11,494	3	13,127	2	10,959
2	9,941	8	9,357	8	12,482	12	10,636
4	9,761	2	8,848	10	11,877	10	10,607
11	3,358	11	6,424	11	9,268	11	8,476

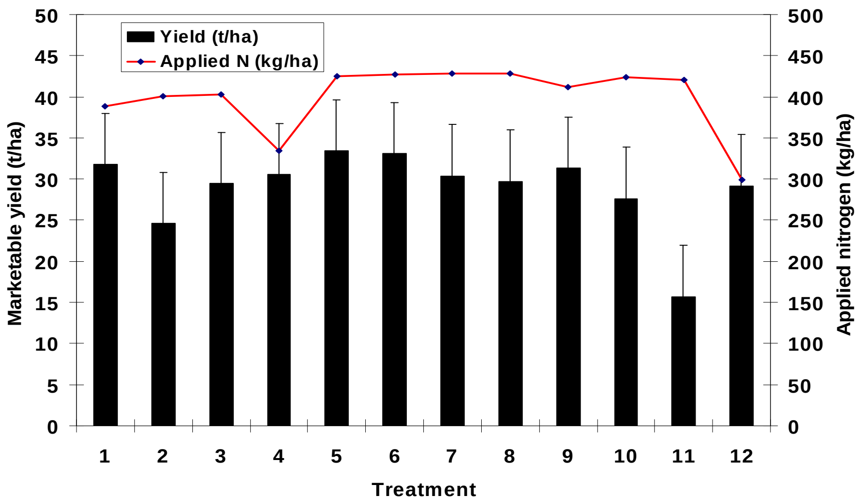

Figure 6.16 **Marketable yield from different treatments**

Despite this variability, analysis of the mean head weights showed that two treatments (2 and 11) yielded significantly less than all others (Figure 6.16). It is unclear why treatment 2 performed so poorly. It did not have the lowest rate of nitrogen; both treatments 3 and 4 received less nitrogen and other treatments also had no broadcast fertiliser at planting. Treatment 11 received the di-ammonium phosphate and we suspect that the extremely high rate of phosphorus early in crop growth had adverse effects which carried through to harvest. Analysis of the big vein ratings showed no significant difference between treatments although treatments 2 and 11 did have slightly higher ratings.

A field walk for growers was held in the last stages of the trial and Table 6.9 was presented on the day as a summary of results.

Table 6.9 **Summary of results presented to growers at a field walk for the trial**

Treatment	Mean head weight (g)	Total yield/ha (t)	Fertiliser cost ($/t)	Fertiliser cost without topdressing after row closure*	Comments
1	497.4	31.6	2,815	$2,131	Lowest cost and less labour
2	384.4	24.4	3,265	$2,582	Poor performing treatment
3	460.4	29.2	3,418	$2,734	Low cost – current practice
4	483.2	30.3	3,240	$2,734	Low cost and less topdressing after row closure
5	527.3	33.2	3,523	$2,840	Low cost, less labour and broadcast benefit
6	517.9	32.9	3,676	$2,992	Low cost and some broadcast benefit
7	475.5	30.2	4,167	$3,483	Broadcasting easier than spraying for some
8	469.8	29.5	4,167	$3,483	Broadcasting with less labour than 7
9	490.3	31.1	3,073	$2,389	Lower cost and less labour than 5 and 6
10	432.2	27.4	3,515	$2,831	Poor performing treatment
11	246.9	15.6	4,124	$3,440	Poor performing treatment
12	461.3	29.0	2,734	$2,734	Low cost without topdressing after row closure – compare 3

* This assumes that the lack of yield increase observed with treatment 12 from topdressing after row closure would equally apply to all the other treatments if done the same way.

Conclusion

Statistical analysis of the yield data showed that the only treatments that performed significantly worse were treatments 2 and 11. All remaining treatments were similar in yield and degree of variability within the plot. Nitrogen application rates as low as 300 kg/ha produced lettuce as good as the higher rates of more than 400 kg/ha. The fact that treatment 12 performed as well as the others reinforces our previous experience that there is no advantage in fertilising iceberg lettuce after row closure as long as adequate fertiliser is supplied before this time. For a grower, the choice of program from the list above will be based on lowest fertiliser cost, greatest convenience, or a mix of the two.

Spring 2008

Introduction

Because fertiliser prices were still high the treatments used in this trial again prioritised reducing costs and were similar to those used on other crops at this time. The trial focused on three aspects of fertilising:

- reducing cost by examining lower cost alternatives to Nitrophoska Blue Special® such as Turf Special® and Hort Special®
- continuing comparison of weekly or twice-weekly fertiliser application in the first three weeks after transplanting
- evaluation of the impact of reducing the rates of banded fertiliser to further reduce leaching, and cost during this period of greatest leaching.

Method

The trial bay had been recently planted to broccoli which had been harvested over several days finishing on 21 August 2008. Soil samples were taken from selected plots to establish the phosphorus status. Results showed 115-128 mg/kg phosphorus (bic P) therefore no phosphorus was applied up front to any treatments apart from treatment 12 where the intention was to determine if there might be a response to freshly applied phosphorus. Potassium levels were also good at 76-120 mg/kg.

Seedlings for the trial (cultivar ‘Silverado’) were bought in from a specialist nursery and planted on 19 September 2008. Seedlings were planted at four rows per bed with 300 mm between rows and 350 mm between plants. Each trial plot consisted of 32 plants equally spaced out along the 100 m bay length with buffers between each plot and at each end.

Immediately after transplanting, Kerb® was applied at 3 kg/ha and followed with 6 mm irrigation.

The trial was irrigated as follows:

- 1.0 times EPan from day 0 to day 7 with applications not exceeding 3 mm per irrigation
- 1.4 times EPan thereafter with individual irrigations not exceeding 8 mm.

Fertiliser treatments

Table 6.10 details the fertiliser treatments.

Table 6.10 **Schedule of treatments applied to a winter iceberg lettuce crop. Row closure was between days 35 and 42 All quantities shown are in kg/ha of nitrogen (as contained in the product)**

Treatment	Pre-plant	Day number													
		0	3	7	10	14	17	21	28	35	42	52 (Harvest)	N	P	K
1	Nil	S1	S1	S1	S1	S1	S1	Nitro3	Nitro3	Nitro3	F5		210.8	46.8	172.5
2	Nitro2	S2		S2		S2		Nitro5	Nitro5	Nitro5	F5		306.8	88.4	285.3
3	Nil	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	F5		282.8	78	257.1
4	Nil	S2		S2		S2		Nitro5	Nitro5	Nitro5	F5		282.8	78	257.1
5	Hort2		Hort1	Hort1	Hort1	Hort1	Hort1	Hort5	Hort5	Hort5	F5		300.4	77	224.4
6	Nitro2	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	F5		306.8	88.4	285.3
7	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro5	Nitro5	Nitro5	F5		284	109.2	296.1
8	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro4	Nitro4	Nitro4	F5		248	93.6	253.8
9	Nitro1		Nitro1	Nitro1	Nitro1	Nitro1	Nitro1	Nitro3	Nitro3	Nitro3	F5		212	78	211.5
10	Nitro2			Nitro2		Nitro2		Nitro5	Nitro5	Nitro5	F5		284	109.2	296.1
11	Turf2		Turf1	Turf1	Turf1	Turf1	Turf1	Turf5	Turf5	Turf5	F5		302.6	39.6	136.4
12	Double	S1	S1	S1	S1	S1	S1	Nitro5	Nitro5	Nitro5	F5		282.8	108.09	257.1

S1 = Spray 20 g/L KNO_3 + 20 g/L urea at 1000 L/ha (12N:7.5K) without wash off
S2 = Spray 40 g/L urea + 40 g/L KNO_3 at 1000 L/ha (24N:15K) without wash off
F5 = Fertigate by boom-spray 100 kg (76 L)/ha Spurt N (32N) and wash off
Nitro1 = Nitrophoska Blue Special 100 kg/ha (12N)
Nitro2 = Nitrophoska Blue Special 200 kg/ha (24N)
Nitro3 = Nitrophoska Blue Special 300 kg/ha (36N)
Nitro4 = Nitrophoska Blue Special 400 kg/ha (48N)
Nitro5 = Nitrophoska Blue Special 500 kg/ha (60N)
Hort1 = Horticulture Special 100 kg/ha (12N)
Hort2 = Horticulture Special 200 kg/ha (24N)
Hort5 = Horticulture Special 500 kg/ha (60N)
Turf1 = Turf Special 100 kg/ha (12N)

Turf2 = Turf Special 200 kg/ha (24N)
Turf5 = Turf Special 500 kg/ha (60N)
Double = Double Phos 170 kg/ha (30P)
(yellow) = Banded application
(blue) = Broadcast application
(green) = Lysimeter buried under these plots
(light green) = Sprayed application

Results

Figure 6.16 **Clockwise from top left, T1, T3, T12 and T7 at 35 days after transplanting when T7 appeared slightly ahead and was one of the better treatments at the end of the trial**

The crop established well and growth was more even than the previous crop (Figure 6.16). There was some rain in the first three weeks with one particularly big fall of 27 mm on day 6. However, fertiliser was applied on days 3 and 7 so probably had little impact on leaching and hence plant growth. A graph of rainfall during the trial is shown in Figure 6.17.

Frame size was good and the incidence of disease was low. Later in the crop a few plants were lost to *Sclerotinia*. This appeared more prevalent on those treatments which had broadcast Nitrophoska but the incidence was not high enough for concern. Some tomato spotted wilt virus and big vein virus were also apparent towards the end.

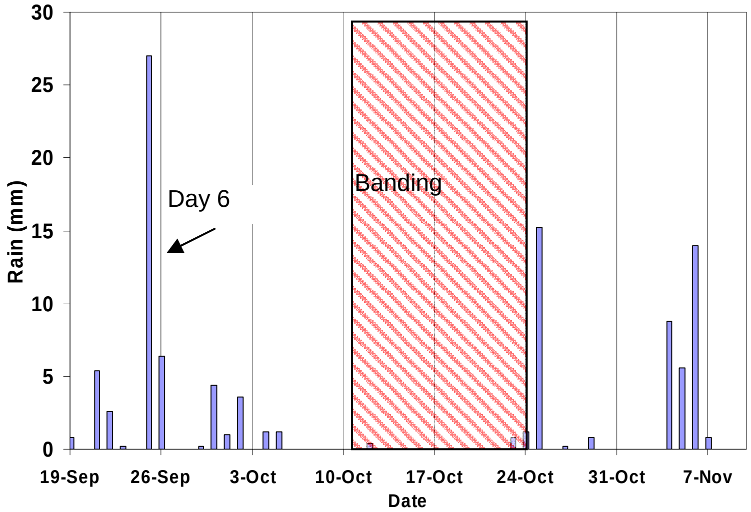

Figure 6.17 **Rainfall recorded during summer iceberg fertiliser trial at Medina Research Station**

The crop was harvested on 10 November, 52 days after transplanting. Heads were picked as for processing with one wrapper leaf. Each head was weighed separately and the data analysed using analysis of variance.

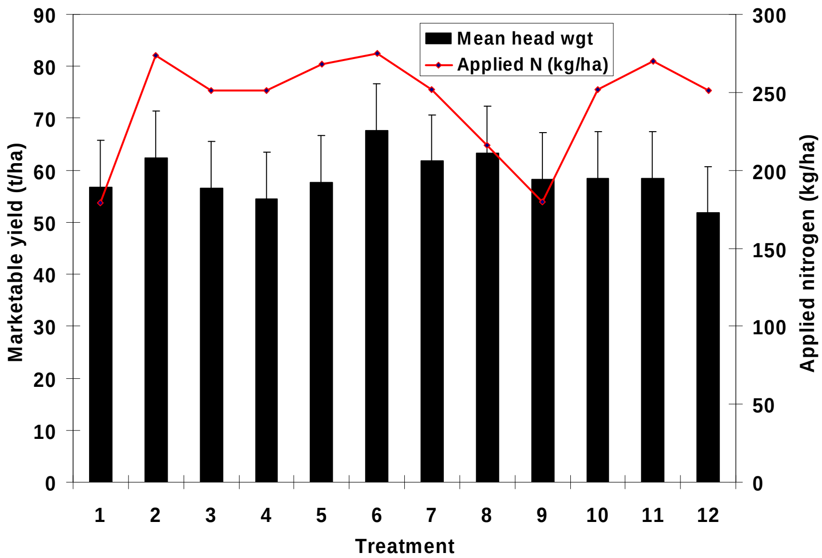

Figure 6.18 **Yield of summer-grown iceberg lettuce subjected to a range of fertiliser treatments**

Treatment differences were less than for previous trials ($p = 0.083$) as shown in Figure 6.18. Again, there was a high degree of variability between replicates. Treatments that performed best (2, 6, 7 and 8) had Nitrophoska broadcast at planting time. The difference in mean head weight between treatments 2 and 4 was 100 g which is significant. The only difference between the two treatments was the presence or absence of broadcast Nitrophoska at planting time.

Treatments 7, 8 and 9 tested reducing the amount of Nitrophoska banded from days 21 to 35. There appears to be no loss in yield when the banding rate is reduced to 400 kg/ha but a further reduction to 300 kg/ha reduced yield slightly.

Treatment 12 tested the application of fresh phosphorus. This treatment did not prove beneficial and was substantially inferior to treatment 6 which had the Nitrophoska broadcast at planting.

Neither Hort Special (57.7 t/ha) nor Turf Special (58.4 t/ha) produced as good a yield as the comparable Nitrophoska treatment (61.7 t/ha) but the differences were not statistically significant.

Comparison of the treatments which received weekly as opposed to twice-weekly spray treatments (T2 versus T6, and T4 versus T3 showed a small benefit for twice-weekly spraying—of the order of 2-5 t/ha. Again, this was not statistically significant and may have been due to the rainfall in the first two to three weeks while the spray treatments were being applied.

Examination of the variation in N, P and K application rates between treatments as a basis for the variation in yield did not demonstrate any systematic correlation.

All defects were recorded at harvest. There was no correlation between any aspect of a treatment and the incidence of problems such as twins or malformed heads.

Leaching data

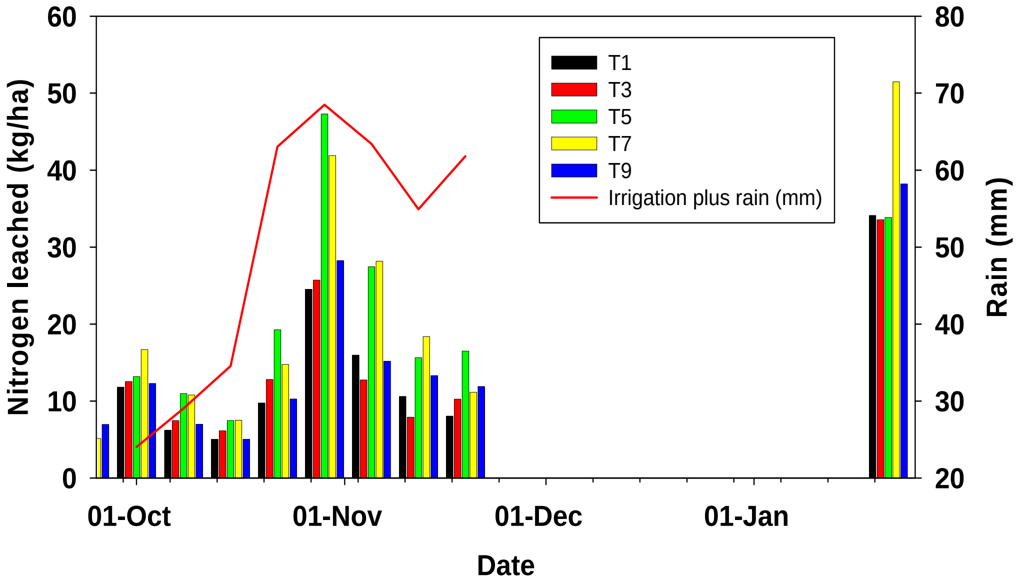

Figure 6.19 **Nitrogen leaching compared with irrigation plus rain over the course of the trial**

Nitrogen leaching for treatments 5 (167 kg/ha) and 7 (154 kg/ha) was up to 50 per cent more than that for the other treatments with lysimeters underneath which ranged from 100-110 kg/ha. All treatments were similar until the leachate collection on day 42. This corresponds to the end of the period of banding (days 21-35). Almost immediately after banding finished there was a 15 mm rain event (day 37) which appeared to leach a significant amount of the fertiliser stored in the soil. Treatments 5 and 7 both had pre-plant granular fertiliser plus the higher rate of banding. Treatment 3 also had the high rate of banding but no pre-plant granular NPK.

Conclusion

All treatments produced a commercially acceptable yield. While the variation between replicates was quite high the following observations can be made:

- A spring lettuce crop can be grown successfully on about 300 kg/ha nitrogen.
- Nitrophoska at 200kg/ha, broadcast at planting time, followed by sprays in Phase 1, increased yield by about 8 t/ha for a cost of about $270.
- When rain is likely, twice-weekly spray treatments may be worth considering.
- The banding rate for Nitrophoska may be reduced to 400 kg/ha without yield loss.

While Turf Special and Hort Special reduced fertiliser costs, both gave apparent yield reductions compared to Nitrophoska®. Although these reductions were not statistically different there is still a possibility that these yield losses may be real, in which case those treatments would not be cost effective. Further trials are required to clarify the yield responses to these two products.

7. DISCUSSION

Broccoli

Broccoli yields ranged from 13–20 t/ha over several trials at various times of the year in this project. The lower yields tended to correlate with lower applied rates of N (314 kg/ha as compared with up to 450 kg/ha in the last spring trial). These rates of N application are at the lower end of the scales as suggested by Bowen et al. (1999). They found that N accumulation by the crop is maximised at application rates of about 500 kg/ha and ranged from about 345 to 465 kg/ha depending on the season.

For our first spring planting of the project, the best treatment received no nitrogen after row closure. The best treatments in autumn and winter plantings did appear to require fertigation after row closure however there were no treatments that received an equivalent rate of N all prior to that stage. Broccoli is known to translocate substantial amounts of N from the leaves to support inflorescence growth in the latter stages of crop growth (Bowen et al. 1999). Shelp and Liu (1992) calculated between 24 and 31 per cent of N was mobilised from the leaves to the inflorescence in a broccoli crop.

Their suggestion to reduce the potential for leaching of nitrogen into the groundwater is to apply lower rates of nitrogen and rely on this translocation of N within the plant to support the final growth phase. This all fits well with our sandy soil scenario since smaller, more frequent applications of fertiliser are likely to minimise leaching. A greenhouse broccoli trial using fertigation in fact found that marketable yield increased by 10 or 69 per cent depending on cultivar, if N supply was reduced from 250 mg/L to 100 mg/L at the time of inflorescence initiation (Nkoa, R et al. 2002).

Efforts to reduce fertiliser rates by either extending the duration of Phase 1 sprays, or by reducing the rate of banding from 500 kg/ha were both unsuccessful.

The leaching fraction achieved in our trials with broccoli was generally in the range 0.24–0.55 whilst that of growers we worked with ranged from 0.53–1.43. Often a large proportion of the leaching fraction is between crops. The harvestable portion of a broccoli crop is the inflorescence and represents only a small proportion of the total plant and only 16–27 per cent of the total amount of accumulated N (Bowen et al. 1999). Everaarts and Willigen (1999) found that about half the total uptake of N by broccoli was accounted for in crop residues.

Cabbage

Marketable yields of cabbage between 80 t/ha (summer)- and 110 t/ha (winter) were achieved in our trials on rates of nitrogen application ranging from 500–600 kg/ha. Work by Fink and Feller (1998) in Germany on sandy soils demonstrated N uptake of up to 455 kg/ha on a sandy soil. Given an N uptake efficiency for white cabbage of 72 per cent (Ruhlmann and Geyer 2002), even at 600 kg/ha applied N, our figures are well below this range.

Either spray or broadcast fertiliser can be used in Phase 1. Calcium nitrate confers no additional benefit to cabbage and there is no need to apply potassium after row closure. Urea is a suitable source of nitrogen in Phase 3 all year-round in the Perth climate. Turf Special® does not appear to be a realistic alternative to Nitrophoska Blue Special®. Banding early (week 3) is not detrimental to the crop.

Leaching fractions of 0.3–0.45 were achieved in our research station trials. These compared favourably with 0.97 recorded from one grower property. According to Huett and Dettman (1989), who investigated the uptake of nutrients by white cabbage in sand culture, maximum uptake of N corresponded to 82.5 kg/ha per week and occurred 8 weeks into a 12 week crop. Our top rate of N application was 73.6 kg/ha/week at week 10 of a 12 week crop. There is some indication from our trials that a stepped rate of nitrogen application can reduce leaching but further trials would be needed to see if this reduction is repeatable and significant. Stepped rates of nitrogen have not been a focus of these trials to date because we have felt that grower adoption would be compromised by having a more complicated program. In addition, since many growers plant successive crops in the same irrigation shift, the practice of matching growth rates to crop growth stage is severely constrained.

Celery

Apart from the first trial our celery yields all ranged from 90–110 t/ha using N application rates of 400–530 kg/ha.

Stark, J. et al. (1982) in California cite yields of 85 t/ha with an N uptake of 268 kg/ha. Sanchez et al. (Spain) obtained yields of 90 t/ha with uptake of 311 kg N, 37.1 P and 566.5 of K. Allowing for the poor N uptake efficiency as cited by Ruhlmann and Geyer (2001) at 52 per cent our yields seem good when compared with our N application rates.

Celery is a slow crop to start, so over the course of the project we evaluated up to five weeks of spray treatments during Phase 1. We found little effect on crop growth so for growers it is a trade-off between the labour requirement for spraying versus the amount of fertiliser (and leaching) saved. Applications of broadcast NPK granular fertiliser, weekly or twice-weekly are equally effective. Banding of Nitrophoska® in Phase 2 at a flat rate of 400 kg/ha proved to be an effective treatment in all trials. In the last trial we omitted banding in Phase 2 and went straight to Phase 3. This seemed a viable option and had no detrimental effect. Celery requires fertiliser application post row closure (Phase 3). Feigin et al. (1976) noted that N uptake was the greatest about 3 weeks prior to harvest. We were unable to show any benefit in applying potassium after row closure. Urea was the best source of nitrogen in Phase 3 and the cheapest option by far, however also leaches the most nitrogen and produces the highest sap nitrate levels (Zhou Ya et al. 2004)

The leaching fractions we achieved for celery in this project ranged from 0.38–0.7 which suggests there are still improvements to be made. A line source trial in California (Stark et al. 1983) showed that leaching fractions varied with the amount of irrigation applied and at 1.2–1.4 EPan it was 0.2–0.3 whilst at 1.4–1.6 EPan it was 0.3–0.4. Yields did not vary substantially as leaching fractions were reduced from 0.45 to 0.05 and were generally in the range of 90–100 t/ha, comparable with ours. Stark et al. found that growers in California at that time had leaching fractions of between 0.49 and 0.83.

Cos lettuce

Cos can be a very short duration crop in summer but is also prone to tipburn and bolting. Only one crop of Cos lettuce was grown in this project and we achieved good yields of around 80 t/ha using only 250 kg nitrogen. Around 100 kg/ha nitrogen or 38 per cent of that applied was leached from under the crop. We were unable to show any additional yield benefit from fertigation beyond row closure in a summer crop of 37 days duration.

Iceberg lettuce

Yields varied greatly over the five iceberg lettuce trials in this project. Up to 65 t/ha was achieved with a spring crop using 300 kg N/ha. As low as 235 kg of applied N also produced good yields of 50–60 t/ha in summer and autumn. Our one winter crop yielded poorly (about 30t/ha) possibly due to severe infection with lettuce big vein virus.

The use of spray treatments in Phase 1 has been shown to produce at least equivalent crop yields to those gained by the use of pre-plant applications of conditioned poultry manure. Significant economies in fertiliser application rates may be made by applying twice-weekly spray treatments in the first four weeks of crop growth at no detriment to crop marketable yield. Under high leaching conditions, the use of a granular NPK fertiliser in Phase 1 appears to give superior results to the spray treatments. There is no need to apply nitrogen after row closure.

Leaching fractions for our iceberg lettuce trials ranged from 0.35–0.41. At that time growers were commonly leaching in excess of 100 per cent of their applied N. The lowest leaching fraction recorded for one grower was 0.57. These figures compare well those obtained by Torstensson, G. and Sandin, H. (2010) in Sweden who reported annual N-leaching of 128 kg N/ha over two crops of lettuce giving an N use efficiency of approximately 22 per cent. In other trials with babyleaf and other Gourmet lettuce types, they found N use efficiency to be higher—from 32–50 per cent with the use of oats as a catch crop.

Table 7.1 summarises all trial results from Medina Research Station over a three year period. On average, it seems that in a worst case scenario on sandy soils, growers should be able to achieve less than 50 per cent leaching of nitrogen from their crops. The main variable is rainfall. Table 7.2 details results from some of the grower sites that have been monitored in another project VG04009. The range of nitrogen leaching is enormous and substantially more than we achieved in our trials under a worst case scenario.

Table 7.1. **Summary of trial results from Medina Research station**

Crop/cultivar	Transplanting date	Crop duration	Nitrogen rate (kg) for best treatments	Marketable yield (t/ha)	Nitrate leaching (kg/ha N)	Percentage of applied N leached
Iceberg lettuce						
Silverado	31 August 2006	53 days	236	60		
Silverado	26 April 2007	71 days	238	50	98	41
Silverado	21 February 2008	42 days	227	40	86-156	38-69
Titanic	11 June 2008	78	300-400	32	123-140	35-41
Silverado	19 Sept 2008	52 days	275	60-65	100-110	38
Broccoli						
Endurance	31 August 2006	64-69 days	314	12-14	21-33	8
Atomic	14 Feb 2007	56-63 days	350	16	60-110	24
Ironman	15 May 2008	85-98 days	500	20	186-207	38
Endurance	26 September 2008	63, 69 days	450	17-20	250	55
Cabbage						
Beverley Hills	22 January 2009	90 days	500-510	95	200-269	45
Beverley Hills	28 May 2009	103 days	600	80	208	30
Beverley Hills	29 October 2009	83 days	570	100-110	150-182	29
Celery						
Big Ben	13 December 2006	96, 97 days	400	70	265	66
Big Ben	5 July 2007	110 days	550	90		
Tango	22 January 2009	83 days	500-530	100	250-280	71
Tango	28 May 2009	109 days	459-665	90	223-296	46-49
Tango	22 October 2009	77 days	500-530	100-108	221	43
Cos lettuce						
Maximus	6 December 2006	37 days	250	85-90	86-118	38.4

Table 7.2 **Leaching of nitrogen from a range of crop on grower properties on the sandy soils of the Swan Coastal Plain**

Crop	Planting Date	Nitrogen Applied (kg/ha)	Nitrogen leached (kg/ha)			% nitrogen leached
			During crop	Before next crop	Total	
Broccoli	21-Feb	236	213	81	294	124.6
Broccoli	10-Mar	358	308	207	515	143.9
Broccoli	17-May	723	358	110	468	64.7
Broccoli	18-Jun	430	205	21	226	52.6
Cabbage	24-Oct	414	209	194	403	97.3
Carrot	4-Jan	118	366	12	378	320.3
Carrot	1-Feb	255	24	7	51	20.0
Carrot	6-Feb	112	15	0	15	13.4
Corn	27-Jan	153	110	60	170	111.1
Lettuce	8-Jan	201	145	24	169	84.1
Lettuce	6-Feb	300	216	151	367	122.3
Lettuce	15-Mar	412	236	72	308	74.8
Lettuce	21-Mar	233	114	142	256	109.9
Lettuce	14-Apr	582	575	83	658	113.1
Lettuce	20-May	670	660	13	673	100.4
Lettuce	1-Jun	350	173	29	201	57.4
Lettuce	13-Jun	398	302	78	380	95.5
Lettuce	21-Jun	752	691	148	839	111.6
Lettuce	12-Sep	311	159	Not recorded		
Lettuce	31-Oct	209	146	306	352	168.4

8. ON-FARM GROWER DEMONSTRATIONS

Introduction

The new stream of activity initiated by the commencement of this project commenced in July 2007 when a leading leafy crop grower (Grower 1) at Carabooda north of Perth was convinced to grow 1.5 hectares of iceberg lettuce using the 3Phase method and compare it to his own program. Before the crop was planted in October 2007, he was convinced that the method was better and cost less than his program and fully adopted it in all subsequent plantings of lettuce to the present day where 83 hectares have now been grown this way on this farm. Records of costs for the two programs show that at the time it commenced, 3Phase cost 40 per cent as much as the former fertiliser program and cut nitrogen available for leaching in half while producing superior quality lettuce. Two demonstrations on broccoli crops of 0.3 ha each have been conducted since on this farm and we hoped to see total adoption.

Work commenced on demonstration plots with four growers of leafy lettuce and 'baby leaf' lines including spinach, rocket and mizuna in April 2008. The work with Grower 2 and the initial spray trials are detailed below.

In addition we have been working in conjunction with the growers involved in HAL irrigation project VG04009. In that project, growers have lysimeters buried below their commercial crops which can monitor nutrient leaching in addition to irrigation drainage. Where possible we have been working with these growers to introduce them to 3Phase and encourage adoption of elements of the program wherever possible.

Spray trials

Grower 1: North of Wanneroo

Grower 1 is a large vegetable grower growing a range of crops including broccoli and lettuce. He was approached and agreed to take part in some on-farm demonstrations of the drench/spray band/technique (now called 3Phase).

As a first step calibration of his equipment used for banding was carried out as detailed in Appendix 2 (using Nitrophoska Blue Special®). An initial calibration in March 2007 showed a maximum banding rate of only 204 kg/ha so the grower made some adjustments to the bander prior to a second calibration and January 2008 which then showed the banding rate to be 380 kg/ha. Since the growers soil had been in vegetable production for some years and was likely to have a reasonable base level of fertility, it was decided that this rate might be sufficient and trials proceeded using that rate for all banding.

Spray trial 1: 31 January 2008 – Yanchep 2 Iceberg lettuce crop

The purpose of this trial was to assess the effects of a range of potential sprays treatments on an iceberg lettuce crop under field conditions. A single unreplicated plot was used (6 m x 1.65 m). All plants were sprayed using a knapsack and the fertilisers were supplied by the grower. The plants were dry when sprayed (12:30 pm – 14:30 pm) and irrigation commenced approximately 2 hours after spraying. The weather was fine and dry with a maximum temperature of about 36ºC. The treatments applied are detailed in Table 8.1 below.

Table 8.1 Spray treatments used on an iceberg lettuce crop

Spray treatment	Age of crop sprayed			
	Day 0	Day 7	Day 14	Day 28 (row closure)
S2	X		X	X
S3	X		X	X
S4			X	X
S5			X	X
S6	X	X	X	X
MAP* 20	X			
MAP* 40	X			

*MAP = mono-ammonium-phosphate
S2 = Spray 20 g/L potassium nitrate + 20 g/L urea @ 2000 L/ha (23.6 N)
S3 = Spray 50 g/L urea @1000 L/ha (23 N)
S4 = Spray 50 g/L urea @ 2000 L/ha (46 N)
S5 = Spray 35 g/L urea @ 2000 L/ha (32 N)
S6 = Spray 80 g/L potassium nitrate + 10 g/L urea @ 2000 L/ha (30 N)
MAP20 = Spray 20 g/L MAP @ 1000 L/ha (2.2 N)
MAP40 = Spray 40 g/L MAP @ 1000 L/ha (4.4 N)

Assessment: 4 February

Day 28, S2: obvious leaf tip burn on older leaves of most plants but might still be acceptable.
Day 28, S3: some leaf tip burn on older leaves of about 25% of plants but probably NOT acceptable.
Day 28, S4: moderate leaf tip burn on older leaves of all plants, probably NOT acceptable.
Day 28, S5: mild leaf tip burn on older leaves of all plants, probably NOT acceptable.
Day 28, S6: very slight leaf tip burn on older leaves of all plants but probably will be acceptable.

Conclusion: all urea only sprays unsatisfactory.

Day 14, S2: slight but noticeable leaf tip burn on older leaves of all plants but probably will be acceptable.
Day 14, S3: slight but noticeable leaf tip burn on older leaves of all plants but probably will be acceptable.
Day 14, S4: mild to moderate leaf tip burn on older leaves of all plants but probably NOT acceptable.
Day 14, S5: very similar to S4 above but less severe and probably will be acceptable
Day 14, S6: very slight leaf tip burn on older leaves of all plants but acceptable.
(Note: Day 14, S6 looks slightly greener and larger than all others)
Day 7, S6: mild to moderate leaf tip burn of older leafs on all plants, some of which could be herbicide damage since all nearby plants also have it. Spray treatment probably acceptable.

Conclusion: for plants sprayed at 14 days after transplanting, all sprays were acceptable except the highest rate of urea (S4) however S6 appears to yield the best results overall.

Day 0, S2: slight but noticeable leaf burn on all plants. Probably acceptable (plants also a bit pale).
Day 0, S3; about the same as S2 but slightly worse. Might be acceptable (plants also a bit pale).
Day 0, S6: about the same as S2 but slightly better. Acceptable (pale plants).
Day 0, MAP 20 1000: very slight damage only. Acceptable (pale plants).
Day 0, MAP 40 1000: only slightly worse than above. Acceptable (pale plants).

Conclusion: all sprays acceptable but the high rate of urea may be best avoided.

Assessment: 13 February

Day 28 plots had been harvested on the day of inspection (day 41). None of the other treatments showed any adverse effects from spraying additional to symptoms from sprays applied to the whole bed. MAP 20 and MAP 40 plots appear slightly more vigorous than the surrounding crop.

Other observations. Routine banding of the crop in the Day 7 bed (day 20 at the time of inspection) showed scorching of old leaves partly from contact injury with Nitrophoska and possibly partly uptake injury in a very hot week with temperatures around 37ºC to 38ºC.

Assessment: 18 February

No treatment showed any adverse effects from spraying additional to symptoms from sprays applied to the whole bed. The day 14 bed looked particularly good and better than previous plantings.

MAP 20 and MAP 40 plots appear slightly more vigorous than the surrounding crop

Other observations. Scorching on the old leaves on the day 7 (Day 25 at the time of inspection) bed were no longer obvious. This bed did however show marked differences in the growth habit and vigour of each pair of rows. The differences suggested a differential effect related to the previous banding. One pair of rows was upright, commencing heading and heads were conical. The other pair were prostrate with crinkled leaves and heading was delayed.

This effect was also visible in the day 14 bed (day 32) but less obvious. The effect suggests that a difference in output rate of banding equipment may have a significant effect on growth rate at the 14 day application. Banding had been applied to the day 7 bed on day 25 because it was too close to row closure to get the 28 day banding on, that is it was banded at day 22 and day 25 at 380 kg/ha.

Spray trial 2: 8 February

The purpose of this trial was to assess the effects of a range of potential sprays treatments on an iceberg lettuce crop under field conditions. A single unreplicated plot was used (6 m x 1.65 m). All plants were sprayed using a knapsack and the fertilisers were supplied by the grower. The plants were dry when sprayed (11:30 pm– 12:30 pm) and irrigation commenced approximately 30 minutes after spraying. The weather was fine and dry with a maximum temperature of about 30ºC. The treatments applied are detailed in Table 8.2 below.

Table 8.2 Spray treatments used on an iceberg lettuce crop

Spray treatment	Age of crop sprayed		
	Day 3	Day 16 (Bay 17)	Day 25 (row closure, Bay 8)
S7	X	X	X

S7 = Spray 120 g/L KNO_3 @ 2000 L/ha (31 N)

Spray trial 3: 2 April (Gibbs Rd farm)

The purpose of this trial was to assess the effects of a range of potential sprays treatments on a broccoli crop (cultivar ‘Endurance’) under field conditions. A single unreplicated plot was used (6 m x 1.65 m). All plants were sprayed using a knapsack and the fertilisers were supplied by the grower. The plants were dry when sprayed (12:30 pm– 14:30 pm) and irrigation commenced approximately one hour after spraying. The weather was fine and dry with a maximum temperature of about 23ºC. The treatments applied are detailed in Table 8.3 below.

Table 8.3 Spray treatments used on a broccoli crop

Spray treatment	Age of crop sprayed		
	Day 0 (Bay 32) 2nd panel east of western edge, start at 3rd sprinkler from north end	Day 7 (Bay 25, near shed with petrol pump) 2nd panel east of western edge, start at 3rd sprinkler from north end	Day 15 (Bay 18) 2nd panel east of western edge, start at 3rd sprinkler from north end
S8	X	X	X

S8 = Spray 20 g/L KNO_3 + 45 g/L urea @ 1000 L/ha (24N)

Assessment: 4 April (Broccoli)

There was no sign of spray damage on any of the three treatment plots. The day 0 plants are acceptable but there was a lot of wilting plants around nearby (Figure 8.1, left). The day 7 plants also looked reasonable but there was quite a lot of yellow spotting on many plants both in the plot and nearby (Figure 8.1, right).

Figure 8.1 Wilting broccoli plants (left), yellow spots on broccoli plants (right)

The day 15 plants were quite variable in size but compares well to the grower's own crop.

Spray trial 4: 4 April

The purpose of this trial was to assess the effects of a range of potential sprays treatments on an iceberg lettuce crop (cultivar 'Silverado') under field conditions. A single unreplicated plot was used (6 m x 1.65 m) in each of three plantings (20 March, 25 March and 3 April). All plants were sprayed using a knapsack and the fertilisers were supplied by the grower. The plants were dry when sprayed (09:30 am– 11:00 am) and irrigation commenced approximately two hours after spraying. The weather was fine and dry with a maximum temperature of about 26ºC. The treatments applied are detailed in Table 8.4 below.

Table 8.4 Treatment schedule

Age of crop sprayed	Day 1	Day 10	Day 15
Spray treatment	Bay 18 Yanchep Rd Near big shed 2nd panel east of western edge, start at 3rd sprinkler from north end	Bay 33, uphill Carabooda 2nd panel south of wind break, start at 2nd sprinkler from east end	Bay 31, uphill Carabooda 2nd panel south of wind break, start at 2nd sprinkler from east end
S8	X	X	X

S8 = Spray 20 g/L potassium nitrate + 45 g/L urea @ 1000 L/ha (24N)

Assessment: 7 April 2008 (Broccoli and lettuce)

The day 0 broccoli plants appeared scorched and there is also a lot of leaf damage that looks like wind blast. There are still some signs of wilting. The youngest leaves of the sprayed day 0 broccoli are much greener than unsprayed plants nearby (Figure 8.2). All other plots of broccoli and lettuce (Figure 8.3) showed no spray damage.


Figure 8.2 Day 0 broccoli plants. Example of crop damage (left). Our treatment plants are greener than the growers (right)


Figure 8.3 Day 1 lettuce plants (left), day 15 lettuce plants (right)

The day 1 lettuce plants look healthy and free from damage and the youngest leaves of the sprayed plants are noticeably greener than nearby unsprayed plants.

Assessment: 16 April (broccoli and lettuce)

The day 0 broccoli plot is now quite uneven, with a few stunted plants, but generally the sprayed plants are bigger and greener than others nearby. The day 7 broccoli plot looks to have slightly prostrate plants but is otherwise normal in appearance. The day 15 broccoli plot is now quite uneven, the eastern half (2 rows) looks like it missed a banding. The western half looks clearly better than the grower crop nearby.

All three lettuce plots look very good and slightly bigger and greener than grower plants nearby. The day 10 lettuce plot is a bit uneven.

Assessment: 21 April (broccoli and lettuce)

All three broccoli plots now look normal but somewhat uneven. All three lettuce plots now look very good and still slightly bigger and more green.

Assessment: 28 April (broccoli and lettuce)

The day 1 lettuce plot looks very good, still slightly bigger and greener than the grower's own plants. There is some leaf margin scorch on all lettuce on the property, probably due to excessive urea fertigation.

Grower 2: Carabooda

This grower cultivates a range of leafy salad greens such as spinach, Cos lettuce, mizuna and rocket. It was felt that his existing program (Table 8.5), while adequate and possibly overcomplicated, could be made cheaper and more simple.

Table 8.5 Grower 2–existing Cos lettuce fertiliser schedule

Day no.	Method of application	Fertiliser	kg/acre	kg/ha	N (kg/ha)	Total N kg/ha) cumulative	K (kg/ha)	Total K (kg/ha) cumulative
Pre plant		Super Spud®	250	625.0	70.6	**70.6**	77.5	**77.5**
Day 2	Broadcast	Nitrophoska®	100	250.0	30.0	**100.6**	35.0	**112.5**
Day 9	Broadcast	Nitrophoska®	100	250.0	30.0	**130.6**	35.0	**147.5**
Day 16	Broadcast	Nitrophoska®	100	250.0	30.0	**160.6**	35.0	**182.5**
Day 23	Fertigation	calcium nitrate	37	92.5	14.3	**174.9**	0.0	**182.5**
Day 23	Fertigation	potassium nitrate	37	92.5	12.9	**187.8**	35.7	**218.2**
Day 26	Fertigation	ammonium nitrate	25	62.5	21.3	**209.0**	0.0	**218.2**
Day 26	Fertigation	potassium sulphate	25	62.5	0.0	**209.0**	25.9	**244.1**
Day 30	Fertigation	calcium nitrate	37	92.5	14.3	**223.4**	0.0	**244.1**
Day 30	Fertigation	potassium nitrate	37	92.5	12.9	**236.2**	35.7	**279.8**
Day 33	Fertigation	ammonium nitrate	25	62.5	21.3	**257.5**	0.0	**279.8**
Day 33	Fertigation	potassium sulphate	25	62.5	0.0	**257.5**	25.9	**305.8**
Day 37	Fertigation	calcium nitrate	37	92.5	14.3	**271.8**	0.0	**305.8**
Day 37	Fertigation	potassium nitrate	37	92.5	12.9	**284.7**	35.7	**341.5**
Day 40	Fertigation	ammonium nitrate	25	62.5	21.3	**305.9**	0.0	**341.5**
Day 40	Fertigation	potassium sulphate	25	62.5	0.0	**305.9**	25.9	**367.4**

Spray trial: 18 April 2008

The purpose of this trial was to assess the effects of a range of potential spray treatments on a range of leafy salad crops under commercial conditions. A single unreplicated plot was used (6 m x 1.65 m) for each of four crops. All plants were sprayed using a knapsack and the fertilisers were supplied by ourselves. The plants were dry when sprayed (10:30) and irrigation commenced approximately two hours after spraying. The weather was fine and dry with a maximum temperature of about 26ºC. The treatments applied are detailed in Table 8.6.

Table 8.6 Treatment schedule for leafy salad crops

Age of crop sprayed	Spinach	Mizuna	Green Festival	Cos lettuce
	Day 7	Day 1	Day 1	Day 1
Site	Bay 13 east of house	Bay 4 east of house	Power pole 4 from house	Power pole 4 from house
S8	X	X	X	X

S8 = Spray 20 g/L potassium nitrate + 45 g/L urea @ 1000 L/ha (24 N)

Figure 8.4 Clockwise from top left – spinach, Cos lettuce on left, mizuna, Festival on right. 18 April 2008

Assessment: 21 April

Spinach: No spray damage at all. Sprayed plants are bigger than nearby plants.

Mizuna: No spray damage at all. Sprayed plants are greener than nearby plants.

Cos lettuce: Moderate leaf margin scorch on most leaves. Might be acceptable. The plants were very large and floppy at planting. No spray advantage seen yet.

Green Festival: Moderate leaf margin scorch on most leaves. Probably NOT acceptable. (Plants very large and floppy at planting) (Figure 8.5 right). No advantage seen yet.

Assessment: 24 April

Spinach:	Very tiny spot of spray damage on narrow leaf tip. Sprayed plants are now bigger and greener than nearby plants (Figure 8.6).
Mizuna:	No spray damage at all. Sprayed plants are now bigger and greener than nearby plants (Figure 8.6).
Cos lettuce:	Moderate leaf margin scorch on most leaves (Figure 8.5 left). Might be acceptable. The sprayed plants are now bigger and greener than others nearby.
Green Festival:	Moderate leaf margin scorch on most leaves. Probably NOT acceptable. Sprayed plants are smaller than nearby plants.

Figure 8.5 Example of spray damage on Cos lettuce plants (left) and floppy Festival plants (right)

Figure 8.6 Our mizuna (left) and spinach (right) appears well advanced compared with the grower's

Spray trial: 24 April

This is the second spray on the same plants as before. The treatment schedule is detailed in Table 8.7.

Table 8.7 Treatment schedule for leafy salad crops

	Age of crop sprayed			
	Spinach	Mizuna (herbs)	Green Festival	Cos lettuce
Spray treatment	Day 13	Day 7	Day 7	Day 7
Site	Bay 3 east of house	Bay 4 east of house	Power pole 4 from house	Power pole 4 from house
S8	X	X	X	X

Assessment: 28 April

Spinach: Some moderate leaf margin scorch on proper leaves. The grower is now concerned that the damage will cause rots to be a problem at harvest and/or post harvest. The sprayed plants are still bigger and greener than nearby plants.

Mizuna: Some moderate leaf margin scorch now on larger leaves. The grower is now concerned that the damage will be unsightly and possibly problematic at harvest. The sprayed plants are still bigger and greener than nearby plants.

Cos lettuce: Further moderate leaf margin scorch on most leaves. The grower is now concerned that the damage will be unsightly and possibly problematic at harvest. The sprayed plants are still bigger and greener than others nearby.

Green Festival: Further moderate leaf margin scorch on most leaves. Probably NOT acceptable. Sprayed plants are smaller than nearby plants.

Assessment: 2 May

Spinach: Leaf margin scorch on proper leaves has diminished but is still quite obvious (Figure 8.7 left). Sprayed plants are much bigger and greener than nearby plants.

Mizuna: Very little leaf margin scorch is now visible on larger leaves. The sprayed plants are much bigger and greener than nearby plants, maybe twice the size (Figure 8.7 right).

Cos lettuce: Leaf margin scorch on most leaves is still quite obvious but diminished. Some leaves are distorted or puckered. The sprayed plants are still bigger and greener than others nearby.

Green Festival: Leaf margin scorch on most leaves is still quite obvious but diminished. Some leaves are distorted or puckered. Sprayed plants are still smaller than others nearby.


Figure 8.7 Spinach at 21 days with slight spray burn (left). Mizuna (right) in the centre of bay nearest sprinkler is noticeably bigger than the grower's own crop

Assessment: 5 May

Spinach: A few spots of leaf scorch still obvious but the damage has diminished. The sprayed plants are much bigger and greener than nearby plants.

Mizuna: The crop had been harvested. The grower has took a sample of some of the leaves which had a leaf spotting symptom which could have been spray damage. (Figure 8.8).

Cos lettuce: Much less leaf distortion now visible. The plants look good, bigger and greener than grower's plants nearby.

Green Festival: Much less distortion now visible, plants look OK, catching up with the grower's own plants.

Figure 8.8 Mizuna with slight leaf spotting (right). Harvested Mizuna crop (left)

Spray trial: May 02

The purpose of this trial was to assess the effects of a range of potential spray treatments on a range of leafy salad greens under field conditions. A single unreplicated plot was used (6 m x 1.65 m) in each of five plantings. All plants were sprayed using a knapsack and the fertilisers were supplied by ourselves. The plants were dry when sprayed (10:30) and irrigation commenced approximately two hours after spraying. The weather was fine and dry with a maximum temperature of about 22ºC. The treatments applied are detailed in Table 8.8 below.

Table 8.8 Schedule of treatments applied to a range of leafy salad crops

Crop	Age of crop sprayed				
	Cos	Red Festival	Green Festival	Spinach	Rocket
Days after transplanting	Day 1	Day 1	Day 1	Day 4	?
Site	Bay between power pole 8 & 9 from house, in sprinkler 4 (south plot)	Bay between power pole 8 & 9 from house, in sprinkler 4 (south plot)	Bay between power pole 8 & 9 from house, in sprinkler 4 (south plot)	Bay 4 from house, in sprinkler 5 (south plot)	Bay 3 from house, in sprinkler 5, (south pl) along side Mizuna (18/04/08)
Spray S10	X	X	X	X	X
Site	Bay between power pole 8 & 9 from house, in sprinkler 3 (north plot)	Bay between power pole 8 & 9 from house, in sprinkler 3 (north plot)	Bay between power pole 8 & 9 from house, in sprinkler 3 (north plot)	Bay 4 from house, in sprinkler 4 (north plot)	Bay 3 from house, in sprinkler 4, (north pl) along side Mizuna (18/04/08)
Spray S9	X	X	X	X	X

S9 = Spray 20 g/L potassium nitrate + 36 g/L urea @ 1000 L/ha (20 N)
S10 = Spray 40 g/L potassium nitrate + 30 g/L urea @ 1000 L/ha (20 N)

Assessment: 5 May

Cos spray S9:	Very slight spray damage only to a few leaves. This plot of cos looks slightly greener than grower's crop.
Cos spray S10:	Very slight spray damage only to a few leaves. No advantage seen yet in this plot.
Red Festival spray S9:	Very slight spray damage only to a few leaves. No advantage yet.
Red Festival spray S10:	Very slight spray damage only to a few leaves. No advantage yet.
Green Festival spray S9:	Very slight spray damage only to a few leaves. No advantage yet.
Green Festival spray S9:	Very slight spray damage only to a few leaves. No advantage yet.
Spinach spray S9:	No damage seen yet. This plot is slightly bigger than grower's plants.
Spinach spray S10:	No damage seen yet. This plot is slightly bigger than grower's plants.
Rocket spray S9:	Very slight spray damage only to a few leaves. This plot is slightly bigger than grower's plants.
Rocket spray S10:	Very slight spray damage only to a few leaves. This plot is slightly bigger than grower's plants.

Assessment: 12 May

Cos spray S9:	Very slight spray damage. This plot looks slightly greener than grower crop.
Cos spray S10:	Very slight spray damage only. No advantage seen yet in this plot.
Red Festival spray S9:	Very slight spray damage only to a few leaves. No advantage yet.
Red Festival spray S10:	Very slight spray damage only to a few leaves. No advantage yet.
Green Festival spray S9:	Very slight spray damage only to a few leaves. No advantage yet.
Green Festival spray S10:	Very slight spray damage only to a few leaves. No advantage yet.
Spinach spray S9:	No damage seen yet. This plot is slightly bigger than grower's plants.
Spinach spray S10:	No damage seen yet. This plot is slightly bigger than grower's plants.
Rocket spray S9:	Very slight spray damage only. Plot is slightly bigger than grower's plants.
Rocket spray S10:	Very slight spray damage only. Plot is slightly bigger than grower's plants.

Spray trial: 12 May

This was the second spray on the same plots as before. The treatments applied are detailed in Table 8.9 below.

Table 8.8 Schedule of treatments applied to a range of leafy salads crops

Crop	Age of crop sprayed				
	Cos	Red Festival	Green Festival	Spinach	Rocket
Days after transplanting	Day 11	Day 11	Day 11	Day 14	? + 10
Site	Bay between power pole 8 & 9 from house, in sprinkler 4 (south plot)	Bay between power pole 8 & 9 from house, in sprinkler 4 (south plot)	Bay between power pole 8 & 9 from house, in sprinkler 4 (south plot)	Bay 4 from house, in sprinkler 5 (south plot)	Bay 3 from house, in sprinkler 5, (south pl) along side Mizuna (18/04/08)
Spray S10	X	X	X	X	X
Site	Bay between power pole 8 & 9 from house, in sprinkler 3 (north plot)	Bay between power pole 8 & 9 from house, in sprinkler 3 (north plot)	Bay between power pole 8 & 9 from house, in sprinkler 3 (north plot)	Bay 4 from house, in sprinkler 4 (north plot)	Bay 3 from house, in sprinkler 4, (north pl) along side Mizuna (18/04/08)
Spray S9	X	X	X	X	X

S9 = Spray 20 g/L KNO_3 + 36 g/L urea @ 1000 L/ha (20 N)
S10 = Spray 40 g/L KNO_3 + 30 g/L urea @ 1000 L/ha (20 N)

Assessment: 16 May

Cos spray S9: Almost no damage, a little leaf distortion but plot is slightly bigger and greener than grower plants.

Cos spray S10: Same as treatment 9 above but very slightly worse (tiny bit more damage).

Red Festival spray S9: Almost no damage, plot is slightly bigger, greener.

Red Festival spray S10: Same as treatment 9 above but very slightly worse damage.

Green Festival spray S9: Almost no damage, plot is slightly bigger and greener.

Green Festival spray S10: Same as treatment 9 above.

Spinach spray S9: Very slight leaf spot scorch, plot is bigger and greener than grower's plants. Grower commented that the crop was suitable for bunching but maybe not for loose leaf.

Spinach spray S10: Same as treatment 9 above but better (slightly less damage). Suitable for bunching, maybe not for loose leaf.

Rocket spray S9: Slight spray damage, leaf scorch on about 50% of leaves but plot is much bigger and greener than grower's plants.

Rocket spray S10: Moderate spray damage, leaf scorch to about 50% of leaves, slightly worse than treatment 9, but plot is bigger and greener than grower's plants.

Assessment: 23 May

Cos spray S9: All plants OK, plot is slightly bigger & greener than grower's crop.

Cos spray S10: As above.

Red Festival spray S9: As above

Red Festival spray S10: As above

Green Festival spray S9: As above

Green Festival spray S10: As above.

Spinach spray S9: Almost no damage visible, plot is bigger and greener than grower's plants.

Spinach spray S10: As above.

Rocket spray S9: Plot has been harvested, no sample kept, all product gone to market?

Rocket spray S10: As above.

Spray trial: 23 May

The purpose of this trial was to assess the effects of a range of potential spray treatments on a range of leafy salad greens under field conditions. A single unreplicated plot was used (6 m x 1.65 m) in each of three plantings. All plants were sprayed using a knapsack and the fertilisers were supplied by ourselves. The plants were dry when sprayed (10:30 am) and irrigation commenced approximately two hours after spraying. The weather was fine and dry with a maximum temperature of about 19ºC. The treatments applied are detailed in Table 8.10 below.

Table 8.10 Schedule of treatments applied to a range of leafy salads crops

Spray treatment	Age of crop sprayed		
	Spinach Day 7	**Swiss chard Day 7**	**Rocket Day 7**
Site	Bay 4 east of house	Bay 3 east of house	Bay 3 east of house
S11	X	X	X

S11 = Spray 20 g/L potassium nitrate + 30 g/L urea @ 1000 L/ha (17 N)

Assessment: 26 May

Spinach spray S11: Almost no damage, very promising at this stage.

Swiss chard spray S11: As above.

Rocket spray S11: Some minor scorch on a few leaves, the grower still has some concern about the damage at this stage.

Spray trial: 30 May

This is the second spray on the same plots/The treatments applied are detailed in Table 8.11 below.

Table 8.11 Treatment schedule

Spray treatment	Age of crop sprayed		
	Spinach Day 14	**Swiss chard Day 14**	**Rocket Day 14**
Site	Bay 4 east of house	Bay 3 east of house	Bay 3 east of house
S11	X	Not sprayed	X

S11 = Spray 20 g/L potassium nitrate + 30 g/L urea @ 1000 L/ha (17 N)

Assessment: 26 May

Spinach spray S11: Almost no damage, very promising at this stage, bigger and greener.

Swiss chard spray S11: No damage seen (one spray only).

Rocket spray S11: A little bit more damage, some minor scorch on a few leaves, the grower still has some concern about the damage at this stage, but bigger and greener.

Spray trial: 3 June

This trial looked at only one spray treatment on a commercial crop of rocket seven days after transplanting. A single unreplicated plot was used (6 m x 1.65 m). All plants were sprayed using a knapsack and the fertilisers were supplied by ourselves. The spray treatment used (S12) consisted of S12 = Spray 20 g/L potassium nitrate + 20 g/L urea @ 1000 L/ha (12 N). The plants were dry when sprayed (12:30 pm) and irrigation commenced approximately two hours after spraying. The weather was fine and dry with a maximum temperature of about 23ºC.

Assessment: 6 June

Rocket: Almost no damage but no benefit seen at this stage.

Grower 3

Grower 3 produces gourmet lettuce and other salad greens. His fertiliser program involved banding from the first week after transplanting at 500 kg/ha, followed by fertigation. He was encouraged to trial our method over the top of his existing program. Figure 8.9 show the results of those trials where it was clear that plants receiving our spray treatment were larger and better coloured.

Figure 8.9 Comparison of gourmet lettuce varieties after three weeks of spray treatment (left top and left bottom) and without spray treatments (right top and right bottom)

Figure 8.10 After an additional two weeks of banding the lettuce with our spray treatment (left) is still larger and more green than the grower's own program (right)

The grower was so pleased with these results he immediately changed to using the 3Phase method in its entirety.

The following graphs (Figure 8.11) show how management of soil nitrate improved as the grower became more familiar with the program and became more proficient at timing his nitrogen application rates to correlate better with crop growth. At the same time department development officer Rohan Prince was working with him to improve his irrigation management as part of HAL project VG04009. The graphs show that after two successive crops, the highest soil nitrate levels coincided with the period of maximum crop growth in the third crop instead of peaking too early when the crop was not able to make use of the nitrogen, or too late when most demand had passed.

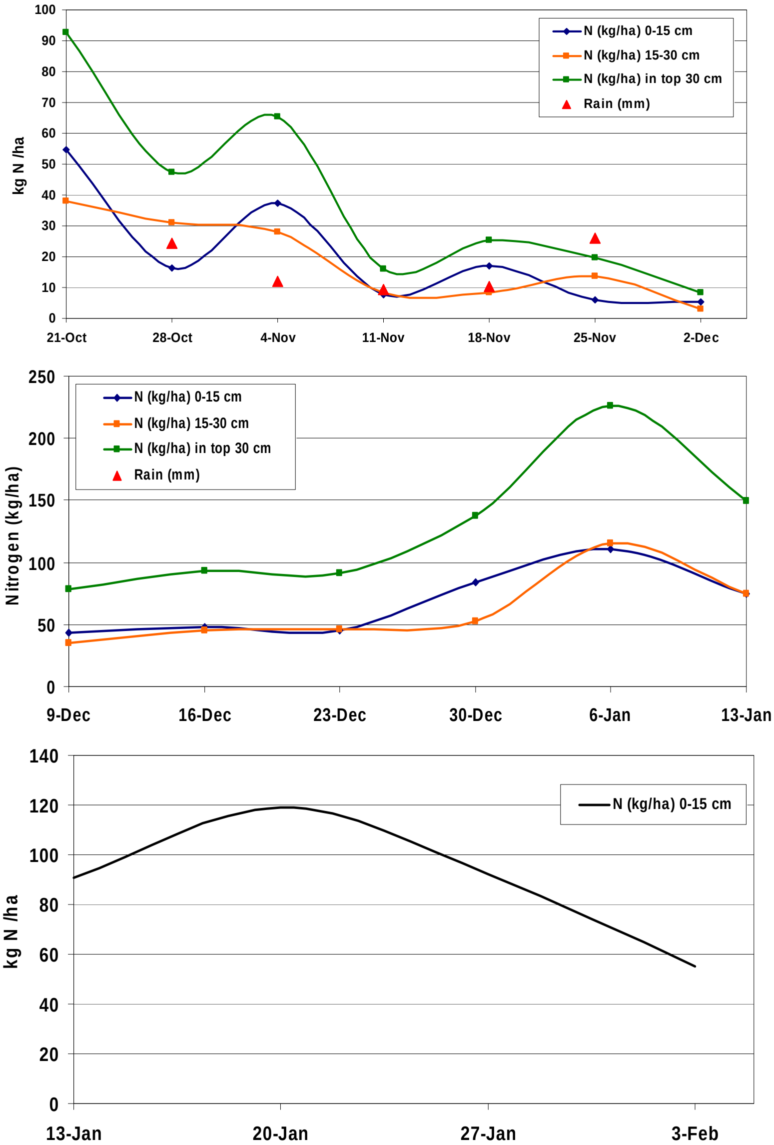

Figure 8.11 From top to bottom; soil nitrate levels for crops one, two and three after adoption of the 3Phase method

Grower 4

This large grower produces a range of leafy vegetable crops. His usual program also involved banding (300 kg/ha/week) commencing the week after transplanting (similar to Grower 3). He was encouraged to substitute the spray treatments for banding in the first two weeks on a bed alongside his usual method for easy comparison.

Again, the spray trial went well. Plants receiving our treatment were greener than the grower's own treatment (Figure 8.12).

Figure 8.12 Lettuce transplants after three spray treatments (left) compared with the grower's usual treatment (right)

Despite this good result the grower decided that spray treatments required too much labour and so were too costly to implement. He now fertigates for the first phase of crop growth. So while he has not fully implemented the 3Phase method, the changes made have been positive in that he has replaced banding with a lower rate of fertigation in Phase 1. That change alone has resulted in significant reductions in fertiliser use without reduction in product quality.

Conclusion

Grower 1 adopted the 3Phase method as a result of participating in these trials, using the program for all his iceberg lettuce and broccoli. Grower 2 started to use the program but eventually reverted to his previous methods of banding and fertigation. The small size of his farm meant more than one crop growth stage existed in an irrigation shift so it was difficult to implement the phases of the program at the correct time for each planting. Grower 3 still uses the 3Phase method for all his crops while Grower 4 has not embraced the program but has made valuable changes to his fertiliser schedule that have resulted in fertiliser savings. Later discussions with Grower 4 revealed he had incorrectly calculated the labour component of our program compared to his existing program however this still has not resulted in adoption.

9. COMMUNICATION/EXTENSION ACTIVITIES

Since the conclusion of HAL project VG 04018 we tried to maintain momentum and interest in these fertiliser programs using industry publications where possible. As the new project commenced this was continued and intensified. The following is a list of media articles published on this project. Copies of articles are included in the Appendix 4.

1. Unlocking the potential of mineral fertilisers. Compiled from an article by Dennis Phillips and Aileen Reid. WA Grower Vol 40 N0 2. June 2007, p3.
2. A summary of the project featured in the HAL/AUSVEG Industry report 07/08 in the 'Competitiveness' category (page 33) in August 2008.
3. Vegetables thrive on minerals. Countryman Horticulture, 8 August 2008, page 5.
4. Veggie tour sprouts knowledge. Kwinana Courier, page 3.
5. Fertilising for a better lettuce, Beth Johnston-farm Weekly (Ripe) August 2008, p 17.
6. Nitrogen fertiliser management – getting it right. Peter O'Malley, Dennis Phillips and Rohan Prince. 38, 39. WA Grower Vol 41 No 3, October 2008, pp 38-39.
7. Efficiency helps water down costs. Countryman Horticulture, 2 October 2008, page 4.
8. Way to grow and Cost saving boost. Sarah Quinton. Countryman Horticulture 6 November 2008 (cover and page 8).
9. Good Fruit and Vegetables December 2008 (page 21).
10. 3Phase counters climbing costs. Aileen Reid and Dennis Phillips, WA Grower Vol 42 No.1. March 2009. pp 18-19.
11. Field trip first of three – Good practice field trip. Gavin Foord. Covered a visit to Medina Research station where Dennis Phillips and Aileen Reid talked on *Busting Fertiliser myths with 3Phase*. WA Grower Vol. 42 No. 3 September 2009 pp 6–8 with a Vietnamese translation pp. 9, 10.
12. Fertilising a three way system. Countryman Horticulture liftout 1 October 2009, page 2.
13. The 3Phase method for growing lettuce in sandy soils, Farmnote 375, July 2009.
14. The 3Phase method for growing broccoli in sandy soils, Farmnote 377, July 2009.
15. The 3Phase method for growing lettuce in sandy soils 2009, Vietnamese translation of same, and the 3Phase method for growing broccoli in sandy soils 2009. WA Grower Vol 42 No.4, December 2009. pp 42-53.
16. 3Phase beats nitrogen leach. Vegetables Australia Nov/Dec 2009, pp 46-47.
17. New fertiliser practices. HAL/AUSVEG Industry Report 08/09, page 29.

Workshops

A workshop for vegetable growers at Mandurah 26 May 2009 on *Improving your farms viability research to practice*, highlighted the use of the 3Phase method.

Field days

Since the start of the project in January 2008, growers have been invited to inspect trials at Medina both through mass media channels and by personal invitation at a time convenient to them. A total of eleven growers visited the site over five dates as well as two consultants and a journalist in July 2008 and four growers and a journalist in November and December.

The method proved better than a field day or field walk, allowing in depth discussion between researchers and growers on a one to one basis each time. This interchange resulted in opportunities to do more demonstrations of 3Phase with growers who hitherto knew little about the project.

10. GROWER ADOPTION

Eight growers were interviewed on their knowledge of the 3Phase fertiliser program and associated project activities. Two other growers who were not directly involved in project activities were also approached to provide feedback however these growers chose not to participate. The growers interviewed produce a range of leafy vegetables including broccoli, cabbage, cauliflower, celery, iceberg, cos and gourmet lettuce, silver beet and baby leaf spinach.

The first part of the survey sought information on general fertiliser practices, recent changes to these practices and where growers source their information when making decisions on fertiliser application. The second part of the survey focused specifically on the uptake of the 3Phase fertiliser program. The final part of the survey looked at the impact of printed material such as Farmnotes and magazine articles, and field days.

All growers said they had made changes to their fertiliser program in the last three years. The changes ranged from delaying the start of banding, replacing those first two weeks of banding with sprays, the implementation of fertigation from row closure to harvest (and in doing so, banding less), applying less fertiliser more often and also to applying more targeted applications such as changing from broadcasting to banding. One grower also mentioned reduced levels of irrigation.

When asked why they made the changes the responses varied. Several growers were conscious of the amount of fertiliser being leached below the root zone and had modified their practices for that reason. Two of those growers had implemented those changes due to their use of external consultants while the others had been working with DAFWA. One grower specifically mentioned that he liked to have a set program to work to as it made it easier to direct staff using a program. Only one grower mentioned economic reasons as a basis for change.

When the growers were asked if they were using less fertiliser now than three years ago all said they were. Changes included:

- less nitrogen applied by compensating for the nitrogen already in the irrigation water and use of calcium nitrate on lettuce instead of ammonium nitrate
- nutrient sprays in the first two weeks resulting in less fertiliser use overall and reduced fertigation rates
- use of superphosphate at 1-1.5 t/ha/year according to soil analysis to replace poultry manure
- reduction in fertiliser use through monitoring of nutrients in the root zone and leaching results from the lysimeters
- fertiliser use cut by about 40 per cent overall through use of the 3Phase method
- reduced application rates for banding (two growers)
- banding instead of broadcasting to reduce total fertiliser usage by half.

When asked about the use of pre-plant fertilisers, three growers were not currently using any pre-plant, one of whom had stopped using poultry manure in the last two years. Those using a pre-plant were using:

- compost (20 m^3/ha once a year)
- a combination of di-ammonium phosphate and mono-ammonium phosphate at 120 kg/ha plus Organic 2000 while trialling zeolite and spongelite to improve the soil nutrient and water-holding capacity
- a low rate of NPK blue (200 kg/ha) one day prior to planting iceberg lettuce
- superphosphate plus trace elements after soil test results (200 kg/ha per crop) 14 days before planting

When growers were asked if they had ever used poultry manure there were only two that didn't – one of whom said he would like to because he wanted to build up the organic matter levels on a new block. One grower used Dynamic Lifter® two weeks after planting, banded and incorporated between the rows at 1 t/ha. One grower remarked it increased the amount of organic matter in the soil but also noted potential problems with stable fly.

When asked why they stopped using poultry manure three growers mentioned nitrogen leaching as a problem. Other comments included:

- too much extra work and cost, problems complying with local government regulations
- root rot and other disease problems in winter
- "We used to use it in winter because of the long growing period—it sticks around in the soil".

None of the growers interviewed could accurately estimate how much of their production costs were associated with fertiliser. Fertiliser and chemical costs were grouped together in the accounting system on most properties, making it difficult to determine the total fertiliser bill. Labour was reported as the biggest input however growers were unable to clearly estimate the labour costs associated with fertiliser applications. Two growers said that fertiliser application accounted for less than 1 per cent of their overall budget. One grower said that the 3Phase program had significantly reduced their costs— "In the last 3 years fertiliser costs have gone up by 200-300 per cent costing us around one million dollars a year. Using the 3Phase method our fertiliser bill dropped to $700,000 a year for the same amount of crop".

Sources of information used by growers were weighted towards previous experience and DAFWA—but in that respect this survey was biased since these growers were already working with DAFWA. Also mentioned were:

- consultants (Root zone/Soil zone)
- field days
- fertiliser/pesticide suppliers
- notes and literature including DAFWA vegetable publications, the Queensland Agrilink series, the vegetablesWA *Good Practice Guide* and plant disorder books.

Several growers said they didn't take advice from fertiliser companies who were trying to sell product.

All growers were aware of the 3Phase program (the survey was biased in that all growers interviewed were already participating in DAFWA research), but few growers were using all aspects of the 3Phase program on all their crops. Two mentioned the program took too much time: "It takes too much time to get around the farm with two sprays per week—decided to stick with fertigation methods," and "The 3Phase program works but it takes too much time—I have now gone back to banding concentrated fertiliser."

One grower had a bad experience with foliage burning on one crop (he applied the wrong spray rate too late in the crop life) and has not used the 3Phase method since. Most had altered the programs to suit their own circumstances by adjusting the rates and timing of fertiliser application, for example, delaying banding until two to three weeks after transplanting. Only two growers had adopted the program in its entirety. All growers were happy with the changes they had made, and their comments included:

- "It produced one of the best crops we have ever grown."
- "The crop is more uniform, with good head formation and no tip burn."
- "The crop is perfect and uniformity is much better making it easier to harvest."
- "The crop cycle is shorter, saving on labour, chemicals and water."
- "The crop has more vigour, it just wants to grow especially now we are feeding early and not waiting a week after transplant before fertilising."

Two of the growers interviewed thought that adoption of the 3Phase method reduced their fertiliser inputs by as much as 40 to 50 per cent.

Asked if they thought their practices were having an effect on the groundwater, most growers acknowledged they did. Several were now also monitoring their nitrate levels in the soil—either through the DAFWA project or using private consultants. One grower was factoring the nitrogen in his irrigation water into his fertiliser program and two said their nitrate levels had stabilised and were now reducing. The impact of rain on leaching was recognised by one grower as being a factor out of his control. Two growers were being monitored for leaching of nutrients as part of their water licence and two were doing it voluntarily for a DAFWA research project.

Between three of the growers interviewed, 133 hectares is now under 3Phase. One grower with 12 ha started using 3Phase but moved away due to reasons of time. Another grower on 25 hectares started, had one failure and consequently discontinued the program. One large grower on around 70 hectares has implemented part of the program.

Media articles and farmnotes

Three of the eight growers surveyed did not recall seeing anything in print. When asked about their response to the material, one grower said he learnt nothing from the article. Two other growers were already involved in trials so understood it better. One additional grower felt the articles explained some detail on nitrogen rates. Only one grower said he was prompted to take action as a result of reading the material.

Field days

Only one of the growers interviewed had not attended any of the field days. Comments showed some found the days useful but “more on-farm assistance would have helped.” Other comments:

- “I didn’t learn anything, it was mind boggling. I had to take the information away and read it and then ask questions to understand how it all worked.”
- One grower said he wasn’t convinced, despite viewing the trials, to adopt banding of Nitrophoska at 100 kg/ha.
- “It was interesting to see the comparative performance of the different fertiliser rates and timing side by side.”
- Two growers stated the main reason for attending the field days was to look at the crops and make sure they were as good as their own.
- One grower stated he didn’t learn anything from the field day.

It seemed that most field day attendance was by growers already interested and involved, with minimal numbers of other growers. Hence, it is difficult to draw major conclusions on the efficacy of field days as a means of promoting research adoption. One grower of the eight interviewed began working in another DAFWA project as a result of the field day and another tried 3Phase as a consequence of attending the field day but later dropped it as it didn’t fit in with his growing program.

11. RECOMMENDATIONS

The survey completed at the end of the project highlighted several clear benefits of the 3Phase method. These included:

- Significant reductions in fertiliser use were able to be achieved
- Improvements in crop quality and uniformity resulting from targeted fertiliser application
- Crop turnaround time was reduced.

Impediments to the adoption of the 3Phase method were also identified and include:

- The need to tailor the program to individual situations and hence the requirement for one-on-one advice.
- A perception that more time and effort is required to implement the program.
- Lack of drivers for adoption – for example the relatively low cost of fertiliser compared to other costs of production for many growers, particularly those with low levels of mechanisation for whom labour costs remain high.

Our results show a clear benefit to industry and the environment from implementing the 3Phase method however for many growers the perceived changes in on-farm practices required to implement the program remain a significant stumbling block. The survey results show that one on one on-farm demonstrations remain the best method of achieving uptake of the 3Phase method but it is evident that method is better suited to some types of enterprises.

The growers of iceberg lettuce in particular, who were involved in this program, were keen to extend the 3Phase method to their baby leaf crops. The program seems especially suited to these growers but the risks of foliage burning are high and more work is needed to develop a fool-proof program specifically for those crops. There is also value in extending the 3Phase method to other crops such as tomatoes however until better drivers exist for implementation, uptake may remain slow.

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APPENDICES

Appendix 1. Medina Research Station weather records

Appendix 2. Grower 1 bander calibration

Appendix 3. Fertiliser practices survey form

Appendix 4. Publications and media articles

Appendix 1. Medina Research Station weather records

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
01-January-2006	11.1	24.6	23.9	65	20.2	35	31893	0	9.5	9
02-January-2006	13.1	29.7	18.8	68.8	21.6	37.7	32599	0	8.9	9.4
03-January-2006	15.8	31.2	13.5	92.7	23.9	38.1	24989	0.6	9.5	9
04-January-2006	17.1	24.7	54.6	86.9	21.4	29.4	15612	0	8.9	9.4
05-January-2006	18.2	28.4	49.5	83.9	24.4	38.1	30644	0	8	7.9
06-January-2006	20.6	32.1	38.7	74.3	26.5	40	30900	0	6.6	4
07-January-2006	21	37.4	31.2	83.1	28.2	42.1	28716	0	7.6	8.3
08-January-2006	19.7	34.5	36	93	27	43	27129	7.8	10.2	9.4
09-January-2006	15.1	25.5	49.8	85	22.7	35.1	25150	0.2	5.9	8.8
10-January-2006	13.9	28	35.2	78.4	22.7	38.4	30939	0	7.5	7.9
11-January-2006	16.8	28.8	24.6	66.1	23.3	38.3	31782	0	9.5	6.8
12-January-2006	18.9	32.5	22.6	80.6	25.9	38.5	24253	0	9.1	8.4
13-January-2006	18	21.7	72.7	89.8	21.2	26.3	7546	10.6	9.6	9.3
14-January-2006	17.5	24.2	60.4	79	21.8	27.4	11629	0	7.5	7.5
15-January-2006	17	26.7	52.9	81.5	20.6	26.5	10585	0	7.9	1.5
16-January-2006	16.8	27.2	50.1	92.2	23.7	37.3	30636	0	7.1	2.9
17-January-2006	16.7	29.7	46.7	88.4	24.4	39.3	30645	0	6.6	3
18-January-2006	19.3	28	47.1	86.4	26	39.8	28525	0	6.5	7.9
19-January-2006	14.2	24.7	58.4	92.8	22.6	33.6	19801	0	6.9	8.4
20-January-2006	14.6	27	42.6	91.4	23	38	31450	0	7.7	7.5
21-January-2006	15.5	29.3	36.4	81.2	23.4	37.8	30644	0	8.4	4.9
22-January-2006	12.7	24.2	42.7	71.4	21.2	36.2	30884	0	7.8	8.3
23-January-2006	16.1	30.8	19.7	63.7	23	38.5	30929	0	11	8.6
24-January-2006	23.9	35.5	18	41.3	27.2	40.3	30450	0	11.8	8.5
25-January-2006	20.8	28.3	39.2	92.6	23.8	30.7	5413	36	8.6	9.3
26-January-2006	14.5	27.1	47.5	85.5	20.5	32.8	19134	0.4	11.1	11.2
27-January-2006	13.7	28.5	25.1	79.9	21.1	37.1	31271	0	7.4	1.4
28-January-2006	14	26.6	30.3	83	21.7	36.3	30337	0	8.4	4.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
29-January-2006	12.9	26.9	39	71.1	20.9	35.6	30461	0	7.4	8.5
30-January-2006	14	24.5	25.6	69.8	21.1	33.7	26174	0	8.6	8.1
31-January-2006	11.9	24.5	41.8	80.7	19.9	31.6	22457	0	10.7	8.5
01-February-2006	11.3	23.1	34.6	85.8	20.3	34.7	30332	0	9.8	7.6
02-February-2006	11	24	40.3	90.8	20.5	35.3	29156	0	7.8	6.2
03-February-2006	15	26.7	41.3	86.7	22.2	36.5	29773	0	9	7.8
04-February-2006	18.6	30.4	31.3	83.6	23.6	37.8	29766	0	7.2	7.4
05-February-2006	17.4	33.8	29.5	72.8	24.3	39.7	29594	0	7.6	7.9
06-February-2006	18.9	29.6	39.6	66.5	24.4	38	28682	0	8	8.7
07-February-2006	21.7	37.1	27.1	91.2	26.3	40.6	25121	2.6	6.8	9.2
08-February-2006	9.8	26.8	46.4	86.3	20.9	37	28347	0	11.8	9
09-February-2006	14.4	25.7	30.9	70	21.3	36.3	29615	0	6.2	7.4
10-February-2006	16.8	32	23	81.1	23.1	38.6	29409	0	10.3	7.4
11-February-2006	20.5	32.1	23.4	76.4	25.3	38.9	28383	0	10.3	8.3
12-February-2006	20.5	33	33.8	77.4	25.9	38.4	23738	0	7	8.7
13-February-2006	20	33.3	37	82.2	25.7	40.3	27956	0	7.9	8.8
14-February-2006	19.5	34.9	30.8	81.2	26.6	40.9	27819	0	8.2	7
15-February-2006	20.2	37.5	24.5	89.7	27.6	41.7	24537	0	8.1	8.3
16-February-2006	18.2	21.2	62.3	89.7	23.1	28.9	9202	0	6.3	8.7
17-February-2006	10.6	23.2	52.1	94.3	20.6	32.2	19041	0	5.7	7.7
18-February-2006	13.8	25.2	48.5	79.5	21.4	36.1	27201	0	9.7	2.5
19-February-2006	14.9	26.8	35.2	70.9	21.2	35.1	26657	0	5.6	4.5
20-February-2006	18.5	28.5	27.9	65.3	22.8	36.7	28124	0	9.2	7.1
21-February-2006	23.4	37.6	18.5	60.2	26.7	40.1	26831	0	10.5	7.5
22-February-2006	21	41.3	17.8	89.4	27.3	42.1	25923	0	8.6	8.2
23-February-2006	18.6	29.6	48.1	89	25.3	38.4	20411	0	8.9	9.6
24-February-2006	12.6	24.2	46.8	73.9	21.4	34.6	22249	0	6.3	8.8
25-February-2006	16	25.8	39	72.3	22.3	35.6	26654	0	6.9	5.5
26-February-2006	19.4	32.6	22.5	60	23.8	37.8	26800	0	8.8	6

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
27-February-2006	22.8	37.1	23.4	64.4	26.6	39.9	25946	0	9.3	7.5
28-February-2006	22.3	37.5	19.5	55.2	26.3	40.9	25981	0	8.6	8.4
01-March-2006	22.1	37.3	20	67.4	27.3	40.9	23819	0	7	8.7
02-March-2006	20.7	27.8	47.1	84.8	26.4	33.6	13462	0	6.5	8.9
03-March-2006	13.2	23.9	52	94.1	22	34.8	20600	0	8.5	8.4
04-March-2006	19.4	31.6	36.2	75.6	25.2	37.4	25544	0	8.4	3.9
05-March-2006	23.1	38.2	20.8	59.9	27.1	38.9	22560	0	5.2	5
06-March-2006	20.4	36.8	27.2	67	27.2	39.8	22956	0	6.6	7.6
07-March-2006	20.6	36.7	23.4	67.4	26.6	41	24956	0	6.6	8.2
08-March-2006	19.4	37.5	21.5	73.9	26.8	41.3	24904	0	9.1	8.3
09-March-2006	17.7	31	41.7	93.4	26.1	39.3	24648	0	8.6	8.5
10-March-2006	17.1	29.9	40.6	92.2	25.8	39.1	23894	0	4.8	8.1
11-March-2006	16.7	25.3	47.6	74.3	24.4	36.1	19224	0	5.9	7
12-March-2006	10.5	22.9	40.6	86.9	20.5	33.7	20388	0	5.4	6.4
13-March-2006	14.7	26.2	25.5	70.7	21.2	34.9	24973	0	8.7	5.3
14-March-2006	15.2	30.5	28.7	76.3	22	36.3	24435	0	7.1	5.5
15-March-2006	16.1	30.2	27	72.2	22.4	35.4	23904	0	9.2	7.1
16-March-2006	16.2	33.7	22.5	67.3	22.9	37.5	24280	0	7.8	7.4
17-March-2006	15.6	32.3	25.6	79.8	22.8	37	23945	0	10	7.6
18-March-2006	14.9	33	18.3	74.5	22.5	37.1	23868	0	8.1	7.8
19-March-2006	18.7	32.1	21.8	59.9	23.6	36.7	23309	0	7.7	7.7
20-March-2006	20.4	34.5	17.2	53.5	24.1	38.1	23266	0	5.7	7.5
21-March-2006	19	37.2	12.9	52.6	25.3	39	23049	0	9	8
22-March-2006	18.9	34.6	19.1	83	24.7	36.1	16764	0	7.4	8.3
23-March-2006	13.1	22.3	51.6	87.7	20.8	32.3	13697	0.2	4.7	8.2
24-March-2006	14.7	20.5	46.1	92.9	20.3	28	15852	10.4	8.3	5.3
25-March-2006	9	20.3	63.2	94.8	15.7	24.8	12953	0.8	10.8	4
26-March-2006	11	22.6	40.1	75.8	16	27.1	17871	0	9.9	4.2
27-March-2006	11.5	26.4	23.2	69.5	17.6	31.2	22664	0	5.3	2.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
28-March-2006	11.2	30	24.6	82.4	18.7	33	22204	0	3.3	4.3
29-March-2006	15.7	26.7	31.8	72.2	19.6	31.5	21585	0	2.1	6
30-March-2006	14.9	30.6	24.5	69.8	19.9	33.1	21593	0	1.9	6
31-March-2006	14.3	30.7	25.2	72.9	19.6	33.4	21866	0	3.6	5.9
01-April-2006	13.8	25.2	35.8	93.1	18.9	28.3	13467	14	2.3	6.2
02-April-2006	13.9	20.7	61.4	88.7	17.2	24.1	11395	0	2.8	6
03-April-2006	11.4	23.4	47	92.9	17.1	28.2	19561	0	4.3	3.7
04-April-2006	11.2	24	33.2	90.1	16.8	29.5	19945	0	4.6	2.5
05-April-2006	11.3	24.4	31.1	87.4	16.6	30	20652	0	5.3	4.7
06-April-2006	13	24.1	35.4	71.2	16.8	29.6	20681	0	4	5
07-April-2006	13	25.6	30.6	80.3	17.3	30.2	20625	0	3.8	5.3
08-April-2006	15.3	27.9	28	66	18.3	31.2	20467	0	7.5	5.9
09-April-2006	14.5	30.7	29.2	92.1	20.6	32.4	19500	0	7.1	6
10-April-2006	7.9	22.3	55.5	92.9	17.4	28.5	15887	0	5.8	6.2
11-April-2006	14.6	23.3	51.6	93.1	19	26.9	12372	1.6	4.4	5.4
12-April-2006	11.9	21.7	48.4	82.2	16.3	25.6	13999	0	6.6	4
13-April-2006	7.9	20.4	42.3	94.7	15.1	27.4	17881	0	5.6	3.1
14-April-2006	14	22.4	47.2	85.5	16.6	27.6	17445	0	5.6	3.6
15-April-2006	10.7	26	30.7	86.7	16.7	29.6	18770	0	4.9	4.3
16-April-2006	9.2	28.4	36.4	92.9	16.9	30	17775	0	8.1	4.6
17-April-2006	5.9	20.3	42.6	88	13.7	25.7	16038	0	5.7	5.1
18-April-2006	4.8	20.5	30.5	93.8	13.7	26.1	17953	0	5.9	4.8
19-April-2006	8	20.5	51.2	95	13.5	24.8	14199	0	7.8	4.2
20-April-2006	9.6	23.8	30.8	74.8	14.7	27.2	18273	0	4.8	4.3
21-April-2006	18	25.4	31.2	61.2	17.6	25.8	14572	0	4.6	3.2
22-April-2006	15.4	30.7	29.1	86.2	19.3	28.7	13864	0	6.2	5
23-April-2006	11.6	20.6	54.6	93.8	17.1	25.8	11297	0	7.8	5.1
24-April-2006	12.8	21.8	50.9	94.6	17.6	27	15039	1.6	6.3	4.2
25-April-2006	13.5	20.7	65.3	94.4	16.4	23.7	10534	5.2	4.3	2.6

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
26-April-2006	10.2	19.8	60.5	94.3	13.9	22.7	8684	8.2	4.5	3.4
27-April-2006	4.1	17.3	61.7	95.7	9.9	20.6	10557	0.2	4	2.1
28-April-2006	6	18.9	43	95.6	11.5	22.8	16697	0	5.5	1.8
29-April-2006	10.3	21.1	49.9	94.1	13.7	24.3	12983	0	3.8	2
30-April-2006	5.1	20.8	50.1	96.7	12	24.8	15338	0	3.9	3.7
01-May-2006	7.8	21.8	45.4	95.4	13.2	24.8	16149	0	3.6	2.9
02-May-2006	9.3	22.3	45	96.2	13.2	25.1	15501	0	3.4	3.4
03-May-2006	5.4	21	43.6	95.1	12.3	24.6	15830	0	3.6	3.7
04-May-2006	8.2	21.9	40.7	95.7	13	24.3	15151	0	4.5	3.6
05-May-2006	7.2	20.1	52.2	94.9	13.2	21.6	10026	0	4.9	3.7
06-May-2006	14.9	20.3	63.6	93.5	15.6	21.2	8133	3.4	4.1	3.6
07-May-2006	9.4	21.4	64.9	90.2	11.5	23	12367	0.4	3.9	2.3
08-May-2006	5.4	21.4	38.1	95.3	10.9	23.5	15198	0	3.9	1.6
09-May-2006	6.7	22.2	33.7	96.4	11.7	23.7	15087	0	5.9	2.9
10-May-2006	6.2	24	35.8	93.4	11.8	23.6	14034	0	4	3.5
11-May-2006	6	26.1	24.4	91.8	11.9	24.8	14829	0	3.5	3.6
12-May-2006	11.5	29.6	16.6	72	13.6	25.6	14917	0	3.8	3.5
13-May-2006	11.8	30.2	16.9	64.6	13.6	26.3	14582	0	3.3	4
14-May-2006	8.6	27.5	19.1	76.3	13.7	23.6	10051	0	4.9	5
15-May-2006	16.2	28.4	19.8	94	16.2	23.2	8876	16.6	4	4.9
16-May-2006	9.4	21.6	62.1	95.3	12.7	22.6	11020	14.4	3.9	3.6
17-May-2006	10.5	21.6	50.1	89.9	12.6	22.7	14104	0.2	5.2	3.1
18-May-2006	10.4	22.1	57.9	92.2	13.2	22.3	12480	0	4.1	2.3
19-May-2006	11.1	22.3	49	84.9	12.9	23.1	13748	0	4.8	3.4
20-May-2006	9.7	20.6	38.8	87.6	12.1	22.6	13792	0	4.3	2.9
21-May-2006	11.2	21.9	44.7	83.2	13	22.7	14025	0	5.6	3.5
22-May-2006	16.2	25.6	30.3	54.6	14.4	23.8	13056	0	6.2	3.6
23-May-2006	15	25.6	27.6	89.6	15.7	21	6043	3	7.2	3.7
24-May-2006	7.8	18.4	73.5	94.7	10.3	19.4	5358	6.2	6.6	4.4

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
25-May-2006	4.2	16.9	44.7	89.1	7.6	18.4	11522	0	4.2	2.3
26-May-2006	1.9	17.9	37.4	95.4	7.4	19.1	13802	0	5.4	1
27-May-2006	4.8	19.4	38.9	94.4	8.5	19.4	13724	0	4.1	2.5
28-May-2006	11.2	21.4	34.9	69.1	10.6	20.2	13192	0	4	3.1
29-May-2006	11.7	22.7	40.7	94.1	12.7	19.4	7767	2	4.4	3.2
30-May-2006	5.7	16.3	51.5	95.7	10.5	17.8	8764	1.4	5.4	3.8
31-May-2006	4.7	16.2	60.7	97.6	8.3	17.6	8071	0.6	5	2.1
01-June-2006	5.6	17.1	61.6	96.3	8.1	16.2	7672	0	5.5	1.9
02-June-2006	6.3	19	44.2	92.4	7.8	16.8	10012	0	2.5	1.3
03-June-2006	5.1	19	53.9	95.6	8.1	18.4	10973	0	3	1.3
04-June-2006	5.9	20	34.5	82.4	8.2	19	12763	0	4.8	2.2
05-June-2006	3.5	22.2	29.6	90.9	7.7	19.5	12788	0	4.7	2.4
06-June-2006	5.6	23.6	28.7	91.3	9.1	19.8	12798	0	4.7	3.2
07-June-2006	7.5	22	49.8	95	10.6	20.3	12487	0.8	3.3	3.1
08-June-2006	0.8	19.2	44	94.6	6.6	18.8	12093	0	3.6	3.3
09-June-2006	2.3	16.7	35.7	95.5	6.7	17.2	12524	0	3.4	2.8
10-June-2006	4.2	16.9	51.6	96.1	8	16.8	11225	0	4.1	2.9
11-June-2006	2.3	18.4	42	95.9	7.2	17.5	11242	0	4.7	2.9
12-June-2006	6.5	20.5	33.9	83.2	8.5	18.3	12133	0	4.8	2.4
13-June-2006	6.8	21.4	28.5	85.7	8.2	18.9	12597	0	4.1	2.6
14-June-2006	12	22.2	24.2	66.1	11.1	17.9	9470	0	4.8	3.2
15-June-2006	7	23.5	20.9	62.4	8.7	20.3	11437	0	4	3.4
16-June-2006	3.9	21.4	20.2	68.8	7.1	19.3	12724	0	4.4	3.2
17-June-2006	-0.8	19.6	18.5	83.1	5.5	18.3	12837	0	5.4	3.7
18-June-2006	0.6	20.1	24.9	96.6	6	17.3	11762	0	5	3.8
19-June-2006	5.4	22	29.8	85.2	7.9	18	11828	0	3	3.2
20-June-2006	12.5	20.3	54.3	85.8	9.7	14.9	5681	6.4	3.1	2.8
21-June-2006	10.1	18.2	46	88.5	10.9	16.2	8118	0	3.1	3
22-June-2006	3	18	51.5	97.6	7	17.8	9135	0	11.8	2

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
23-June-2006	4.5	19.4	41.1	95	7.7	18.6	11935	0	6.2	2.2
24-June-2006	5.1	20.5	29.7	88.4	7.9	18.6	12261	0	2.8	1.8
25-June-2006	2.9	22.1	32.7	94.9	7.4	19	12247	0	4	2.7
26-June-2006	11.6	22.5	40.6	94.6	9.2	19.2	11198	2.6	4.6	3.2
27-June-2006	9.2	17.6	59.9	94.8	10.9	17.6	7170	3	3.4	3
28-June-2006	8.5	19.5	61.5	89.9	10.4	17.4	6543	14.8	3.9	2.7
29-June-2006	6.4	16	54.5	94.2	10	16.1	8281	0	3.5	1.4
30-June-2006	11.6	16.8	61.2	91.5	11	16.1	5563	0.8	10.2	1.9
01-July-2006	11.5	19.9	61.7	94.7	12.8	18.3	7691	4.2	3.2	1.7
02-July-2006	6.8	19.2	48.7	95.8	9.5	20.4	11980	0.2	2.3	1.2
03-July-2006	10.9	22.5	44.3	94.2	11.6	20.3	12234	1	6.7	1.8
04-July-2006	8.7	20.5	71.5	96.7	10.8	17.7	6098	3	2.5	2.5
05-July-2006	6.6	15.4	76.8	94.9	9.4	16.4	5244	0	2.5	2.7
06-July-2006	8	19.4	46.1	87.9	9	18.5	11080	0	4.2	1
07-July-2006	11.8	21.6	48.8	71.5	10.4	19.5	12389	0	2.4	0.7
08-July-2006	4.7	22.8	33.7	93.3	8.9	20.7	12590	0	4.5	2.6
09-July-2006	15.5	22.4	34.4	88.9	10.7	19.9	11865	6.2	7.3	3.5
10-July-2006	9.6	19	53.5	88.2	10.9	19.2	10965	4.6	4	3.3
11-July-2006	6	14.9	46.9	85.5	7.5	17.4	10444	0.2	7.3	3.2
12-July-2006	2.9	15.2	44.6	95.3	6.2	16	11487	0	10.4	3
13-July-2006	0.8	15.7	48.4	97.7	5.7	16.7	11166	0	5.5	2.2
14-July-2006	7.6	17.2	45.8	89	7.9	17.6	12974	0	4.9	2.4
15-July-2006	6.5	16.5	69.6	97.5	8.5	16.2	7046	1.4	3.2	2.1
16-July-2006	6.6	20.6	56.2	96.2	8	19.2	12732	0	3.4	2.7
17-July-2006	3.9	19.9	39.3	88.6	7.4	19.3	13458	0	3.2	1.1
18-July-2006	4.1	19.4	32.8	90	7.1	19	13599	0	3.9	2.6
19-July-2006	2.9	21.2	24	90	7.2	19.2	13668	0	4.8	3.2
20-July-2006	3.2	21.3	26.7	92.8	7	18.8	13678	0	4.2	3.3
21-July-2006	5.5	20.1	47.1	93.4	8.6	16.3	8218	26.4	3.9	3.5

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
22-July-2006	-0.1	14.4	48	97.9	5.1	16.1	12461	0	3.3	3.3
23-July-2006	3.3	16.5	43.8	95	6.7	16.9	13788	0	9	1.9
24-July-2006	8.9	21.2	34.9	89.4	9.1	18.7	13223	0	5.3	2.6
25-July-2006	6.4	14.4	66.5	96.7	7.7	12.6	2793	26.8	4.7	2.8
26-July-2006	9.5	17.3	62.6	95.9	9.9	16.4	8286	11.2	6.1	3.8
27-July-2006	11.1	19	54.4	95.2	11.5	18.8	12549	8.2	5.7	0.5
28-July-2006	4.9	16.3	60.5	94.2	7.5	15.1	5656	9.8	3.3	1.3
29-July-2006	8.6	15.5	51	96.3	9.6	16.3	10787	6.2	6.3	2.7
30-July-2006	9.4	18.3	60.4	96.2	9.7	18.8	11661	6	9.2	1.2
31-July-2006	7.3	18.5	60.2	96	9.9	19.4	11104	0	3.9	2.1
01-August-2006	6.6	17.2	62.8	95.8	8.8	15.6	5337	4.8	4.8	2.3
02-August-2006	11.2	17.7	50.4	94.2	11.6	16.9	9231	4.4	3.2	2.2
03-August-2006	12.7	20	57.7	94.6	13.5	19.6	9642	3.4	4.8	0.9
04-August-2006	8.7	21.5	57.7	96.2	10.5	22.1	12570	0.2	7.2	2.3
05-August-2006	11.5	21.1	62.6	95.3	12.6	22.6	13710	0.2	3.8	2
06-August-2006	14	23.6	45.6	85.2	14	23.1	11722	0.2	3.3	2.5
07-August-2006	17.1	21	70	92.8	15.8	20.9	6898	18.6	3.9	3
08-August-2006	10.5	19.2	51.9	86.8	10.8	20	8298	4.4	4.2	2.9
09-August-2006	7.9	16.3	44	87.4	10.6	19.1	11605	0	10	1.6
10-August-2006	4.3	20.2	40	96.5	8.5	20.7	13091	0	13.8	2.7
11-August-2006	5.3	20.6	40.7	96.3	10.3	22.6	15180	0	5.5	2.7
12-August-2006	15.4	18.6	59.2	92.5	13.9	18.6	7707	8.4	2.6	2.8
13-August-2006	10.7	18.6	64.2	94.8	12.8	18.9	6407	8	3.5	3.4
14-August-2006	10.4	17.1	68.3	95.6	12.3	20.1	10159	2.6	7.2	1.8
15-August-2006	14.2	20.1	62.4	92.6	14.8	20.5	9837	15	6.7	1.4
16-August-2006	6.9	16.6	52.9	95.5	10.6	17.7	8807	12	4.2	1.7
17-August-2006	5.7	15.8	52.1	95.6	8.7	18.5	11748	0	11.6	2.5
18-August-2006	3.6	18.4	40.8	95.5	8.1	21.4	16670	0	9.8	2.2
19-August-2006	14.2	21.8	60.6	94.3	12.6	21.5	12222	19.8	4.1	2.3

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
20-August-2006	14.6	16.9	62.3	94.2	12.3	18.3	4869	11.2	3.4	3.5
21-August-2006	9.2	19.7	49.3	94.1	11.1	20.6	11808	0.2	6.5	2.7
22-August-2006	13.3	22.4	48.2	93.2	14.4	23.5	12869	22.4	8.4	1.1
23-August-2006	11.5	17.9	63.9	93.3	13	20	11045	10.4	4.2	2.6
24-August-2006	7.5	19.3	58.3	96.2	11.3	22.5	14478	0	7.2	3.1
25-August-2006	8	21.5	45.7	96.2	11.3	24.1	16778	0	10	2.5
26-August-2006	9.3	18.8	63.6	89.2	11.5	20	10674	3.2	4	3
27-August-2006	4	17.6	46.9	97	8.5	20.8	14300	0.2	3.6	3.8
28-August-2006	4.7	21.3	39.6	97.4	9.4	24.4	18294	0	5.3	2.4
29-August-2006	8.8	23.5	32.4	91.2	11.4	25.1	17215	0	4	3
30-August-2006	12	25.4	34.6	95	14.1	27.2	18123	0	3.9	4.1
31-August-2006	16.3	22.9	63.7	92.1	16.8	26.2	14064	8.8	3.9	4.5
01-September-2006	8.6	18.8	60.3	95.5	12	19.8	6451	6.8	4.8	4.6
02-September-2006	3.9	16.5	50.4	97.2	8.2	20.9	14179	0	11	3.7
03-September-2006	3.9	18.1	41	97.3	8.9	23.6	19273	0	5.5	1.3
04-September-2006	7.7	19.3	39.3	92.9	12.2	24.7	18291	3.4	3.5	2.7
05-September-2006	4.5	16.1	43.5	84.5	7.4	21.6	17059	0	4.1	4.1
06-September-2006	7.7	16.9	38.2	77.3	8.5	22	19665	0	4.2	4.1
07-September-2006	12.1	18.1	33.2	61.4	12	23	19816	0	8.3	3.9
08-September-2006	13.3	17	51.9	75.5	13.2	19.5	7721	0	7.6	4.8
09-September-2006	9.9	17.9	65.6	92.6	12.3	20.5	9505	0.2	11.3	5.6
10-September-2006	15.8	26.2	47.3	91.4	15	24.4	12470	1.6	13	2.6
11-September-2006	15.3	21	72.1	89.2	16.2	22.5	8438	2.8	7	2.1
12-September-2006	12	18	63.4	87.1	13	21.9	12777	5.8	5.5	3
13-September-2006	4.3	17	41.9	96.2	9.3	24.1	20891	0	8.1	1.9
14-September-2006	7.5	21.2	39.5	93.2	11	26.4	21194	0	11.9	3.1
15-September-2006	8.9	26.2	35.1	94.4	13.6	29.2	20838	0	5.5	4.6
16-September-2006	11.4	25.2	50.6	94.9	15.3	30.2	20167	0	5.7	5.1
17-September-2006	13.1	21.6	58.2	94.4	16.1	28.9	18174	3.6	4	5.4

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
18-September-2006	12.4	20.5	45	92.3	14.8	28.3	19528	2.4	3.9	4.8
19-September-2006	10.6	19.1	50.8	89.2	14.4	24.5	18346	0.4	5.4	4.1
20-September-2006	13.3	19.4	50.6	87.7	15.6	26	15253	0	7.3	4.8
21-September-2006	14.5	20.1	56.3	90	16.4	28.7	18260	1.8	9.3	4.5
22-September-2006	13.7	19	53	87.9	13.7	20.9	9099	0.2	6.8	3.7
23-September-2006	15.3	18.4	47.3	78.4	15.6	24.6	13964	0	8.3	4.2
24-September-2006	8.8	18.5	52.6	92.9	14.3	25.4	16306	0	9.6	2.5
25-September-2006	7.1	20.3	44.8	94.8	14.2	29.8	23862	0	10.9	3.9
26-September-2006	9.6	20.4	50.8	94.3	14.7	29	19757	0	6.4	3.7
27-September-2006	4.7	19	49.8	96.7	12	26	17429	0	4.5	5.3
28-September-2006	5.9	19.8	52	96.1	12.9	29	22776	0	5.3	4.4
29-September-2006	8	24.2	32.4	95.8	13.9	30.5	23832	0	5	3.9
30-September-2006	15.1	28.6	22.2	87.6	17.2	32.2	22375	0	4.8	5.1
01-October-2006	8.3	20.7	49.2	93.3	15.6	30	21984	0	6.1	6
02-October-2006	5.7	21.3	43.5	95.6	14.2	31.4	24521	0	7.2	6.2
03-October-2006	14.4	22.7	46.8	88.3	18.1	30.7	23274	0.6	7.5	5.4
04-October-2006	14	19.9	45.6	90.4	14.3	22.9	14711	5.2	4.5	5.7
05-October-2006	4.8	18.7	41.2	95.2	12.8	29.6	23670	0	9	5.9
06-October-2006	4.9	23.7	36.4	95.3	13.4	31	24532	0	13.8	4.3
07-October-2006	11.8	21.8	49.9	90.8	15.9	30.5	25224	0	4.4	5.3
08-October-2006	10.9	23.3	23.4	58.4	15.1	31.6	24967	0	4.3	6
09-October-2006	11.2	24	28.4	65.1	15.5	30.8	24637	0	8.1	6.1
10-October-2006	8.1	27	30.3	93.6	16.1	33.2	25386	0	11.6	7.4
11-October-2006	14.2	22.5	55.7	91.2	19.5	33.2	21873	3.2	8.9	7.3
12-October-2006	12.9	17.2	48.4	90.8	14.9	21.6	12755	6.8	4.9	6.5
13-October-2006	12	19.5	60.9	94.6	15.9	27.2	18328	7.4	8.7	5.5
14-October-2006	7.7	19	41.8	90.2	12.5	26.6	22549	0	12.3	3.4
15-October-2006	8.8	22.8	37.5	91.8	14.3	30.1	25829	0	6.6	4
16-October-2006	7.9	23.2	38.2	93.7	14.9	31.2	21628	0	6.5	5.3

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
17-October-2006	5.9	18.9	43.4	93.8	13.2	26.7	19235	0	7	6.4
18-October-2006	7.2	18.7	46.9	95.5	13.7	27.4	21286	0	6.3	5.2
19-October-2006	12	21.9	44.8	88.4	15.9	31.5	26656	0	7.1	4.5
20-October-2006	13	28.6	30	72.1	16.9	33.3	25233	0	5.8	4.8
21-October-2006	23.4	30.2	27.1	51	21.4	33.6	25162	0	7.5	6.4
22-October-2006	17.4	27.2	49.6	88.7	21.9	35.5	20588	0	9.1	7.6
23-October-2006	15.1	20.6	67.8	85.8	20.1	30.2	13808	0	11.3	9
24-October-2006	9.5	20.6	48.4	86.7	15.9	29.7	20034	0	8.3	5.2
25-October-2006	12.5	26.2	24.5	65.2	17.2	34	27928	0	7.2	3.1
26-October-2006	11.3	26	31.8	82.4	17.3	32.5	23323	0	8.1	5
27-October-2006	14.6	27.2	35.1	71.6	18.8	35.2	27760	0	9.8	8.2
28-October-2006	15.5	27.8	35.6	80.7	19.8	35.9	27727	0	5.9	6.4
29-October-2006	12.9	31	29.9	94.1	20.1	36.5	23794	0	10.6	7.9
30-October-2006	11.5	21.1	57.9	87.5	17.7	32.2	21149	0	8.3	8
31-October-2006	11.3	22.8	46.2	88.2	17.8	32.6	24510	0	6.4	6.5
01-November-2006	13.7	26.1	38.6	73.6	19.6	34.7	26299	0	8.8	5.1
02-November-2006	8.4	20.9	43.4	91.6	16.8	33.4	27478	0	7.3	6.1
03-November-2006	11	23.6	36	93	17.6	34.2	28933	0	9.6	7.1
04-November-2006	17.9	26.9	35.2	69.7	21.1	35.7	25574	0	7.8	6.8
05-November-2006	18.2	26.9	28.4	70.6	19.8	28	12214	0	7.4	7.2
06-November-2006	20	30.5	28.2	56.2	20.7	30.6	16337	0	9.9	7.6
07-November-2006	19	31.9	30.3	90.5	23.3	36.3	22926	0	7.9	4.3
08-November-2006	16.9	25	53.1	88.2	21.5	35.1	23777	0	10.9	6.3
09-November-2006	13.4	25.6	48.4	93.2	21.7	37.5	27571	0	8.6	7.4
10-November-2006	17.3	25.5	61	91.7	20	35.2	22326	4.6	7.7	6
11-November-2006	16.5	22.7	59.8	85.1	18.3	30.2	21646	2.4	5.1	6.8
12-November-2006	10.9	21	52.7	93.9	17.5	31.2	26318	1	8	5.6
13-November-2006	15.9	24.8	41.5	82.8	18.8	33.8	25562	0	11.5	5.4
14-November-2006	20.3	33.8	19.3	55.1	22.7	38.2	29478	0	7.4	6.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
15-November-2006	16.2	33.4	24.2	92.3	22.6	37.6	24866	0	9.7	7
16-November-2006	18.2	28.6	38.2	80.4	23.5	38.3	26448	0	9.9	10.2
17-November-2006	15.4	23.5	54.3	92.2	21.4	36.7	22782	0.6	5.2	6.8
18-November-2006	13.2	23.5	47.2	92.4	19.9	35.2	24258	0	6.9	6.9
19-November-2006	12.9	28.6	34.9	93.7	20.8	36.2	26734	0	7.5	5.5
20-November-2006	13.9	22.8	55.5	91.7	21.7	36.5	24603	1	6.6	6
21-November-2006	10.1	23.3	42.5	91.9	18.3	32.3	24849	0.2	5.6	6.7
22-November-2006	14.2	27.2	40.8	89.5	20	36.2	29122	0	6.6	5.9
23-November-2006	15.1	29.4	34.4	91.9	22.2	38.9	29456	0	7.5	6.1
24-November-2006	14.8	27.8	46.2	81.8	21.3	38	29974	0	7.6	7.5
25-November-2006	16.5	26.3	37.7	72.4	22.2	37.8	30613	0	7.2	8.2
26-November-2006	16.6	30.6	30.2	78.5	22.6	39.8	29769	0	10	8
27-November-2006	14.3	34.3	21.9	91.7	23.9	40	28622	0	10.4	8.5
28-November-2006	16.1	24.4	57.1	89.8	23.9	39.3	26531	0	9.6	9.1
29-November-2006	12.8	29.7	37.9	92.6	18.7	31.5	11301	13.4	6.2	8.3
30-November-2006	17.3	21.9	53.3	69.1	20.2	31	24372	0.2	5.9	6.5
01-December-2006	9.6	21.7	36.8	82.7	17.3	32.8	23757	0	8.4	3.2
02-December-2006	14	25.3	26.2	70.4	18.9	37	31692	0	10.6	6.5
03-December-2006	14.4	30	19.8	74.3	20.6	38	30576	0	8.9	6
04-December-2006	14.9	31.8	23	83.1	21.4	39.2	31520	0	9	8.7
05-December-2006	12.8	24.4	39.4	73.4	20	36.7	31218	0	7.1	8.9
06-December-2006	12.6	26.1	27.3	72.8	20.2	37.3	31797	0	9.9	9.4
07-December-2006	14.5	30.7	26.6	93.2	22.5	39.6	30448	0	12.2	8.4
08-December-2006	15.9	22.8	53.7	91.3	22.3	34.5	23133	2.6	8.4	8.7
09-December-2006	7.4	21.1	31.6	87.6	17.7	34.5	29936	0	6.4	8.4
10-December-2006	13.4	22.3	31	76.2	20	36.2	31296	0	8.3	5.7
11-December-2006	15.8	29.1	21.4	67.8	21	38.4	29225	0	9.1	7.8
12-December-2006	20.2	32.7	19.4	56.5	23.3	37.6	27119	0	10.1	8.4
13-December-2006	16.2	32.5	23.2	77.2	22.7	40.4	30731	0	11.5	8.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
14-December-2006	14.5	24.7	38.7	73.6	21.8	37.1	30287	0	8.1	9
15-December-2006	14.5	28.4	29.4	80.1	22.1	39	31964	0	9.4	9.5
16-December-2006	14.2	32.8	23.1	82.4	22.9	40.4	31782	0	10	8.1
17-December-2006	18.6	36.9	18.4	74.5	25.8	41.7	29504	0	7.2	8.9
18-December-2006	20.7	30.8	43.3	86.9	26.9	41.9	26688	0	5.9	9.3
19-December-2006	20.6	30.6	38.1	87.9	26.3	37	14753	0	6.3	9.4
20-December-2006	19.5	30.2	43.9	92	24.3	32.9	11912	1.2	6.6	7.4
21-December-2006	18.9	24.4	57.7	79.3	24.5	38.3	24102	0	4.8	4.2
22-December-2006	16.3	24.4	42.1	70.5	22	36	24658	0	4.8	3
23-December-2006	16.7	31.8	22.6	65	23.5	40.6	31655	0	9.3	6.2
24-December-2006	16.5	34	15.6	59.7	24.1	41.8	32103	0	10.2	6.8
25-December-2006	18.5	34.2	15.2	54	24.5	41.9	32457	0	10.2	9.8
26-December-2006	18.2	35.1	12.7	65.4	24.4	43.6	32721	0	12	11
27-December-2006	18.8	36.5	12.2	42.3	25.2	44	31746	0	11.1	11.3
28-December-2006	15.1	39	10.7	66	24.9	45.1	29736	0	8.1	10.7
29-December-2006	17.5	30.5	29.6	86.3	25.5	41.8	29174	0	7.8	11.4
30-December-2006	14.1	25.3	45.2	85.1	23.2	40	27993	0	5.8	10
31-December-2006	16	29.5	30.1	91.2	24	41.2	31441	0	8.6	7.9
01-January-2007	13.8	32.7	24.6	93.7	23.9	43.4	31849	0	7.5	9.1
02-January-2007	17.3	25.9	48.7	83.7	24.7	41.7	28268	0	7.6	7.3
03-January-2007	11.7	23.9	57.5	93.4	19.2	33	12790	12.4	5.9	2.7
04-January-2007	13.4	20.2	46.5	76.4	17.2	24	13798	0	9	3.4
05-January-2007	10.9	23.5	36	86.6	17.2	32.8	21921	0	7.5	5.9
06-January-2007	13.3	24.1	37.8	76.7	19.5	36.1	31642	0	8.9	8.4
07-January-2007	13.3	27	34.7	92.7	20.7	37.6	30976	0	7.7	8.1
08-January-2007	13.8	33.2	20.1	91.7	22.4	39.8	31608	0	6.5	8.9
09-January-2007	17.1	25.7	39.8	84.8	23.8	39.1	30111	0	8.8	8.1
10-January-2007	16.7	25.6	47.8	88.4	22.6	36.9	23501	2	12.5	6.4
11-January-2007	14.6	24.3	53.8	92.5	19.9	33.8	19396	6	6.1	4.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
12-January-2007	10.7	23.7	49.2	95.1	17.8	30.9	21482	0	5.5	5.1
13-January-2007	13.1	29.2	35.8	94.1	20.6	36.1	31964	0	6.6	8.3
14-January-2007	16.7	34.9	27.5	86.1	23.8	38.9	31498	0	5.5	9.4
15-January-2007	19.8	35.1	25.3	85.1	25.9	40.7	28222	0	8.7	8.7
16-January-2007	9.4	23.4	37.8	84.8	19.7	32.2	22643	0	11.4	6.3
17-January-2007	11.6	23.7	27.8	81.8	20.2	35.1	31858	0	8.8	8.4
18-January-2007	13.6	25	35.4	84.7	21.3	36.2	31436	0	9	8.3
19-January-2007	12.1	23.1	38.2	78.7	20.4	34.3	27960	0	10.7	7.6
20-January-2007	12.5	22.4	35.3	66.3	20	34.8	31200	0	10.3	8.5
21-January-2007	12.9	26.1	27.8	91	20.8	35.9	31376	0	8.3	8.5
22-January-2007	13.7	33.4	17.2	70.9	22.4	38.7	31206	0	7.1	10
23-January-2007	15.1	29	30.1	76.5	23.2	38.5	31057	0	8.8	9
24-January-2007	15.2	27.6	36.1	87.8	23.5	38.7	30135	0	6.7	8.1
25-January-2007	19.5	28.7	36.2	70.2	25.1	38.8	29003	0	8.8	8.4
26-January-2007	22.2	39.7	17	64.3	27.5	42.8	28927	0	10.5	10.6
27-January-2007	23.8	41.8	14.4	52.6	29.4	44.1	26724	0	14	11.2
28-January-2007	25.8	41.6	14.4	72.6	29.4	42.9	23968	0	9.7	9.8
29-January-2007	24.4	38.7	17.6	73.4	29.1	42.9	23074	0	6.2	8
30-January-2007	20.2	29.8	48.2	85.4	28.1	42.7	25449	0	8.2	6.8
31-January-2007	19.2	25.1	50.2	78	27.3	41.5	27018	0	6.8	7.1
01-February-2007	14.1	26.2	47.9	92.3	24.4	40.5	26209	0	5.9	6.7
02-February-2007	18.1	27.8	39.8	88.5	25.7	40.8	28584	0	7.8	7.8
03-February-2007	24.6	36.7	25.9	64.3	28.8	42.7	25716	0	6.1	8.5
04-February-2007	19.3	41.3	15.6	90.7	26.5	44.7	25964	0	7.6	8
05-February-2007	16.2	31.5	30.8	59.3	24	39.4	26946	0	13.7	8.8
06-February-2007	16.7	32.2	19.6	65.5	24.2	39.8	26426	0	11.3	9
07-February-2007	18.1	34.6	23.5	75.9	24.6	42.2	26945	0	9.8	8.5
08-February-2007	17.4	37.2	22.7	90	25.6	43.9	28201	0	7	8.4
09-February-2007	15.4	25.9	51	74.1	22.9	37.9	25211	0	10.4	7.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
10-February-2007	21.2	31.8	28.4	74.7	26.1	41.6	26745	0	8.6	7.9
11-February-2007	13.5	24.1	52.4	89.7	22.1	34.2	15158	0	6.1	3.8
12-February-2007	19.1	27.4	40	82.3	24.5	41.1	28419	0	6.8	7.6
13-February-2007	13.8	25.3	41.7	82	21.9	40.3	28547	0	7.9	7.6
14-February-2007	11.8	27.7	36	93.9	21.8	40.6	27581	0	5.7	7.1
15-February-2007	14.2	25.1	54.2	86.9	23.5	39.7	27055	0	6.5	6.9
16-February-2007	11.5	23.3	48.6	91	20	31.1	14790	1.6	6.5	3.7
17-February-2007	16.7	24.6	38.2	83.7	22.3	33.6	21971	1.2	8.6	5.9
18-February-2007	11.7	22.5	45.1	88.2	19	31	20675	2.4	7.5	5.1
19-February-2007	11.7	24	37.3	85.1	19.1	36.7	27136	0	5.8	7
20-February-2007	12.9	25.6	33.6	92	20.6	37.1	27961	0	7.5	7.5
21-February-2007	14	31.2	30.7	89.7	21.6	39.8	27579	0	6.3	8
22-February-2007	14.8	32.3	29.7	93.8	22	40.7	27441	0	6.9	7.8
23-February-2007	18.2	27.9	46.7	86.8	23.3	39.3	26805	0	8.2	7.5
24-February-2007	19.8	35.4	25.9	65.3	24.8	41.8	25494	0	9.5	8.6
25-February-2007	22.2	34.9	27.9	68.1	26	41.8	25997	0	12.2	9.1
26-February-2007	25	36.4	24.7	54.6	27.9	42.6	21571	0	11.2	8.6
27-February-2007	21.6	32.5	31	90	27	40	18228	0	6.4	5.7
28-February-2007	20.4	29.3	54.7	88	26.7	42.6	22781	0	6	6
01-March-2007	17	21.9	47.3	81.3	21.4	29	8111	0.8	13	2.9
02-March-2007	17.1	22	68	91.7	20.7	26.5	12953	5.6	9.4	3.1
03-March-2007	16	23	61.3	85.4	19.8	31.1	18678	0.2	7.5	4.6
04-March-2007	17	29.9	32.7	72.1	20.4	36	24830	0	9.6	7.3
05-March-2007	21.6	36	21.4	65.1	23.9	39.3	25893	0	8.8	9
06-March-2007	25	40.3	13.9	46.4	25.7	42.5	25941	0	8.1	10
07-March-2007	20.4	41.3	12.4	66	25.5	43.8	26195	0	7.1	9.9
08-March-2007	20.3	43.9	9.4	50.4	26.2	45.1	26155	0	5.2	9.9
09-March-2007	17.9	33.9	19.5	84.3	24.4	43.4	25577	0	8.6	7.8
10-March-2007	10.1	22.5	41.8	77.6	19.3	35.9	24303	0	11.9	7.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
11-March-2007	15.7	28.6	19.6	62.9	20.9	37.3	25330	0	8.8	8
12-March-2007	16.8	30.5	15.9	64.9	22.1	38.4	24927	0	9.7	8.4
13-March-2007	20.6	32.1	23.1	66.8	23.9	40.3	24391	0	7.4	7.8
14-March-2007	16.1	31	36.8	89.6	23.1	40.4	23825	0	5.4	6.6
15-March-2007	17.1	28.8	47.8	84.5	22.5	38.9	23797	0	8.9	6.4
16-March-2007	16.8	26.5	46.5	71.9	22.2	37.3	23464	0	9.6	6.8
17-March-2007	19.8	33.3	28.7	66.7	24.2	40.3	23351	0	9	7.8
18-March-2007	20.6	36.8	22.1	62.4	25	41.9	21551	0	6.6	7.5
19-March-2007	22	36.3	22.5	64	25.9	42.7	21834	0	7.1	7.8
20-March-2007	19.1	33.5	24.8	78.1	24.3	41.3	22210	0	7.4	7
21-March-2007	16.9	32.2	29.7	85.8	24.2	40.8	22715	0	5.7	6.6
22-March-2007	14.7	27.1	50.6	83.1	22.5	38.7	20911	0	6.7	5.6
23-March-2007	13.3	23.6	42.5	70.2	20.4	33.5	15679	0	10.1	4.6
24-March-2007	13.3	25.5	25.3	59.9	18.7	36	23210	0	8.5	7
25-March-2007	11.8	28.9	17	51.9	19.3	36.2	23062	0	6.7	7.5
26-March-2007	9.6	30.3	19.1	92.8	18.6	38	22715	0	5.5	6.7
27-March-2007	5.8	22.5	48.7	95.4	15.2	32.2	17226	0.2	9.4	4.4
28-March-2007	4.1	19.9	32.5	90.9	14	30.8	22753	0	8.4	6.2
29-March-2007	11.9	23.1	24.7	66.7	16.2	32.1	21916	0	7.8	6.3
30-March-2007	10.1	25.7	21.5	68.8	16.7	34	21905	0	6.7	6.6
31-March-2007	9	31.5	13.6	83.3	17.1	36	21691	0	4.4	6.6
01-April-2007	11.9	23.8	44.7	87.5	18.3	33.9	20170	0	6.9	5.2
02-April-2007	11.5	24	42.3	92.1	17.2	32	18902	0	8	5.1
03-April-2007	17	29.1	30	73.3	18.9	31.4	14938	0	7.3	4.8
04-April-2007	13.5	32.8	21.4	69.2	19.2	35.7	19412	0	5.5	6.6
05-April-2007	14	34.7	18	77.9	20.3	35	17343	0	3.9	5.4
06-April-2007	13.5	27	55.4	94.8	19	34.1	15964	0.4	4.9	3.8
07-April-2007	13.4	27.6	40.3	93.1	19.6	34.7	19288	0	5.2	5.2
08-April-2007	17.3	27.2	42.4	88.9	20.9	33.5	14593	3	7.4	3.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
09-April-2007	4.7	20.8	48	95.4	12.9	27.3	16251	0.4	8.3	4.2
10-April-2007	8.8	22.7	33.6	83.4	14	29	18313	0	6	4.8
11-April-2007	11.3	23.4	36.5	89.4	15.6	29.9	19326	0	5.4	5
12-April-2007	13.3	26	35.3	86.7	16.4	30.2	17631	0	7.1	4.8
13-April-2007	11	29.7	21.8	77	16.9	32.9	18545	0	4.4	5.5
14-April-2007	15	24.7	55.4	91.3	18.8	32.1	16587	0	4.1	4
15-April-2007	18.5	26.3	51	90.8	21.3	32.9	16671	0	5.2	4.3
16-April-2007	14.4	23.5	51.7	93.6	16	24.3	3567	46.2	10	1.3
17-April-2007	8.7	21.1	44.9	95	14.1	25.7	16418	0	5.1	3.9
18-April-2007	13	22.6	44.9	93.9	16.3	25.7	13678	1.2	4	3.3
19-April-2007	7.7	21.6	49.7	95.8	13.6	27.1	18275	0.2	5.3	4.4
20-April-2007	7.5	21.2	43.2	93.5	14.3	25.9	16467	0	4.3	4
21-April-2007	9	21.4	53.8	95	14.7	26.4	14892	0	4.5	3.4
22-April-2007	11.8	22.9	40.4	89.5	15.5	27.8	17508	0	6.3	4.6
23-April-2007	12.2	27.4	35.7	93.6	16.3	28.8	13716	0.6	4.4	3.5
24-April-2007	12.7	24.2	59.5	93.2	16.7	28.8	16307	0	5.3	4
25-April-2007	12.6	22.3	63.7	94.3	16.2	22.3	6855	16.6	3.8	1.2
26-April-2007	7	20.8	41.8	95.8	12.1	23.9	13426	0	3.7	3
27-April-2007	6.5	21.9	33.9	94.7	12	25.3	16273	0	4.3	3.9
28-April-2007	5.2	22	33.9	95.3	11.8	25.4	16189	0	3.6	3.9
29-April-2007	15.6	23	32.1	87.3	16.1	25.7	15879	1.6	6.5	4.3
30-April-2007	15.6	22.8	62.6	90.9	16.1	24.2	12487	13	11.2	3.4
01-May-2007	17	20.7	62	90.4	16.2	23.3	10799	5.8	13.6	3.2
02-May-2007	15.9	19.2	60.2	89.3	16.5	19.9	6485	0.8	9.3	1.9
03-May-2007	15.7	20	54.6	85.6	14.6	22.3	10408	1	10	3
04-May-2007	13.9	20.5	55.7	85.4	16.2	24	11427	0	5.4	2.9
05-May-2007	14.5	22.5	67.6	93.9	16.5	24.2	9225	3.8	4.3	1.8
06-May-2007	12.7	22	62.4	94.9	15.4	25.2	13350	0	3.6	2.9
07-May-2007	8.7	22.9	48	95.5	14	26.3	15078	0.2	5	3.6

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
08-May-2007	8.3	22.1	47.3	94.6	12.8	24.5	13295	0	4.3	3.1
09-May-2007	6	23.1	38	97.1	11.8	25.2	15321	0	3.4	3.6
10-May-2007	9.9	25.9	31.5	83.4	14.2	25.1	15248	0.2	4.9	4.5
11-May-2007	12	28.6	31.2	81.9	15.2	26.1	14408	0	3.6	4.2
12-May-2007	14.7	24.4	39.5	94.3	16.2	21.9	6897	2.4	3.7	1.9
13-May-2007	10.5	21	67.3	94.9	14.8	23.4	11901	1.8	4.9	2.6
14-May-2007	5	18.8	49.9	94.3	10.2	21.4	10362	0	4.1	2.2
15-May-2007	5	18.5	43	96.2	9.9	21	13375	0	3.4	2.9
16-May-2007	5.4	19.3	43	94.6	10.2	21.4	14501	0	3.5	3.2
17-May-2007	5.3	20.1	42.2	94.4	10	21.8	14382	0	3.8	3.2
18-May-2007	11.6	20.8	41.9	94.9	13.3	22	13731	0.4	5.1	3.2
19-May-2007	9.3	18.6	41.6	84	12.8	20.6	10735	0	3.7	2.6
20-May-2007	11.9	17.7	60.5	93.6	13.6	19.6	8239	2	6.2	1.9
21-May-2007	4.9	18.1	47.8	93.9	8.9	19.3	9840	0.2	4.3	2.1
22-May-2007	3.3	18.1	45.5	97.6	8.1	19.4	12845	0	3.3	2.6
23-May-2007	12.5	19	52.3	88.4	11.8	19.8	11285	0	4.3	2.7
24-May-2007	16.6	20.7	59	81.4	15.6	20	7000	0	6.6	2
25-May-2007	16.4	22.1	60.3	93.1	16.5	20.9	7470	1.4	6.4	2
26-May-2007	14.6	21.5	62.8	92.9	15.5	21.9	9071	6	6.5	2.2
27-May-2007	11.4	17	54.2	94.5	13.8	18.7	6893	6.2	7.1	1.7
28-May-2007	12.4	17	71	93.3	13.2	18	6838	23.8	8	1.4
29-May-2007	8	16.9	47.9	91.7	11.6	18.5	11902	0	5.7	2.8
30-May-2007	11.1	18.7	46.9	88.2	12.7	18.5	8109	0	2.8	1.8
31-May-2007	5.1	19.5	49.8	97.7	9.3	19	7825	0	2.2	1.5
01-June-2007	5.6	22.2	35.5	93.1	9.5	19.5	13107	0	4.1	3.2
02-June-2007	4.7	22.2	30.2	92.9	9.4	19.4	13065	0	4.5	3.4
03-June-2007	8.5	22.8	40.6	90.2	10.6	19.6	12815	0	4.9	3.3
04-June-2007	3.1	21.3	53	97.2	8.6	19.6	12782	0	4.8	2.9
05-June-2007	10.2	17.2	45.6	78.7	10.2	17.3	12718	0	9.1	3.3

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
06-June-2007	12.5	20.1	42.4	59.3	11.2	18.3	11747	0	12.1	4.1
07-June-2007	13.3	17.9	34.1	70.5	12.2	14.2	3417	0.8	9.6	2.3
08-June-2007	12.9	22.5	38	94.6	13.4	17.8	8053	5	5.4	2.1
09-June-2007	6.3	19.6	67.1	97.8	10.4	19.1	8192	0	3.4	1.5
10-June-2007	7.1	20.3	45.7	94.8	9.4	18.7	12115	0	4.1	2.7
11-June-2007	6.2	18.7	49	92	8.2	17.5	11421	0	5.5	2.6
12-June-2007	11.1	19.1	46.6	72.4	10	17.3	11771	0	7.2	3.2
13-June-2007	11.9	23.1	34.3	82.6	11.7	18.5	11408	0	4.6	3.2
14-June-2007	10	21.8	57.8	96.9	12.3	18.4	7345	20.6	4	1.5
15-June-2007	6.7	20.5	49.6	95.5	9.7	18.7	11783	0	3.3	2.5
16-June-2007	10	20.5	51.1	84.5	10	17.9	12135	0	6.4	3
17-June-2007	4.9	17.9	53.5	89.8	8.3	16.8	12273	0	6.2	2.8
18-June-2007	3.7	16.1	37.5	95.4	7	15.5	12166	0	4.8	2.8
19-June-2007	8	17.4	51.8	90.6	8.2	15.5	11890	0	6.5	2.7
20-June-2007	8.7	16.5	57.1	85.5	8.7	15.9	11710	0	7.6	2.8
21-June-2007	5.8	15.7	52	90.4	8.2	15.6	12152	0	7.2	2.7
22-June-2007	8.3	17.4	42.9	76.3	8	15.9	11955	0	7.5	3.2
23-June-2007	9.7	16.6	35.8	97	9.7	12.5	4124	25.6	5.9	1.1
24-June-2007	7.4	15.9	59.6	96.2	8.6	13.4	5214	15.8	8.1	1.2
25-June-2007	10.1	17.2	57.6	97	10.2	15.4	8376	4.8	3.8	1.5
26-June-2007	9.6	19.3	66.3	94.8	9.8	17.7	10971	1.4	4.6	2.2
27-June-2007	10.3	21	34.2	84.6	10.6	16.9	12348	0.2	5.4	3.6
28-June-2007	11.9	21.2	33.3	94.7	12.3	15.6	5768	23.6	8.8	1.6
29-June-2007	11.8	20	52.2	95.4	12.6	18.2	10885	4.2	5.3	2.5
30-June-2007	14.8	20.7	64.6	93	13.8	18.5	10133	6.2	9	2.5
01-July-2007	13.2	18.2	56.9	95.1	12.9	18.1	7618	10.6	5.6	1.7
02-July-2007	15.1	17.9	57.1	94.3	12.3	16.4	4331	18.6	13.3	1.8
03-July-2007	12.7	19.1	52.2	86.5	11.3	16.8	7643	12.4	16.6	2.7
04-July-2007	14.1	17.1	53.9	83	12.2	15.2	8603	2.4	13.3	2.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
05-July-2007	14.3	18.6	60.7	78.2	13.6	17.8	9864	0.2	5.7	2.5
06-July-2007	11.8	19.7	52.1	95.7	13.4	18.5	9723	0.8	3.7	2.1
07-July-2007	10.3	20.6	49.4	82.9	10.2	18.9	11667	0	4.7	2.8
08-July-2007	13.2	22.2	36.8	93.3	12.2	17.7	10619	7.4	5.1	2.8
09-July-2007	6	19.3	68.7	92.7	9.9	17.4	5221	10.6	5.5	1
10-July-2007	4.4	17.7	43.2	94.4	8.7	16.2	12249	0	4.5	2.7
11-July-2007	6.4	18.2	54.7	94.9	8.8	16.3	11742	0	4.2	2.5
12-July-2007	13.9	20.1	52.9	73.8	10.6	16.6	11640	0	6.6	3.1
13-July-2007	14.3	20.6	39.9	60.3	12.4	16.4	6978	0	6.3	2.5
14-July-2007	10	19.2	41.4	77.3	11.3	16.6	7268	0	4.8	2.1
15-July-2007	3.4	19.8	35.7	97.5	8.4	18.3	11305	0	3.3	2.6
16-July-2007	7	19.7	43.5	97.1	10.3	17.3	12965	0	2.9	2.8
17-July-2007	4	17.9	51.4	98.7	8.9	17.2	10658	0	3.6	2.2
18-July-2007	4.9	19.9	50.2	95.5	8.4	17.6	13038	0	4.2	2.9
19-July-2007	12.2	22.1	37.9	85.7	11.2	17.4	10629	2.4	4.4	3.1
20-July-2007	12.9	17.2	59.6	93.3	12.5	14.3	2569	10.4	8.2	0.8
21-July-2007	8.9	19	57.4	93.4	11.6	17.9	8594	1.4	4.6	1.8
22-July-2007	12.8	17.1	55.8	91.3	11.9	15.6	5850	13.4	11.6	1.7
23-July-2007	12.4	17.8	59.2	92.8	12	16.7	8789	1.4	8.6	2.1
24-July-2007	12.2	16.9	63.1	92.3	11.7	16.4	5716	17.4	11.4	1.5
25-July-2007	12.4	16	66.8	91	12	16.2	9100	11.6	9.9	2
26-July-2007	8.8	15.6	78.8	96.8	10	15.2	5223	7.8	4.5	0.7
27-July-2007	9.6	19	63.8	93.2	10.1	17.8	9788	1.8	5.3	2
28-July-2007	13.4	20.1	51.3	95.5	12.1	16.9	8123	21.6	11.7	2.4
29-July-2007	14.5	19	62.5	89.2	13.6	17.8	8938	4.2	8.5	2.2
30-July-2007	14.4	19	70.4	95.5	14.4	18.4	6698	35.8	7.4	1.3
31-July-2007	12.4	19	59.4	91.6	11.4	16.7	4533	9	15.3	1.6
01-August-2007	14.2	17.5	52.1	79	12.2	17.2	11277	1.6	12.9	3.3
02-August-2007	4	16.9	63.2	98	8.6	17.1	9216	2.4	5.8	1.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
03-August-2007	8	16.3	53.6	94.9	10.6	18	11985	0	3.3	2.3
04-August-2007	5.5	18.1	50.5	97.8	8.1	20	13905	0	3.2	2.8
05-August-2007	8.9	20.5	34.5	88.8	8.9	20	15018	0	5.1	3.6
06-August-2007	13.4	21.8	52.9	94.2	12.3	20.8	11638	13.6	7.3	2.7
07-August-2007	11.4	15.6	52.9	92.2	11.3	16.1	6541	5.8	10.3	1.9
08-August-2007	14.3	17.3	64.2	89.2	11.7	18.3	9591	0.4	7.9	2.4
09-August-2007	14	18.5	56.6	77.1	12.9	19.4	9892	0	7	2.7
10-August-2007	13.4	19.3	67.4	95.1	14.8	19.5	7963	10.8	10.6	2
11-August-2007	4.9	13.5	90.9	99.1	9.1	15.7	4182	20.4	3.8	0.3
12-August-2007	3.3	17.3	44.5	98.8	7.4	19.9	15148	0	3.5	3
13-August-2007	2.7	18.3	37	98.2	7.5	20.4	16417	0	3.6	3.4
14-August-2007	8.4	18	51.2	96	10.7	20.5	14338	9.8	4.6	2.9
15-August-2007	5.2	16	55.8	98.4	9.1	19.4	14003	0.4	4.9	2.8
16-August-2007	4.3	17.3	66.2	99.3	8	20.1	13206	0	3.7	2.4
17-August-2007	4.6	18.7	46.8	96.2	7.8	20.1	15152	0	4.8	3.3
18-August-2007	10	20.4	45.7	82.3	9.7	22.2	17021	0	6.3	4.2
19-August-2007	12.5	24.4	32.7	74.9	12	22.6	14980	0	5.1	4.3
20-August-2007	10.2	19.1	71.4	95.6	11.6	17.2	5506	5	5.1	0.8
21-August-2007	8.7	20.4	63.8	98	11.3	21.8	13673	0.2	3.7	2.7
22-August-2007	11.6	21.1	67.9	96.6	12.9	23.9	14645	0	4.2	3
23-August-2007	15.7	20.3	58.5	94.4	13.6	21.9	9040	10.4	10.4	2.5
24-August-2007	11.2	17.9	52.8	92.1	14	21.9	11418	0	4.4	2.6
25-August-2007	14.9	19.2	58.9	90.4	14.5	21.3	11148	1	6.7	2.6
26-August-2007	13.9	19.5	61.7	94.7	15.3	21.3	10715	11.2	9.9	2.5
27-August-2007	13.1	17.5	57.3	84.4	12.5	18.6	9779	2.6	12.4	2.8
28-August-2007	14.7	17.8	59.1	83.9	13.1	20	10635	0.6	7.6	2.4
29-August-2007	15	19.1	66.3	90.4	14.9	21.5	11689	1.4	7.7	2.6
30-August-2007	2.6	19.9	57.4	99.6	7.6	20.2	8222	17.4	9.8	1.8
31-August-2007	7.3	16.7	47.3	92.8	11.8	21	15644	0	3.6	3.3

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
01-September-2007	7.9	17.3	51.9	93.7	10.9	20.5	11799	0	3	2.3
02-September-2007	6.7	17.8	56.7	98.3	9.8	21.8	14025	0	4.5	2.8
03-September-2007	11.4	18.6	50.2	85.7	11.3	24.1	18545	0	8	4.4
04-September-2007	14.2	27.3	27.7	94	15.1	27.3	18800	0.6	6.1	5.1
05-September-2007	10.4	17.4	69.7	96.4	12.9	19.3	10258	3.4	6	1.9
06-September-2007	8.4	18.5	53.5	93.9	11.4	23.8	16740	0	4.9	3.6
07-September-2007	6.9	22	37.7	97.5	12.1	26.3	19970	0	4.2	4.6
08-September-2007	6.6	15.5	67.6	98.4	9.5	17.2	7966	11.2	7.5	1.3
09-September-2007	7.8	18.1	61.5	97.2	11.3	21.6	17468	0.2	6.2	3.7
10-September-2007	3.8	18.5	49.3	98.6	9.2	25.4	20611	0	4.3	4.4
11-September-2007	5.8	22.4	35.1	97.2	11	26.7	21034	0	3.6	4.9
12-September-2007	10.9	20.9	66.2	96.6	13.5	26.2	14555	24.2	8	3.2
13-September-2007	11.4	16.9	60.2	91	11.8	18.1	10779	10	13.9	2.7
14-September-2007	9.6	18	59.6	94.1	13.2	21.4	14568	0	4.4	3
15-September-2007	11.1	16.7	62.1	90.5	10.8	17.8	7478	6	9	1.8
16-September-2007	13.7	17.8	65.6	89.6	12.2	18.8	10859	0.6	8.7	2.5
17-September-2007	10.9	19.3	65.3	94.7	13.5	23.8	15159	0.2	4.6	3.1
18-September-2007	14.3	20.8	61.4	91.6	13.4	24	14310	1.2	9	3.5
19-September-2007	7.8	18.9	57.1	97	11.1	22.9	16713	3.8	7	3.6
20-September-2007	10.8	18.6	53.7	94.9	13.2	24.6	17386	0.4	4.9	3.8
21-September-2007	9.8	21	51.9	97.5	13.4	28.7	22629	0.2	4.5	5
22-September-2007	14.2	21.3	54	92.9	16	29.5	21895	2	7.2	5.1
23-September-2007	5.4	19.3	43.6	96.6	11.5	27.8	21066	0	4.7	4.6
24-September-2007	13.7	19.8	51.9	93.6	15.1	26	17671	6.2	8.7	4.3
25-September-2007	4.8	16.1	55.9	98.5	9.8	21.1	16147	17.8	6.4	3
26-September-2007	14	17.2	50	87.5	14.2	21.8	15736	0.4	10	3.7
27-September-2007	14.3	20.6	61.4	90.2	15.3	25.6	17779	1.2	9.3	4.2
28-September-2007	12.4	19	72.2	96.2	15.1	22.8	12781	1.8	5.2	2.4
29-September-2007	6.8	21.8	51.9	97.8	12.5	28.5	21497	0	4.2	4.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
30-September-2007	11.3	20.3	65.2	94.9	15.8	29.3	21856	0	4.6	4.8
01-October-2007	7.5	19.1	68	97.7	12.7	23.4	12858	0.2	4.5	2.5
02-October-2007	15.3	19.5	51.9	81.6	17.2	29.7	23197	0	9.1	5.6
03-October-2007	5.3	19.4	54.5	97.2	12.3	26.2	16211	0	5.5	3.5
04-October-2007	6.7	20.4	46.4	97.5	13	29.9	24449	0	4.7	5.3
05-October-2007	9.2	20.4	56.7	93.5	14	30.2	24519	0	6.3	5.5
06-October-2007	9.9	22.8	53	91.7	14.5	30.4	22886	0	6.4	5.4
07-October-2007	7.8	25.4	41.3	93.5	15.4	32	24671	0	6.1	6.3
08-October-2007	13.9	23.9	44	96	17.3	31.5	17701	30.4	5.4	4
09-October-2007	13.4	19	79.3	95.8	16.3	24.5	13075	12.2	7	2.4
10-October-2007	8.8	17.6	61	96.8	14.1	23.5	17394	5	6.5	3.5
11-October-2007	7.5	18.5	63.8	97.9	12.6	23.2	18501	1.8	5.5	3.7
12-October-2007	7.5	20	44	96.1	12.8	27.4	22720	0	5	5.2
13-October-2007	8.6	24.7	35.6	94.3	14.2	30.5	26370	0	5.6	6.3
14-October-2007	11.4	26.6	39.4	96.7	16	33.1	26513	0	5.3	6.8
15-October-2007	13.7	21.8	59.1	89.4	17.7	31.8	26067	0	8.6	6.1
16-October-2007	12.7	25.6	44	76.3	17	33	24723	0	7	6.4
17-October-2007	13.3	28.1	39.5	93.3	19.7	34.2	24785	0	6	6.2
18-October-2007	9.9	20.4	53.3	90.4	14.8	27.1	12979	1.2	8.4	3.2
19-October-2007	8.9	20.2	40.8	88.8	13.5	27.9	20352	0	5.8	4.7
20-October-2007	11.1	24.4	38.7	94.3	16.1	30.2	20159	7.6	6.6	4.9
21-October-2007	10.7	18.8	57.7	95.9	13.8	24.7	21592	4.4	9.7	4.8
22-October-2007	9.4	20.1	49.5	84.6	13	25.5	20977	0	7.6	4.9
23-October-2007	9.9	22.9	29.7	76.4	14.2	30.9	27799	0	8.7	7.3
24-October-2007	11.5	25.3	25	73	15.9	32.5	28820	0	7.7	8.1
25-October-2007	10.2	29.3	19	90.8	17.2	34.2	27290	0	4.7	7.7
26-October-2007	16	25.6	48.7	84	19.5	34	24862	0	9.3	6.3
27-October-2007	9.1	20.3	51.9	92.8	11.9	23.8	11827	8.6	14.8	3.2
28-October-2007	8.2	15.2	51.8	94.8	12.4	23.2	23920	5	11.3	5.2

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
29-October-2007	4.2	16.9	46.9	96.6	10.7	23.4	22449	0	6.6	4.9
30-October-2007	5.8	18.1	47.7	96.4	13.1	26.3	21354	0	5.9	4.7
31-October-2007	6.3	18.7	44.1	97.1	13.4	30.1	27524	0	6.4	6.2
01-November-2007	9.3	21.1	47.3	87.4	14.8	31.3	28323	0	8.4	6.9
02-November-2007	10.5	25.1	31.4	76.3	15.4	31.9	27313	0	9.2	7.2
03-November-2007	10.3	25	24.9	63.9	15.7	32.9	29980	0	10	8.3
04-November-2007	13	25	18.1	62.8	16.7	32.8	30469	0	9.8	9
05-November-2007	15.6	30.4	16.2	54.4	18.9	35.3	29692	0	7.8	9.6
06-November-2007	13.2	31.6	19.2	93.4	19.6	35.6	25389	0	5.9	6.9
07-November-2007	11.2	21	55.4	92.3	18	32.8	26437	0	7.8	6.2
08-November-2007	10.6	21.8	45.9	94.9	19.1	34.1	28489	0	6.9	6.8
09-November-2007	13.5	23.3	46.1	89.2	19.2	34.1	29048	0	10	7.2
10-November-2007	14	22.9	44.8	79	19.1	34.5	29224	0	9.3	7.5
11-November-2007	18.3	32.4	24	60.6	21.7	36.9	29427	0	8.2	9.2
12-November-2007	22.8	36.6	20.3	45.4	24.5	39	28997	0	8.9	10.3
13-November-2007	19	38.9	17.3	94.3	25.5	40.4	28465	0	4.9	8.5
14-November-2007	15.4	30.3	50.6	94.6	22.9	39.2	28050	0	6.2	7.1
15-November-2007	12	28.5	42.5	95.4	21.2	38.6	29920	0	6.3	7.6
16-November-2007	13.8	27.5	36.8	82.5	21.4	37.7	29138	0	8.6	7.9
17-November-2007	9.4	26.9	32.1	96.1	20.6	37.5	30629	0	6.3	7.8
18-November-2007	15.3	23.2	49.5	89.4	21.8	34.8	26853	0.4	10.7	6.8
19-November-2007	16	21.2	40.3	66.5	21.6	34.5	29447	0	11.7	8
20-November-2007	7.8	20	39.2	83.3	18.3	32.4	27489	0	9.9	7.1
21-November-2007	10.7	23.1	33.5	86.1	18.6	34.3	31333	0	8.8	7.9
22-November-2007	14.5	28.6	20.9	80.8	20.5	36.6	31523	0	7.7	9.2
23-November-2007	18	34	14.8	54.6	23.2	38.4	30507	0	8	10.2
24-November-2007	15.2	37.1	14.7	89.7	22.7	39.5	30898	0	5.3	9.4
25-November-2007	15.3	30	30.7	94.7	24.5	39.4	27811	0	5.8	7.6
26-November-2007	13.7	23.5	56.4	93.3	22.3	37.5	30616	0	7.7	7.2

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
27-November-2007	13.1	26.5	38.1	86.4	21.7	37.9	31142	0	8.5	8.3
28-November-2007	16.2	28.2	29.9	82.1	23.5	38.4	30444	0	7.9	8.5
29-November-2007	17.8	34.2	21.7	85.6	24.8	40.1	28209	0	9	8.2
30-November-2007	16.5	23.5	49.1	91.9	22.3	36.8	26707	4.4	7.7	6.7
01-December-2007	15.1	22	45.9	90.1	20.1	32.5	25267	1.8	10.9	6.4
02-December-2007	9.1	20.5	47.8	87.4	17.2	30.2	24811	0.2	8.9	5.8
03-December-2007	10.6	21.5	41.8	91	18.9	34.6	31089	0	8.2	7.6
04-December-2007	12.3	22.7	43.9	89.3	20.1	35.5	31006	0	8.4	7.6
05-December-2007	16.5	24.2	43.2	75.2	22	36.8	28910	0	9.5	7.6
06-December-2007	7	20.7	50.8	89.6	15.2	31.2	20755	6.6	9.6	5
07-December-2007	8.7	20	41.6	92.4	17	31.2	30779	0	6.7	7.1
08-December-2007	11.3	21	45.8	85.6	19.3	35.1	31324	0	8.9	7.7
09-December-2007	11.4	23.2	36.7	68.4	18.7	35.6	32474	0	10.7	8.6
10-December-2007	15.2	29.9	17.7	60.5	21.3	36.8	32967	0	10.5	10.3
11-December-2007	22.5	34.7	18.1	38.9	25.3	39	29291	0	9.8	10.5
12-December-2007	14	31.6	23.2	95.8	20.5	38.1	23583	5.6	4.2	6.2
13-December-2007	11.6	24.1	50.7	90.4	19.9	36.4	30048	0.2	7.8	7.2
14-December-2007	14.8	23.3	47.7	70.4	20.5	34.5	26270	0	11	7
15-December-2007	15.2	25.4	33.4	62.4	21.2	36.4	29268	0	12.3	8.7
16-December-2007	16.5	22.4	47.7	81	20.2	28.5	12638	0	11.1	3.9
17-December-2007	14.7	21.8	61.4	94	19.5	26	14231	0.4	7	3.1
18-December-2007	16.6	21.3	66.8	93.4	21.2	32.9	23340	2.8	8.7	5.3
19-December-2007	13.7	23.3	61.9	95	20.5	34	27505	0	6.3	6.3
20-December-2007	13.5	23	54.9	93.3	21.1	36.6	28635	0	7.4	6.9
21-December-2007	11.3	23.4	38.3	90.2	19.9	35.6	29999	0	9.3	7.7
22-December-2007	14.3	23.7	37.9	74.6	20.9	36	32327	0	9.9	8.5
23-December-2007	18	28.8	27.6	83.2	23	34.8	25333	0	7.4	7.2
24-December-2007	19.2	33.5	20.5	68.3	24.2	39.9	32228	0	9.5	10.4
25-December-2007	21.3	34.4	14.1	68.4	24.5	38.1	24312	0	8.5	9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
26-December-2007	22.3	41.4	12.7	42.9	26.7	42.8	32132	0	7	11.7
27-December-2007	20.3	44	11.8	84.3	28.4	45.5	31316	0	6	10.7
28-December-2007	18.1	31.4	40.2	86.8	26.1	42.7	31090	0	9.9	8.5
29-December-2007	16	28.5	42.7	69.2	24.1	41.3	31909	0	10.5	9
30-December-2007	15.3	33.3	27.2	83.1	24.8	42.8	31996	0	7	9.1
31-December-2007	13.5	25.1	41.9	79.4	22.9	40.6	32005	0	11.1	8.8
01-January-2008	14.5	30.6	26.8	65.7	23.5	41.5	32200	0	10.2	9.6
02-January-2008	23.8	34.7	20.6	47.5	28	40.5	20885	0	7.8	7.8
03-January-2008	26	36.2	26.3	42.8	28.5	35.8	12034	0	6.2	5.2
04-January-2008	21	35.1	28.9	83.6	26.5	36.3	13256	0	8.3	4.6
05-January-2008	13.9	28.1	45.5	77.5	22.9	39.6	26564	0	10.4	7.4
06-January-2008	16.8	25.7	34.2	73.4	23.9	40.4	32369	0	10.4	9
07-January-2008	18.1	28.7	33	67	24.5	42.1	30734	0	8.9	9.2
08-January-2008	26.7	38.5	18.6	52.2	28.9	45.4	30937	0	8.2	10.7
09-January-2008	19.5	29.4	52.4	78.4	27.5	43.1	28256	0	9.1	7.7
10-January-2008	15.8	24.5	48.2	75.9	25.2	42.3	30010	0	9.4	7.9
11-January-2008	12.2	23	37.4	72.6	22.2	40.4	30347	0	10.5	8.4
12-January-2008	12.6	25.3	33.6	82.5	22.1	41	32223	0	9.1	8.6
13-January-2008	17.5	25.5	40.3	82.8	24.3	40.8	31568	0	9.3	8.3
14-January-2008	15.5	29.5	36	86.2	24.5	43.7	31089	0	7.4	8.6
15-January-2008	16.1	29.1	39.1	74.7	23.6	41.8	30957	0	11.3	8.7
16-January-2008	17.2	34.8	17.1	64.5	24.6	44.4	31851	0	10.4	10.5
17-January-2008	23.8	36.4	21.3	49.7	28	44.8	30381	0	11.3	11.1
18-January-2008	20.4	41.6	16.9	88.3	28.9	48.3	27301	0	7.8	9.2
19-January-2008	18.9	26.7	61.1	80.1	26.7	39.9	20256	0	7.2	5.3
20-January-2008	18.7	33.6	32.1	72.2	25.7	43.9	27840	0	9.5	8.5
21-January-2008	19.5	33	29	68.5	26.2	45.6	30821	0	11	9.8
22-January-2008	18	32	24.9	62.2	25.6	43.5	28702	0	11.6	9.6
23-January-2008	19.6	35	22.5	61.3	26.4	46.4	30739	0	9.7	9.8

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
24-January-2008	21.6	35.8	22.1	60.2	27.4	47.1	30603	0	10	10.2
25-January-2008	19.1	35.2	25.6	83.1	27.4	47.6	30310	0	6.5	9.5
26-January-2008	22.7	35.7	27.4	72.3	28.5	47.7	29457	0	8.1	9.5
27-January-2008	19.9	32.3	33.9	61.2	27.5	46	29615	0	9.7	9.5
28-January-2008	18.8	32.2	28.2	75.8	26.5	45.7	29543	0	8.8	9
29-January-2008	18.3	28.7	36.2	77	25.6	44.9	29983	0	8.8	8.9
30-January-2008	18.4	29.8	34.9	74.7	25.9	45.4	30261	0	10.3	9.1
31-January-2008	16.8	33.1	26.7	69.7	25.5	46.6	30332	0	9.5	9.5
01-February-2008	19.4	33.2	25.7	74.9	26.6	46.5	30294	0	9.4	9.1
02-February-2008	20.9	36.2	28.2	70.6	28.4	47.8	27241	0	9.2	9
03-February-2008	23.5	37	27.6	64	29.3	47.8	27071	0	8.1	9.3
04-February-2008	21.3	34.4	31.6	71	28.6	48.4	28393	0	10	9.3
05-February-2008	25.1	35.1	26.7	54.2	29.6	45.1	22366	0	11	8.5
06-February-2008	22.8	36.6	28.2	80.4	27.8	42.7	18054	0	6.5	6
07-February-2008	17	35.2	23.4	92.7	24.3	41.7	16998	16.2	10.8	7.2
08-February-2008	17.2	24.9	63.8	93.8	21.2	24.1	5314	51.6	10.4	1.5
09-February-2008	19.7	28.2	48	75.9	23.2	32.9	20741	0.2	11.4	6.3
10-February-2008	20.2	31	37.6	67.3	24.2	37.4	27396	0	9.4	8.5
11-February-2008	21.6	36.4	27.6	72.8	26	40.7	28112	0	6.2	9
12-February-2008	21.2	36.5	25.9	62.3	25.9	41.4	27646	0	11.7	9.8
13-February-2008	22.7	36.3	21.5	45.9	26.4	40.8	27579	0	13.5	10.8
14-February-2008	25.4	36.3	20.6	71	27.3	40	26051	0	9.9	10
15-February-2008	20.7	28.6	58.7	81.8	27.5	40.6	24382	0	8.6	6.6
16-February-2008	17.8	24.6	66.8	91.3	24.3	32.2	12299	0	8.3	3
17-February-2008	19.8	26.1	52.9	87.6	25.6	38	23829	0	7.8	6.1
18-February-2008	15.5	26.5	48.5	90.2	23.1	37.4	24728	0	8.6	6.5
19-February-2008	13.2	24.1	41	73.9	21.1	36.7	28675	0	11.6	7.9
20-February-2008	14.5	27.6	20	66.7	21.4	37.1	29046	0	9.8	8.9
21-February-2008	14.6	26	26.4	69.2	20.9	33.3	23138	0	7.2	6.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
22-February-2008	12.8	29.7	22.6	65.3	21.1	37.1	28610	0	9	8.8
23-February-2008	14.4	28.2	22.4	64.6	21.2	36.3	28692	0	11.7	9.2
24-February-2008	15.8	29.6	19.4	71.7	22	36.8	28811	0	8.6	9
25-February-2008	18.4	33.5	18.4	79.3	23.5	38.4	28289	0	7.4	8.9
26-February-2008	16.6	34.4	19	71.4	24	39.7	27625	0	6.5	8.9
27-February-2008	21.9	34.6	22.9	59	26.1	40.5	24623	0	7	8.2
28-February-2008	22.3	37.4	24.1	63.2	26.9	40.3	24361	0	8.9	8.5
29-February-2008	17.1	40.5	17.7	89.1	26.4	42.2	26012	0	4.4	8.3
01-March-2008	21.7	30	57.4	85.6	28.3	40.7	24323	0	7	6.4
02-March-2008	18.5	26.8	58.1	87.3	25.7	39.9	25189	0	8.5	6.5
03-March-2008	18	29	47.1	73.3	24.9	38.7	26075	0	9.6	7.5
04-March-2008	18.3	32	32.9	84.3	25.2	39.5	25986	0	6.9	7.4
05-March-2008	17.7	29.8	41.9	88.2	25.3	39.2	25362	0	6.2	6.9
06-March-2008	17.5	30.8	39.4	93.7	26	40	22878	0	4.8	6.2
07-March-2008	21.3	26.7	49.2	90.9	24.7	30.6	7791	1.8	6.1	2.2
08-March-2008	15.2	26	62.1	83.7	22	32.5	16528	0	6.8	4.2
09-March-2008	14.7	25	59.1	91	21.4	34.7	21205	0	6.3	5.3
10-March-2008	17.7	26.9	43.3	74.2	23	36.2	24995	0	9.5	7
11-March-2008	25.4	30.9	37.8	53	27.1	38.1	17671	0	9.2	4.8
12-March-2008	16.4	33.1	32.6	92.6	24.5	39.2	24836	0	5.6	7.2
13-March-2008	19.5	33	32.7	86.9	25.8	39	23200	0	9.7	7
14-March-2008	10.3	22.7	47.8	82.1	20	31.6	16957	0	9.3	4.8
15-March-2008	11.2	23.6	38.3	91.8	20.6	35.1	24467	0	5.6	6.3
16-March-2008	12.3	24.3	46.9	95.2	21.3	35.1	24130	0	6.1	6
17-March-2008	12.1	26.3	50.2	93.6	20.7	34.2	21549	0	5.2	5.4
18-March-2008	18.6	28.3	34.4	67.5	22.7	34.7	21823	0	11.9	6.8
19-March-2008	17.7	31.4	31.3	68	23.2	36.2	22819	0	8.9	7.7
20-March-2008	17.5	32	33.4	69	23.6	37.7	23189	0	9.5	7.3
21-March-2008	18.4	30.8	21.9	64.2	23.3	37.2	23203	0	9.3	7.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
22-March-2008	18.1	32.9	28.2	67.2	25.1	38.3	20799	0	7.6	7.1
23-March-2008	16.2	28.7	39.1	76.7	23	37.5	21976	0	9.1	6.7
24-March-2008	13.4	26	31.8	67.8	20.6	35.9	23003	0	10.1	7.1
25-March-2008	14.2	26.5	24	68.2	20.9	34.7	22814	0	10.8	7.3
26-March-2008	15.4	27.1	20.4	61.4	20.6	33.2	20711	0	13.8	7.5
27-March-2008	19.8	30.2	23.1	37.6	22.5	34.9	21854	0	10	8.2
28-March-2008	18.9	32.6	20	52.8	22.4	37.7	21248	0	6.8	7.5
29-March-2008	16.2	32.4	15.8	65.5	21.7	35.4	19879	0	9.1	7.2
30-March-2008	14.7	29.3	24.2	67.2	21	35.9	21936	0	9.4	7.2
31-March-2008	13.6	28.8	24.6	90.9	21.8	35.2	19522	6.6	10.8	7.3
01-April-2008	13.4	18.1	69.6	94.5	16.4	20.2	3947	43.8	10.6	0.9
02-April-2008	10.4	22.6	53.1	89.1	15.3	27	19956	0	7.3	5
03-April-2008	12.5	22.9	34.4	70.3	15.7	28.3	21409	0	7.2	5.8
04-April-2008	15.2	26	28.1	59.3	17.4	29.6	21037	0	6.2	6.3
05-April-2008	17.8	28.3	31.1	93.7	20.4	30.4	16528	17.2	4.2	4.9
06-April-2008	17.6	23.6	73.7	94.6	19.9	25.5	8863	9	2.7	1.7
07-April-2008	15.2	25.6	61.8	89.8	19.5	29.6	16339	0	4.7	4
08-April-2008	17.5	24.9	55	92.4	20.2	30.1	17466	6.4	6.5	4.5
09-April-2008	11.6	24.4	39.4	94.4	17.1	29.3	17987	0	4.4	4.5
10-April-2008	15.4	24.2	48.2	91.3	19.5	28.1	15890	0.6	6.8	4.1
11-April-2008	8	21.5	46.6	96	14.7	27.2	16352	0.2	6.3	4.1
12-April-2008	9.3	24.6	40	90.8	15.1	28.8	19916	0	4.9	4.9
13-April-2008	12.7	28.1	25.1	76.1	16.2	29.5	19950	0	6.1	6.1
14-April-2008	15.2	29.7	22.4	64.6	17.2	30.5	19543	0	5	6.3
15-April-2008	10.8	32.1	17.6	88.9	17.2	31.2	19110	0	3.4	5.7
16-April-2008	14.9	28.2	35.3	89.1	18.9	29	15696	0	4.3	4.2
17-April-2008	15	27.4	39.3	94.7	18.3	28	11675	19.8	6.1	3.1
18-April-2008	12.6	19.4	80.5	96.2	16.3	22.2	6481	4	3	0.9
19-April-2008	6.5	21.3	56	95.6	12.7	24.5	13803	0.2	6.7	3.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
20-April-2008	7.1	18.8	44.4	95.8	13.3	23.2	16591	1.6	5.5	3.8
21-April-2008	6.2	19.2	61.1	96.5	11.6	21.7	13544	1.6	5.9	2.8
22-April-2008	10.7	17.6	58.9	94	14.5	23.9	16152	1	4.1	3.3
23-April-2008	17	22.5	50.1	87.7	17.2	24.7	14611	0.6	8.5	4
24-April-2008	8.6	21	56.1	94.6	14.2	23.4	11956	0	6.8	3.1
25-April-2008	9.4	22.9	43.1	88.1	13.6	25.4	15840	0.2	5.1	4
26-April-2008	12.5	23.4	39.9	85.8	14.4	25.7	17077	0	6.6	4.6
27-April-2008	15	21.6	53.3	72.4	16	22.9	11945	0	7.3	3.4
28-April-2008	15.3	20.4	64	79.9	15	18	3992	0.8	6.5	1.3
29-April-2008	16.4	23.4	62.8	90.2	16.7	24.1	11200	0.4	5.6	2.8
30-April-2008	16.7	20.8	51.7	87.5	16.5	24.4	13365	1.6	10.3	3.9
01-May-2008	8	21	46.4	94.7	13	24.7	15188	0.2	4.3	3.5
02-May-2008	7.1	21.8	46	94.7	12.3	24.8	15741	0	3.3	3.6
03-May-2008	7.4	22.8	36.3	95.6	13.1	24.1	14724	0	2.9	3.4
04-May-2008	8.9	22.1	64.6	96.2	13.3	24.7	13161	0	3.8	2.9
05-May-2008	7.2	22.4	45.6	96.4	12.6	25.1	15138	0	3.7	3.6
06-May-2008	9.8	22.8	46.6	95.3	13.8	24.5	15322	0	4.9	3.7
07-May-2008	10.9	26	38.7	95.4	15.2	25.4	15249	0	3.4	3.7
08-May-2008	11.1	25.1	56	95.9	15.1	25.8	13331	0	3	3.1
09-May-2008	12.4	24.2	68.7	96.8	15.7	22.6	8794	0	2.4	1.7
10-May-2008	11.9	26.1	51.2	96.3	15.9	26.1	13049	0.6	3.3	3.1
11-May-2008	14.4	21.9	71.5	95.8	16.2	21.9	8284	7.6	4.3	1.6
12-May-2008	9.4	22	55.9	96.9	13.4	23.4	12146	0	4.1	2.7
13-May-2008	16.1	24.1	46.8	91.1	16.6	24.2	14336	2.2	4.4	3.6
14-May-2008	7.6	18.3	69.4	95.4	11.8	19.1	5227	4.6	5.1	0.8
15-May-2008	11.6	18	49.9	96	14	18.8	10268	1.4	4.1	2.1
16-May-2008	7	19.3	78.2	96.6	12.1	20.8	7764	10.4	4.8	1.4
17-May-2008	5.6	17.6	58.1	97.8	11	18.8	9072	0	3.3	1.8
18-May-2008	5.9	19	56.2	97.9	10.5	20.9	13770	0	3.3	2.8

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
19-May-2008	7.7	21.5	47.9	96.7	11.8	21.6	14084	0	2.7	3
20-May-2008	8.7	22	51.5	96.3	12.4	22.1	13262	0	3.7	2.9
21-May-2008	6	22.6	45.5	97.9	11.1	21.5	12496	0	2.9	2.7
22-May-2008	10.1	22.8	45.8	93.6	13.4	21.8	13353	10.8	6.1	3.3
23-May-2008	13	17.4	52.1	89.9	13.8	18.4	9116	7.6	11.8	2.5
24-May-2008	17	19.1	60.9	79.3	14.5	18.7	9131	0.4	12.3	2.9
25-May-2008	14.6	21.4	62.6	96	15.9	20.7	9977	13.2	6.4	2.2
26-May-2008	12.3	21.2	72.8	96.1	13.7	20.7	7936	0	3.2	1.4
27-May-2008	11.3	22.9	62.4	96.6	13.1	21.3	10176	0.2	3.1	2.1
28-May-2008	14.4	24.7	39.9	92.3	14.6	21	11191	0	5.1	2.9
29-May-2008	10.6	19.4	86.7	96.9	13.6	18.7	3676	22.2	4.6	0.5
30-May-2008	12.2	19.7	57.3	92.6	13.9	19.8	9659	0	4.1	2.1
31-May-2008	17.5	23.3	60.1	86.4	16.4	21.1	9638	1	4.1	2.4
01-June-2008	14.8	20.3	87.3	96.4	15.9	18.7	3243	28.6	3.5	0.3
02-June-2008	10.7	21.9	63.2	97.2	13.3	21.8	8013	0	3	1.5
03-June-2008	9.4	22	65	94.9	12.2	21.5	11873	0	4.2	2.5
04-June-2008	11.3	23	57.3	82.5	12.7	20.7	12582	0	8.2	3.4
05-June-2008	10.1	19.6	44.4	85.4	11.4	19.7	12949	0.2	6.3	3.2
06-June-2008	6.3	19.9	55.3	95.9	10.9	19.2	12635	0	5.3	2.9
07-June-2008	9.3	21.3	46.5	91.3	10.7	19.5	12751	0	4.4	3.1
08-June-2008	8.6	21	39.3	86.4	10.6	19	12650	0	4.5	3.3
09-June-2008	13.5	21	37.9	93.3	12	17.2	9381	25.8	8	3.1
10-June-2008	7.5	17.3	64.1	97.9	10.6	16	4706	8.2	4.8	0.7
11-June-2008	12.6	18.4	54.1	93.6	12.2	17.5	9671	4.6	6.3	2.4
12-June-2008	11.5	19.5	61.9	97.2	13	18.4	7231	4	3.3	1.3
13-June-2008	6.9	19.1	63.7	98.2	10.4	18.6	9695	0	3.3	1.8
14-June-2008	9.1	20.1	51	91.6	10.5	18.3	12376	0	5.2	2.8
15-June-2008	13.5	22.6	53	94.4	12.5	18.9	11574	12.2	4.8	2.7
16-June-2008	9.8	17.6	62.4	95.2	11.8	16.2	4390	24.4	8.1	1.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
17-June-2008	10.6	15.6	68.4	95.9	12.4	16	7974	8	5.9	1.5
18-June-2008	3.9	16.6	58.8	99	8.7	17	7929	4	3.6	1.3
19-June-2008	4.5	17.9	52.4	98	8.6	15.8	9241	0	3.4	1.7
20-June-2008	5.5	19.4	45.6	95.6	8	17	12349	0	4	2.6
21-June-2008	3.2	19.8	41	96.2	7.7	16.9	12604	0	3.7	2.8
22-June-2008	6	19.9	42.5	92.8	8.7	16.9	12635	0	4.4	3.1
23-June-2008	3.8	20.9	42.9	98.4	7.9	17.1	12479	0	3.3	2.8
24-June-2008	4	21.5	32.2	95.2	7.6	16.6	12711	0	3.9	3.1
25-June-2008	14.6	21.9	32.4	89.4	9.4	16.6	10909	1.8	10.5	3.6
26-June-2008	5.3	18.7	42.3	97.5	9.2	17.3	8360	0	4.3	1.9
27-June-2008	11.2	14.3	66.1	92.6	10.4	12.8	3394	0	4.8	0.7
28-June-2008	11.4	17.7	67.8	94	11.6	15.4	3358	14.8	8.5	0.8
29-June-2008	13.2	17.2	57.9	91	11.9	16.8	10210	9.4	10.4	2.7
30-June-2008	5.7	17.8	58.9	97.4	9.8	17.4	9400	0	5.7	1.9
01-July-2008	3.9	18.2	56.4	98.8	8.2	16.4	9113	0	2.6	1.6
02-July-2008	2.8	18.7	57.7	99.1	7.6	16.5	11293	0	3.4	2.3
03-July-2008	7.2	20.4	42.1	95.1	9.7	17	12179	0.2	3.8	2.8
04-July-2008	8.4	20.3	51.1	97.5	10.9	17.9	11163	1.8	2.7	2.1
05-July-2008	12.5	17.4	59.7	95.6	11.8	16.7	7285	10.4	5.3	1.5
06-July-2008	1.4	15.7	59.2	99.6	6.7	16.6	8253	3.4	5	1.5
07-July-2008	2.6	15.8	41	95.1	7	15.5	12977	0	4.4	2.7
08-July-2008	6.6	19	38.1	87.7	7.7	15.6	12751	0	4.8	3.1
09-July-2008	11.3	19.3	41.6	94.1	8.7	15.3	9918	4.8	4.9	2.3
10-July-2008	10.9	18.3	70.7	93.5	12	17	7157	6.6	9.2	1.6
11-July-2008	12.7	20.2	53.9	91.4	12.5	15.7	5532	2.2	10.5	1.6
12-July-2008	9.4	17.2	57.8	94.9	11	17	10103	1.4	8.1	2.4
13-July-2008	5.8	16.7	66.7	98.5	8.9	16.9	8472	1	2.5	1.4
14-July-2008	7	19.5	58.5	97.4	10.2	17.4	9966	0	2.7	1.8
15-July-2008	11.9	19.9	46.4	82.9	12	17.8	10555	0.2	5.8	2.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
16-July-2008	10.5	16.3	61.3	93.5	11	14.4	1960	33.2	8.2	0.7
17-July-2008	7.8	15.4	68	97.2	10.4	15.9	8808	5.8	4.3	1.4
18-July-2008	11.3	16.5	60.8	95	11.4	16.1	9057	16.2	8.3	2
19-July-2008	4	14.3	61.7	95.6	7.4	13.3	5812	14.6	12.8	1.7
20-July-2008	1.3	14.8	54.7	99.4	6.2	15.4	13138	0	3.9	2.5
21-July-2008	2.7	17.1	49.8	98.3	7.5	16.1	11842	0	2.8	2.2
22-July-2008	4.6	16.2	58.7	94.7	7.6	14.6	8000	0	3.9	1.6
23-July-2008	11.7	18.2	43.7	78.8	9.2	15.6	10457	0	6.2	2.7
24-July-2008	13.4	16.5	66.2	94.7	10.8	13.6	2087	28	7.6	0.8
25-July-2008	8.4	17.5	56.9	95.6	10.2	17.5	10476	0.2	5.2	2.2
26-July-2008	5.7	15.6	73.7	98.2	8.8	14.1	5101	9.2	4	0.7
27-July-2008	10.2	18.6	50	95.4	11.3	18.8	13577	5	5.5	2.8
28-July-2008	11.7	19.4	73	96.2	12.5	18	6923	7.6	4.8	1.2
29-July-2008	12.4	16.3	58.8	95.7	10.3	15.4	5126	6.8	9.1	1.5
30-July-2008	13	17.9	63.6	94.2	12.3	17.7	11212	21.6	9.7	2.5
31-July-2008	7	15.8	48.1	96.9	9.8	17.3	12729	15	11.7	3.4
01-August-2008	7.2	14.5	71.2	98.1	10.3	16.1	8526	3	3.5	1.3
02-August-2008	11.3	14.7	66.5	96.1	11.7	16.3	7712	35.6	7.6	1.4
03-August-2008	5.9	16.4	55	95.4	9.7	18.1	13610	0	5.7	3
04-August-2008	2.3	16.8	54.5	99.1	6.6	19	13200	0	3.5	2.6
05-August-2008	3.6	18.7	44	98.7	7.5	19.1	15224	0	3.2	3.1
06-August-2008	3	19.9	48.5	98.4	6.9	19.2	14799	0	3.3	3.1
07-August-2008	4.9	19.3	44.5	97.7	9.1	19.6	14609	0	3.3	3.1
08-August-2008	5.8	16.2	63.1	92	8.2	15.2	5868	0	4.5	1.1
09-August-2008	7.7	16.6	44.9	79.4	8.8	19.2	15661	0	8.4	3.8
10-August-2008	9.6	17.4	45.4	70.9	9.5	19.2	15635	0	10.3	4.3
11-August-2008	7.1	17.9	45.7	75.2	9.1	20	15749	0	8.5	4.2
12-August-2008	4.9	20.3	36.7	89.3	8.6	21.6	15924	0	5.3	4
13-August-2008	6.3	18.5	35.3	87.7	8.9	19.9	15802	0	6.3	3.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
14-August-2008	4.2	19.6	28.8	87	8.2	21	16496	0	5.7	4.2
15-August-2008	3.9	21.1	22.5	87.4	8.6	21.4	16694	0	5.1	4.4
16-August-2008	5.3	22.9	23.5	90	8.8	21.4	16355	0	3.8	4.3
17-August-2008	6.3	22.6	26.8	84.2	9.6	22.9	16976	0	4.2	4.5
18-August-2008	2.1	23.5	26.2	94.5	8.9	23.3	17303	0	3.4	4.3
19-August-2008	8.3	22.2	20.9	91.7	11.3	22.5	15882	0.6	4.2	4.1
20-August-2008	5.5	17.8	61.6	92.1	8.7	17.9	8878	0.6	4.8	1.6
21-August-2008	5	17.2	43.9	88.3	8.9	20.4	16895	0.2	6.1	3.9
22-August-2008	2.8	16.1	43.4	92.6	8.3	20.2	16756	0	8.1	4.1
23-August-2008	4.4	19.6	35.4	84.1	8.9	21.7	17949	0	6.4	4.5
24-August-2008	5.2	20.8	27.7	91.4	9.3	23	17490	0	4.1	4.3
25-August-2008	4	19.9	35.8	98.7	9.7	20	13369	0	3.4	2.9
26-August-2008	6.7	21.5	47.5	94.2	10.6	23.1	16989	0	6.3	3.8
27-August-2008	9.1	21.1	36.8	84.3	11.7	23.7	18428	0	6.4	4.7
28-August-2008	5.4	22.6	37.4	97.5	11.6	25.3	17372	0	3.8	4.1
29-August-2008	7.7	20.7	57.3	95.6	13.4	24.4	15765	0.2	4.6	3.4
30-August-2008	2.2	17.3	61	97.6	9.8	22.2	15942	0.2	6.6	3.4
31-August-2008	7.5	16	44.6	91.2	12.8	22.9	17973	0	5.1	4
01-September-2008	11.3	17.5	53.3	96.6	13.7	19.1	8833	2.4	5.3	1.8
02-September-2008	5.7	18.6	64.9	98.8	9.9	20.9	11338	2	2.8	1.9
03-September-2008	4.7	21.7	44.2	98	10.1	24.7	19341	0	3.7	4.4
04-September-2008	8.9	24.5	28.9	94.3	12.4	24.9	18221	0	6.1	4.5
05-September-2008	9.2	18.3	46.4	92.1	12.8	24.7	19187	0	8.2	4.5
06-September-2008	6.8	21.5	47.1	93.2	12.4	25.7	19859	0	7	4.6
07-September-2008	7	19.5	37.8	83.4	11.7	25.3	19647	0	5.6	4.6
08-September-2008	4.2	19.5	38.5	96.8	11.1	25.5	19939	0	5.1	4.4
09-September-2008	3.8	21.7	33.6	98.4	11	24	17672	0	3.7	4
10-September-2008	5.7	20.4	42.9	97.1	12.7	25.9	19449	0	4.9	4.5
11-September-2008	13.5	17.8	55.7	90.5	14.8	19.8	10331	1.8	9.6	2.6

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
12-September-2008	14.9	19.7	66.8	90.1	14.7	21.2	12178	1.6	9.5	3
13-September-2008	12	19.5	59.9	90.9	12.8	22	14089	5.8	12.2	3.4
14-September-2008	13.4	17.2	50.1	83.3	14.4	20.1	13964	0	12.4	3.8
15-September-2008	7.2	18.9	52.7	92.2	11.8	21.5	15275	0	8.5	3.5
16-September-2008	4.3	19	41.6	96.7	11	23.9	19271	0.2	3.9	4.3
17-September-2008	11.3	20.7	38.2	89.9	16.3	26.7	20106	2.4	6.2	4.9
18-September-2008	13.6	18.2	61.8	91.4	13.9	22.1	15538	2.6	9.8	3.7
19-September-2008	15.1	19.8	63.9	88.1	14.3	21.9	14261	0.8	12.3	3.7
20-September-2008	12.8	18.6	54.5	89.6	14.9	23.6	16640	0	9.8	4.2
21-September-2008	13.8	20.6	55.9	92.6	16.1	27.8	19568	5.4	8.2	4.5
22-September-2008	-0.2	14.7	54.4	98	8.6	19.5	14331	2.6	7.8	2.8
23-September-2008	3.8	18.5	39	94.1	9.8	24	23293	0.2	4.8	5.2
24-September-2008	9.7	24.5	24.4	86.2	14	24.8	20813	0	4.8	5.8
25-September-2008	14	24.1	39.5	95.6	17.4	28.2	20160	27	9.1	5.1
26-September-2008	8.8	14.5	79.3	96.3	12.2	18.4	5804	6.4	4.6	0.7
27-September-2008	7.9	17.1	62.1	84.7	12.2	22.3	13888	0	6.3	3
28-September-2008	11.1	19.1	44.9	93.5	14.7	21.9	16136	0	5.1	3.7
29-September-2008	7.9	20.7	60.1	96.8	14.1	28.2	23790	0.2	4.3	5.1
30-September-2008	12.6	23	47.7	93.8	16.1	29.6	24376	4.4	6.5	5.8
01-October-2008	15	18.5	64.9	86.7	16.2	24	16313	1	9.5	3.9
02-October-2008	12.5	20.9	67.6	93.9	16.1	24.3	15135	3.6	7.3	3.2
03-October-2008	6.2	17.3	47.4	92.7	12.2	25.5	22541	0	6.2	5
04-October-2008	8.3	17.5	50.9	95.4	15.1	26	19652	1.2	5.8	4.2
05-October-2008	3.1	18.7	45.6	96.4	10.7	22.8	18959	1.2	8.7	4.3
06-October-2008	7.4	18.1	44	90.8	11.9	23.6	20843	0	6.2	4.7
07-October-2008	6.6	20.5	38.8	89.3	12.7	26.8	23669	0	5.1	5.5
08-October-2008	9.8	22.7	35.3	88.6	13.9	28.9	25943	0	7.1	6.2
09-October-2008	6.2	25.2	27.5	95.9	14.6	30.5	25668	0	4.2	6.4
10-October-2008	9.8	21.2	51	86.3	15.4	29.8	25559	0	7.9	6.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
11-October-2008	8.4	22.6	43.8	95.9	16	30.9	24781	0	5.3	5.8
12-October-2008	10.7	19.5	52.5	93.5	16.5	27.8	19195	0.4	7.2	4.4
13-October-2008	5.3	18.6	41.1	96.9	13.9	28.2	24068	0	6.3	5.5
14-October-2008	11.7	20.9	40.5	80.5	15.6	28.8	24212	0	8.4	6.1
15-October-2008	18.7	29.8	26.8	57.5	19.3	32	26063	0	7.7	8.3
16-October-2008	16.7	31.8	22.8	88.7	20.9	32.9	23733	0	7.1	6.2
17-October-2008	14	20.3	54.9	84.7	19.3	27.8	16331	0	7.6	3.8
18-October-2008	14.8	20.8	45.5	93	20.6	31.9	24662	0	5.9	5.7
19-October-2008	13.4	24.4	48.8	88.6	18.8	32.8	25667	0	8.2	6.5
20-October-2008	22.6	32.6	22.9	45.4	22.7	34.8	26741	0	8.7	9.1
21-October-2008	17	33.4	25.2	81	22.3	34.8	20703	0	5	6.4
22-October-2008	15	30.9	38.1	93.6	21.6	34.3	21151	0	4.7	5.5
23-October-2008	17.2	27.5	47.5	88.9	20.7	31.1	14028	0.8	7.1	3.9
24-October-2008	17.7	30.9	41.3	92.2	21.4	28.7	12215	1.2	7.5	3.7
25-October-2008	13.5	22.7	66.8	92.1	17.7	26.5	16717	15.2	9.4	3.8
26-October-2008	7.7	19.8	55.8	95.9	15	27.8	22198	0	6.2	4.9
27-October-2008	8.1	20.1	50.1	95.7	16.2	31.4	27795	0.2	5.2	6.3
28-October-2008	15.5	21.5	49.2	86.2	19.1	32.4	25292	0	9	6.5
29-October-2008	16.3	20.7	69.9	90.6	18.6	23.4	10124	0.8	9.9	2.2
30-October-2008	9.6	20.6	49.4	93.3	17	29	24897	0	10.9	5.9
31-October-2008	8.4	19.2	43.7	85.3	16.2	31.5	27629	0	8.6	6.7
01-November-2008	11.1	22.8	41.7	82.5	16.6	28.4	22380	0	7	5.7
02-November-2008	10.1	24	30.5	89.2	17.5	33	29527	0	6.5	7.4
03-November-2008	12.7	23.1	46.9	83.8	20	34.1	25570	0	8.3	6.5
04-November-2008	13.6	20.2	36.6	90.6	17.2	29.9	20668	8.8	11.6	5.1
05-November-2008	13.5	18.8	63.7	88.4	16.8	25.4	20221	5.6	10.2	4.6
06-November-2008	9.5	17.3	50.9	92.6	13.5	21.6	11811	14	11	2.7
07-November-2008	5.2	17.7	56	96.7	12.8	24.7	26049	0.8	9.7	5.8
08-November-2008	7.5	20.4	46.7	96.7	14	23.5	20809	0	5.9	4.6

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
09-November-2008	10.9	21.8	47.2	95.2	17	31.6	29699	0	7.5	6.9
10-November-2008	13.5	24.2	60	94.4	18.4	32.3	27583	0	6.4	6.6
11-November-2008	16.2	25.7	48.9	89.4	20.5	32.7	24437	0	6.8	5.9
12-November-2008	11	21.7	57.8	89.4	17.3	25	10980	0	5.5	2.6
13-November-2008	10.6	22.4	44.3	81.7	17.5	31.5	26481	0	8.7	6.5
14-November-2008	11.1	23.7	29.5	75.5	17.5	32.3	28372	0	8.2	7.6
15-November-2008	12.2	23.9	27.5	72.8	18.2	32.5	28576	0	9.7	8
16-November-2008	12.9	25.3	27.7	66.9	18.7	33	29510	0	11.3	8.6
17-November-2008	13.2	27.2	23.3	70.9	19.4	33.2	27983	0	8.3	8
18-November-2008	13.2	26.6	27.8	70.9	19.9	35.2	30492	0	8.1	8.4
19-November-2008	10	25.3	37	95.7	19.6	35.9	30096	0	6.3	7.5
20-November-2008	15.7	27.8	37.4	92.7	21.7	37.3	28551	0	6.6	7.5
21-November-2008	13.7	23.5	52.8	93.1	21	35.2	27025	0.2	5.3	6.3
22-November-2008	11.9	23.7	43	92.2	21.2	37	30401	0	4.9	7.4
23-November-2008	13.8	24.7	46.7	95.4	19.7	31.6	22122	13.4	5.5	5.1
24-November-2008	13.5	21.2	59.6	91.1	19.8	31	25273	0.2	9.8	5.8
25-November-2008	12	20.3	58.9	94.8	18.6	33.7	26926	2.2	8.7	6.1
26-November-2008	12.7	21.6	49.6	93.5	19.8	33.3	24746	1.6	6	5.6
27-November-2008	13.9	20.4	59.5	94.3	18.8	29.4	25180	8.4	8	5.6
28-November-2008	11.6	21.5	45.7	89	18.7	33.5	30401	0	9.2	7.3
29-November-2008	9.5	22.9	40.9	95.7	19.1	35.9	32068	0	6.1	7.8
30-November-2008	12.6	22.7	48.6	89.9	20.3	35.3	29614	0	8.8	7.2
01-December-2008	11.6	23.3	36.3	78.1	19.8	36.2	32023	0	9.5	8.1
02-December-2008	10.9	25.2	38.1	95.1	20.6	36.9	29928	0	6.6	7.4
03-December-2008	17.6	31.4	28.2	93.2	23.7	37.3	26525	0	6.9	7.4
04-December-2008	17.5	21.5	54.4	89.9	21.5	32.5	20555	1.8	8.7	5.1
05-December-2008	12.7	23.4	54.9	85.3	20.4	32	25007	0.2	7	6
06-December-2008	12.7	21.9	47.8	87.5	20.2	36.4	30576	0	8.5	7.6
07-December-2008	10.8	25.3	37.6	93.7	20.7	37.6	31895	0	7.1	8.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
08-December-2008	13.2	25.4	38.2	86.9	21.7	38.4	30431	0	9.8	7.8
09-December-2008	10.3	21.3	48.9	93	20.6	35.1	25590	0	7.8	6.3
10-December-2008	11.3	21.2	45.5	95	19.7	34.6	25780	3.4	5.6	6
11-December-2008	10.8	20.6	52	93.6	16.4	27.2	20528	2	6.3	4.5
12-December-2008	13.4	24.1	44.2	88	19.5	34.6	29703	0	9.6	7.5
13-December-2008	14.1	25.9	46.8	88.6	21	37.6	31483	0	7.9	7.9
14-December-2008	19.5	30.2	34.7	83.5	24.2	39.2	31361	0	8.7	9.1
15-December-2008	18.1	37.8	18.5	93.4	25.8	42.8	29890	0	6	9
16-December-2008	15.7	25.6	53.2	83.2	23.5	40.3	29245	0	9.8	7.6
17-December-2008	12.4	25.2	40.6	81.1	22	38.8	29857	0	8.9	7.8
18-December-2008	14.8	23.7	39.3	71.5	22.2	39.5	32662	0	9.9	8.6
19-December-2008	13.5	28.6	32.2	90.3	22.8	41.4	32207	0	7	8.7
20-December-2008	18.5	27.9	42.4	86.4	25.3	41.3	29776	0	10.8	7.8
21-December-2008	15.6	21.6	53.5	82.3	20.9	30.2	20725	11.8	10.5	5.1
22-December-2008	12	22.5	45	89.2	20.3	35.3	28260	0.2	7.4	7.1
23-December-2008	13.6	25.8	42.2	86.4	21.5	37.4	31546	0	8.4	8.1
24-December-2008	13.2	24	47.9	85.7	21.6	36.7	31194	0	10.3	8.2
25-December-2008	14.1	24.9	41.9	83.1	22.1	38.2	31693	0	9.8	8.1
26-December-2008	13.7	25.5	43.7	88.8	22.4	38.2	32781	0	10.7	8.5
27-December-2008	13.2	24.1	41.7	89.8	22.7	38.3	32007	0	9.7	8.2
28-December-2008	15.6	26.5	49.1	90.6	23.9	39.5	31733	0	8.9	8.1
29-December-2008	18.2	30.1	32.5	80	24.5	40.9	32216	0	7.9	9.1
30-December-2008	19.7	35.7	18.6	56.8	26	42.7	32417	0	9.3	11
31-December-2008	20.9	38.8	19.5	70.6	27.5	44.6	31474	0	8.2	10.4
01-January-2009	18.6	36.5	26	61.4	26.9	45.7	31491	0	9.3	10.1
02-January-2009	21.2	36.3	23.9	81.6	27.7	46	31762	0	7.7	10
03-January-2009	19	32.1	36.5	81.7	27.1	46.3	31704	0	9.1	9.3
04-January-2009	18.7	31.1	36.6	68.6	26.6	45.4	31654	0	9.2	9.5
05-January-2009	22.5	34.7	24.3	70.8	27.6	46.6	31645	0	9.1	10

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
06-January-2009	19	35.2	22.4	79.5	27.3	47.4	31901	0	8.9	9.8
07-January-2009	18.9	33.2	33.1	69.9	26.8	47.1	31998	0	10.6	9.8
08-January-2009	19.1	35.7	25	68.3	26.8	48.1	31894	0	9.1	9.8
09-January-2009	18	34.8	30.6	76	26.9	48	31844	0	8	9.9
10-January-2009	19.5	32.6	32.4	71.5	27.3	48.3	32064	0	7.8	9.8
11-January-2009	21	32.5	28.7	71.2	27.3	47.8	31940	0	8.8	9.7
12-January-2009	14.6	36.6	22.7	93.2	26.3	50	32300	0	6.9	9.9
13-January-2009	10.9	25.8	46.9	91.1	23.3	43.9	25826	0	9.1	6.8
14-January-2009	15.6	24.6	36.7	73	24.3	44.4	30440	0	9.6	8.4
15-January-2009	18.9	29.3	33.3	63.9	25.3	44.3	29958	0	11.3	9.1
16-January-2009	24.6	39.4	16.6	54.6	29.5	49.1	31123	0	9.2	11.4
17-January-2009	17.5	41.9	12.5	82.6	27.2	50.9	31424	0	8.2	10
18-January-2009	19.9	28.8	45.1	73.3	25.8	40.1	16803	0	6.4	4.8
19-January-2009	15	32.3	30.9	89.8	22.3	39.7	18205	4.8	7.8	5.5
20-January-2009	14.4	28.1	40.8	73.8	21.9	42.6	31415	0.2	7.9	8.5
21-January-2009	15.9	26.1	36.3	83.6	23.3	42.6	32031	0	9.9	8.5
22-January-2009	18.9	24.7	49.2	88.3	26.2	41.9	29136	0	9.1	7.5
23-January-2009	20.2	25.8	57.9	82	27.1	41.2	24356	0	8.6	6.2
24-January-2009	13.3	26.2	55.2	93.4	23.8	42.8	28974	0	7.2	7.3
25-January-2009	17	28.8	28.9	82	25	43.9	31000	0	7.9	8.9
26-January-2009	18	36.9	22.6	92.7	26.5	46.2	30614	0	7.7	9
27-January-2009	17.6	28.1	48.9	81.6	25.7	45.3	29353	0	9	7.7
28-January-2009	21.1	30.9	39.5	74.2	27.9	43.4	23205	0	7.7	6.9
29-January-2009	18.7	28.6	53.7	81	26.8	38.5	15370	0	8.8	4.3
30-January-2009	16	25.2	54.5	88.8	23.9	36.3	17295	0	6.4	4.4
31-January-2009	21.6	30.4	46.3	77.9	26.3	39.6	21228	0	7.4	6
01-February-2009	21.4	35.1	40.8	87	27.4	43	24476	0	6	7.1
02-February-2009	21.3	34.9	43.1	92.3	28.4	48.3	29558	0	6.5	8.3
03-February-2009	19.4	33.7	43.8	94	28.2	48.9	29252	0	6.9	8

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
04-February-2009	18.2	29.2	55	83.8	26.7	47.8	29728	0	8.5	8.1
05-February-2009	16.2	29.8	37.6	66.3	25.1	45.8	29531	0	10.4	8.7
06-February-2009	15.1	29.1	32.1	77	24.4	45.8	29640	0	11.2	8.4
07-February-2009	12.7	24.8	41.4	79.1	23.9	43.5	29132	0	10.3	8
08-February-2009	15.1	25.4	34.8	65.9	22.9	43.7	29426	0	11.3	8.6
09-February-2009	17.9	33.5	16.3	63.4	25.1	45.6	29992	0	10.5	10
10-February-2009	20.2	35	16.2	59.2	26.3	47	29940	0	10.8	10.5
11-February-2009	25.2	37.6	16.6	37	28.8	47.6	28809	0	8	10.4
12-February-2009	20.9	39.2	13.8	48.4	28.9	50.6	28424	0	6	10.2
13-February-2009	20.9	37.8	14.8	72	28.8	46.8	24124	0	10	8
14-February-2009	18.8	28.8	36.4	78.8	26.7	43.5	19915	0	9.5	6.3
15-February-2009	15.9	28.3	38.9	91.6	23	31.1	8680	0	5	2.7
16-February-2009	17	28.5	48	93.6	25.7	45	28129	0	7.2	7.4
17-February-2009	15.4	25.1	48.6	82.3	23.8	43.5	27729	0	10.5	7.5
18-February-2009	16.8	29.1	36.5	70.6	24.4	44.6	28085	0	10.3	8.5
19-February-2009	16.5	33	21.6	65.1	24.5	46.1	28630	0	8.6	8.9
20-February-2009	18.7	30.8	29.9	64.8	25.6	46	27987	0	9.6	8.9
21-February-2009	24.6	37.9	18.8	40.3	28.2	48.1	27378	0	8.1	10.1
22-February-2009	19.1	38.9	16.4	75.3	26.9	44.2	20556	0	7.5	7.2
23-February-2009	17	29.5	30.8	71.8	24.9	44.9	27678	0	12	8.5
24-February-2009	17.7	33.6	28.6	90	25.9	43.7	21764	0	6.1	6.3
25-February-2009	14.8	23.8	57	84.7	23.4	35.4	16005	0	6.5	4
26-February-2009	10.5	20.3	55.6	93.9	16.4	26.1	9953	8	6.7	2.2
27-February-2009	12.7	22.3	42.3	82.7	17.9	32.5	21881	0	7.2	5.6
28-February-2009	17.4	27.1	32.1	74.3	21.7	38.6	26262	0	8.5	7.5
01-March-2009	24.2	37.9	22.8	67.8	26.4	41	23723	0	7.9	8.1
02-March-2009	18.2	31.7	46.7	85.9	25.6	39.7	20517	0	10.5	6.1
03-March-2009	6	21.9	37.4	89.7	18.6	36.8	24643	0	10.5	6.9
04-March-2009	13.1	27.2	22.1	66.4	20.6	37.9	27339	0	6.7	7.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
05-March-2009	14.9	30.6	18.7	68.8	21.8	39	27250	0	7.5	8.8
06-March-2009	13.6	32.2	20	71.3	22.3	41.2	26872	0	5.9	8.3
07-March-2009	16.9	34.4	17.1	71.9	23.5	41.9	26450	0	10.7	8.9
08-March-2009	18.4	32.5	23.9	78.5	23.6	41.9	26277	0	7.7	8.2
09-March-2009	13.9	34.1	18.7	76.4	22.9	41.9	23601	0	4.7	7.6
10-March-2009	13.4	34.1	17.2	80.6	23.2	43	25597	0	4.7	8.1
11-March-2009	12.6	36.9	15.8	76.7	22.9	44	25265	0	4.3	8.1
12-March-2009	18.5	29.2	34.2	78.5	24.7	36.3	16565	0	6.8	4.6
13-March-2009	12.2	25.6	49.5	82.6	20.8	35.2	17310	0	7.8	4.7
14-March-2009	14.1	27.4	33.2	68.2	20.8	40	25092	0	9.6	7.3
15-March-2009	21.6	31.5	23.8	37.8	25	40.3	23397	0	8.9	8.5
16-March-2009	17	38.1	16.9	86.2	24	40.8	20401	0	4.5	6.8
17-March-2009	19.7	30.8	37.5	80.1	24.8	42.5	21661	0	5.6	6
18-March-2009	15.8	24.8	49.6	83.3	22.3	32	14607	0	8.8	4.1
19-March-2009	9.8	23.1	41.7	88.7	19.1	37.6	22601	0	6.3	5.8
20-March-2009	14.9	23.6	41	79.3	23.7	38	19237	0	7.6	5.4
21-March-2009	13.1	24.7	43.7	93.1	19.9	35.4	15542	1.8	5.7	3.7
22-March-2009	7.4	23.7	37.9	95.2	16.9	32.5	19123	0	4.3	4.7
23-March-2009	13.6	23.3	43.9	91.2	20.7	36.1	22442	0	4.7	5.6
24-March-2009	14.6	23.5	61.6	91.1	19.5	30.4	17106	2	5.1	4
25-March-2009	15.6	25.4	49.4	95	20.5	35.4	21238	0.8	5.3	5.2
26-March-2009	16.1	24.4	48.7	82.8	20.4	35.3	21959	0	8.1	5.9
27-March-2009	14.3	29.8	34.6	91.7	21	38.5	21554	0	5.1	6.1
28-March-2009	16.3	33.1	24.4	90.5	21.8	40.5	22012	0	7.5	6.5
29-March-2009	16	26	46.9	77.3	21.5	38	20999	0	9.6	5.9
30-March-2009	16.5	26.2	38.2	76.9	22.2	35.7	17438	0	7.6	5.3
31-March-2009	13.3	23.9	53.6	93.7	19.7	31	11310	0	6.5	2.9
01-April-2009	10.3	23.9	45.5	86.1	18.2	34.9	19490	0	9.1	5.3
02-April-2009	9.6	22.7	31	77.7	17.3	35.6	21709	0	6.8	5.8

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
03-April-2009	13.4	24.7	31.8	80.1	18.3	35.6	21456	0	8.9	5.9
04-April-2009	13.4	28.1	30	69.2	18.8	35.6	21168	0	7.5	6.5
05-April-2009	14.8	29.4	23.3	73	19.5	36.2	20696	0	7.6	6.6
06-April-2009	14.8	27.7	27.5	70.6	19.2	36	20952	0	8.4	6.8
07-April-2009	16.1	29.2	22.5	57.3	19.6	36.6	20870	0	7.6	7
08-April-2009	14.5	32.6	19.3	61.8	20.2	38	20382	0	5.7	6.8
09-April-2009	15.3	33.4	18.7	58.7	20.6	38.5	19713	0	4.1	6.6
10-April-2009	17.3	33.1	18.1	70.1	21.7	38.2	19564	0	7	6.7
11-April-2009	14.8	35.7	17.1	78.1	21.7	38.6	19333	0	4.3	6.2
12-April-2009	15.1	27.4	25	88.4	21.6	36.7	18523	0	7	5.7
13-April-2009	21.5	33.9	11.3	53.8	23.7	37.8	18217	0	10.9	8
14-April-2009	17.1	24.9	44	89.6	20.1	27.3	5265	1.8	5.2	1.8
15-April-2009	13	28.5	38.5	76.9	18	32.3	17306	0	6.7	5.2
16-April-2009	12.9	24.7	36.3	72.1	17.5	32.9	18063	0	6.3	5.2
17-April-2009	12.5	27.1	37.5	87.3	18.2	34.2	18327	0	5.6	5
18-April-2009	19.1	29.5	35.1	71.6	21.1	34	15455	0	5.6	5
19-April-2009	13.5	28.7	35.7	88.6	18.8	28.9	9895	0.2	3.6	2.8
20-April-2009	13.4	28.6	41.3	96	18.7	34.9	17491	0	4.3	4.5
21-April-2009	11.4	25.8	50.5	92.8	18.3	34	17424	0	4.8	4.4
22-April-2009	11.5	30.3	33.4	94.6	18.2	35.1	17108	0	6.2	4.7
23-April-2009	5.6	19.9	40.5	84.5	14.2	26.8	12192	0.4	7.7	3.5
24-April-2009	11.4	20.6	46	91.2	17.6	27.6	13044	0	5	3.2
25-April-2009	11.4	21.7	61.9	95.8	16.6	27.2	10497	0	4.6	2.3
26-April-2009	8.1	22.5	57	97.1	14.6	26.5	10382	0	3.7	2.3
27-April-2009	9.3	24.4	51.8	92.8	15.9	30.6	16174	0	4.4	3.9
28-April-2009	12.1	27	30.5	88.9	16.6	31.9	16516	0	5.3	4.4
29-April-2009	12	28.4	32.6	82	17.3	32.3	15831	0	4.3	4.6
30-April-2009	8	24.5	40.4	95.2	14.4	27.7	10153	0	5.3	2.6
01-May-2009	12.2	23.2	37.9	73	14.9	29.5	16289	0	7.3	4.4

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
02-May-2009	10.7	24.7	30.6	65.8	14.7	29.9	16136	0	5.9	4.8
03-May-2009	7.8	27	31	91.6	14.5	31.1	13216	0	3.8	3.7
04-May-2009	9.1	27.7	26.9	77.6	14.8	29.2	12287	0	3.8	3.7
05-May-2009	12.1	27.9	20.4	64.8	15	31.3	15813	0	5.3	5.1
06-May-2009	12.5	28.9	21.7	59.1	15.1	31.3	15727	0	5.5	5.2
07-May-2009	11.8	27.4	24	77.1	14.7	30.8	15523	0	5.1	4.7
08-May-2009	10.9	27.4	25.7	74.1	14.5	30.4	15400	0	4.6	4.5
09-May-2009	9.6	25.9	27.3	79.5	14	30	14581	0	4.7	4.2
10-May-2009	10.2	26	25.4	80.5	14.5	29.6	14356	0	3.3	4.1
11-May-2009	11.9	23.1	32.4	84.5	15.8	23.2	7286	0	3	2
12-May-2009	12.5	26.6	27.5	84.4	15.1	29.1	14521	0	7	4.2
13-May-2009	13	24.9	30.1	83.4	15.3	28.9	14622	0	6.6	4.2
14-May-2009	9.1	23.9	36.4	83.6	13.3	27.3	13434	0	5.2	3.5
15-May-2009	9.1	24.2	34.7	91.2	12.8	27.8	14472	0	3.7	3.7
16-May-2009	7.3	25.1	25.4	82.6	12.5	27.8	14411	0	3.4	4
17-May-2009	6.7	25.6	24.7	86	12.7	27.8	14419	0	4	4.1
18-May-2009	5.3	26	23.5	90.4	11.7	27.3	13460	0	2.9	3.6
19-May-2009	10.3	22.9	47.2	93.5	14.5	26.4	12979	0	3.1	3
20-May-2009	12.2	22.6	66.3	95.9	14	22.8	7990	1.4	3.1	1.5
21-May-2009	16.8	25.6	47	94.6	16.8	25.9	12382	13.6	7.4	3.2
22-May-2009	10.7	22.9	61.6	87.6	12.8	21.3	6302	8.2	13.2	2
23-May-2009	11.6	15.8	61.1	91.8	13.3	15.9	6821	16.8	14.6	1.9
24-May-2009	4.8	16	54.7	96.9	9.8	18	9168	0.6	5.3	1.9
25-May-2009	4.6	19.1	48	97.3	8.9	19.9	13482	0	3.6	2.8
26-May-2009	6.5	18.2	45.5	89.6	10	18.3	11319	0	6.2	2.9
27-May-2009	13.4	22	33.4	60.2	12	20.8	13067	0	8.6	4.4
28-May-2009	12.9	21.3	37.8	64.9	12.3	20.2	10425	0	8.2	3.6
29-May-2009	12.9	22.7	35.9	70.6	12.8	21.1	10971	0	6.9	3.5
30-May-2009	13.3	23.7	35.5	70.8	13.3	22.9	12867	0	6.4	4

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
31-May-2009	15	25.2	37.5	77.4	14.7	22.5	10998	0	4	3.1
01-June-2009	13	24.5	42.9	86.6	14.6	23.4	9883	0	5	2.7
02-June-2009	13	25.4	38.3	92.9	14.6	23.7	10654	2.8	4.2	2.7
03-June-2009	9.1	22.3	60.1	96.7	13.4	22.8	10991	0	3.1	2.3
04-June-2009	6.6	19.4	66.9	95.1	11.3	19.9	9296	4.6	5.8	1.9
05-June-2009	5.4	17.4	61.8	97.7	9.4	18.3	10277	0.2	5.7	2.2
06-June-2009	8.1	19.7	60.6	97.5	10.4	19.4	12094	0	4.4	2.4
07-June-2009	4.4	19.9	49.8	98.2	9.2	19.8	11824	0	3.8	2.5
08-June-2009	5	18.2	51.6	97.9	9.5	19.2	12669	0	3.2	2.5
09-June-2009	6.7	20.8	51.6	94.8	9.6	19.4	11893	0	4.1	2.7
10-June-2009	13.2	23.1	29.2	93.7	11.6	19.9	11655	2.4	4.9	3.1
11-June-2009	14	21.9	61.1	91.5	14	21.2	10853	8.8	5.6	2.7
12-June-2009	5.8	14.5	86.9	98.5	9.6	16.3	4058	15	2.9	0.4
13-June-2009	5	15.6	63.6	97.4	8.9	16.3	6918	0	2.3	1.1
14-June-2009	2.7	16.4	56.3	98.4	7.5	16.5	10237	0	3	1.9
15-June-2009	8.4	18.7	56.8	96.9	9.8	18.3	12400	0	3	2.5
16-June-2009	7.4	20.8	53.3	95.3	9.1	19.8	12352	0.2	4.1	2.8
17-June-2009	5.2	20.9	40.7	97.3	8.4	19.2	12198	0	3.7	2.8
18-June-2009	11.5	20.9	44.5	90.1	10.4	18.7	11914	1.2	6.2	3.1
19-June-2009	14.3	20.3	67.5	90.9	13.5	18.6	6350	11.8	7.8	1.5
20-June-2009	12	15.7	52.7	89.2	12	15.5	7551	4.2	13.7	2.3
21-June-2009	10.6	18.2	62.6	89.2	12.2	17.9	7861	9.8	11.9	2.1
22-June-2009	4.9	15.1	53	91.1	9.4	17.3	9795	0	4.9	2.1
23-June-2009	9.9	16.1	49.8	86.8	10.5	17.6	9992	1	6.7	2.5
24-June-2009	10.3	12.2	81.7	95.8	10	12.6	1874	13	5.9	0.2
25-June-2009	11.7	17.6	73.5	95.3	11.2	15.7	5552	19.8	8.5	1.2
26-June-2009	11.7	19.4	67.6	92.1	12.3	18.2	8049	1.2	6.6	1.8
27-June-2009	13.6	16.4	63.2	93.3	11.9	14.6	2432	6.8	8.6	0.8
28-June-2009	14	18.5	52.5	90.7	12.7	17.7	9874	11	12.6	3

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
29-June-2009	14.6	17.8	67.6	90.9	13.4	17.4	7157	9.6	13.5	2
30-June-2009	10.4	14.8	54.7	88.9	10.5	15.2	6047	14.6	16.2	1.9
01-July-2009	8.4	14.9	62.5	95.6	10.3	15.1	7102	3.4	5.8	1.4
02-July-2009	2.6	17.5	62.3	98.6	6.9	17.7	10303	0	3.3	1.9
03-July-2009	6.2	17	59.2	94.2	7.1	17.5	12250	0	4.6	2.4
04-July-2009	8.6	16.3	62.1	89.4	8.6	14.9	7858	0	6.4	1.7
05-July-2009	7.7	17.2	61.5	95.1	8.8	16.1	6853	0	3.1	1.2
06-July-2009	13	20.8	47.4	94.6	10.9	18.9	11182	4.2	5.5	2.7
07-July-2009	13.6	18.3	53.4	94.8	11.6	16.8	4721	4.4	8.5	1.5
08-July-2009	11	17.7	55.5	94	11.5	17	6418	0.8	4.6	1.2
09-July-2009	11.5	17.9	56	95.6	12.5	18	7113	12.6	5.7	1.7
10-July-2009	12.2	18.9	58.2	94.8	12.3	19	9464	8.2	7.1	2.2
11-July-2009	11.3	16.5	58.3	85.4	11.7	17.1	8440	0.8	7.9	2.2
12-July-2009	4	17	60.8	98	7.9	18.8	9704	0	3	1.8
13-July-2009	3.2	16.6	44.6	97.6	8	18.3	13073	0	3.5	2.6
14-July-2009	2.8	17.3	54.6	98.4	6.7	18.5	13067	0	3.7	2.6
15-July-2009	4.4	18.2	48.1	94.1	7.8	18.2	13545	0	5	2.9
16-July-2009	13.6	21.1	29.3	94	9.8	18.8	12810	6.4	9.2	4
17-July-2009	13.3	17	58	90.9	11.9	17.4	9564	7	12.5	2.5
18-July-2009	14.2	17.2	61.3	74.8	12	17.6	9578	0.2	8.3	2.7
19-July-2009	10.1	19.3	59.7	95.6	12.6	19.9	10130	27.2	8.6	2.2
20-July-2009	9	16.9	55.7	95.3	10.2	18.7	10121	17.2	10.5	2.4
21-July-2009	9.5	15	56.7	84.3	10.3	14.7	8478	10.4	16.3	2.6
22-July-2009	8.1	15.7	63.3	96.9	10.3	17.2	10399	2.8	4.1	1.9
23-July-2009	11	16.8	69.5	96.7	12.1	17.7	8449	20.6	5.4	1.5
24-July-2009	3.7	15.8	58.2	97.4	7.5	19	11761	0	3.5	2.2
25-July-2009	5.6	16.4	45.1	95	8.9	18.3	13920	2.6	6.7	3.1
26-July-2009	2.5	15.2	50.5	97.7	7.9	17.8	12180	0	4	2.3
27-July-2009	4.1	16.4	51.4	97.4	8.7	17.4	11089	0	3.5	2.1

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
28-July-2009	4.9	15.2	62.6	98	7.9	15.8	6981	0	2.5	1.1
29-July-2009	2	17.2	54.2	97.9	6.6	19.3	14478	0	3.5	2.9
30-July-2009	2.9	18.6	43.2	97.8	7.1	19.4	14942	0	4.1	3.1
31-July-2009	3.3	20.2	40	98	7.6	20.2	14840	0	2.9	3.2
01-August-2009	2.4	20	41.2	98.2	7.5	20.6	14921	0	3.3	3.2
02-August-2009	4	18.9	50.9	98.2	8.6	20.3	14726	0	3.6	3
03-August-2009	4.2	19.4	56.7	98.5	8.6	19.5	11870	0	2.9	2.3
04-August-2009	4.6	20	59	98.4	9	21.3	14446	0	3.4	3
05-August-2009	4.9	21.2	41.9	96.9	9.8	22.3	15417	0	3.2	3.4
06-August-2009	13.2	19.7	61.9	94.8	13.1	19.7	10346	11.4	8.6	2.3
07-August-2009	6.3	17.9	59.5	97.8	10.6	21.6	13171	0.2	4	2.6
08-August-2009	10.8	18.8	56.6	95.8	14.1	22.2	13808	3.8	3.4	2.9
09-August-2009	11.7	20.6	76.1	95.4	13.6	21.6	9769	0	4.1	1.9
10-August-2009	14.5	20.4	64	92	14.6	23	12006	1.2	5.8	2.8
11-August-2009	9.7	19.5	57	93.6	11.9	19.9	9672	5	7.4	2.1
12-August-2009	14.2	19.2	54	93.6	14.1	20.9	11540	7.4	7.3	2.6
13-August-2009	13.9	18.2	55.3	91.9	13.7	19.9	10295	7.8	8.3	2.4
14-August-2009	14.8	19.2	68.8	91.2	14.6	19.9	10814	13	11.1	2.5
15-August-2009	11.5	18.7	57.3	88.3	11.5	19.1	8996	7.8	14.8	2.6
16-August-2009	10.9	14.8	51.9	87.2	11.4	16.9	11646	2.6	12.3	3
17-August-2009	11.6	17	67.6	97	12.9	18.3	10049	12.2	5	1.8
18-August-2009	9.9	18.4	66.7	94.7	11.6	21.2	12024	0.4	5.1	2.4
19-August-2009	13.7	17.9	67.9	94	13.2	19.7	9917	6	6.6	2.1
20-August-2009	15	19.8	48.9	92.9	14	22.6	13637	3.2	7.3	3.2
21-August-2009	10	18.1	71	96.6	12.1	16.4	4105	14.6	4.2	0.5
22-August-2009	13.9	16.4	50.6	84.9	12.8	20.3	14984	0.6	13	4
23-August-2009	12.3	17.3	65.3	92.7	12.6	21.3	13647	4	13.8	3.5
24-August-2009	12	15.1	57.2	88.2	12.5	19.4	12321	0	9.9	2.9
25-August-2009	5.9	17	71.7	98.6	10.2	21.9	14289	0.2	4.7	2.7

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
26-August-2009	4.6	19.6	56.5	98.3	9.3	21.8	13956	0	4.1	2.7
27-August-2009	5.2	17.5	58.6	98.5	9.2	23.5	18465	0.2	4.8	3.7
28-August-2009	11.4	17.3	50.1	91.4	12.8	21.8	15579	0	4.8	3.4
29-August-2009	0.7	14.8	61.9	98.3	7.2	18.3	10577	0.2	5.8	2
30-August-2009	6.4	15.9	45.7	93.8	11.4	21.9	17652	0	4.2	3.6
31-August-2009	2.8	15.5	66.7	98.7	8.4	19.2	10341	0	2.9	1.7
01-September-2009	10.7	19.1	47.6	95.6	12.9	23.3	17353	1.6	4.5	3.8
02-September-2009	11	19.2	56.8	91.9	11.5	22.9	14568	2.2	11.4	3.7
03-September-2009	8.7	14.7	50.5	88.9	11.7	19.1	12194	0	6	2.6
04-September-2009	3.3	16.1	46.6	92.8	8.8	19.9	12962	0	4.3	2.6
05-September-2009	10.8	20.9	36.7	88.1	12.1	24.8	19712	8.6	10.1	4.9
06-September-2009	8.5	15.7	53.1	96.4	11.3	19.8	17149	2.2	9.8	3.9
07-September-2009	12.9	17	64.4	92.3	13	20.1	12256	3.2	4.6	2.4
08-September-2009	5.3	18.8	58.5	97.8	9.1	21	12675	7	6	2.7
09-September-2009	12.7	18.1	56.4	88.8	14	22.8	17923	0.8	5.5	4
10-September-2009	15.1	20	61	85.3	15.2	24.8	16506	0.6	9.5	4
11-September-2009	13	18.1	64.7	91.3	14.1	19.6	10273	12.2	13	2.3
12-September-2009	12.7	17.8	53.3	92.4	11.5	18.6	10352	11.4	14.9	2.8
13-September-2009	9.7	17	57.7	95.5	11.8	20.3	16982	4.6	9.9	3.8
14-September-2009	9.4	18.2	48	94.2	14.2	24.2	18021	0	4.3	3.9
15-September-2009	13.8	19.9	65.2	93	14.8	23.6	15488	8.8	8.4	3.5
16-September-2009	7	15.9	61.6	96.8	10.7	19.5	12292	0.2	5.8	2.4
17-September-2009	12.4	18.5	52.5	89.7	14.3	24.2	17408	0.6	5.6	3.8
18-September-2009	12.7	18.4	60.7	91.1	12.3	19.8	10433	4.4	11.8	2.6
19-September-2009	10.2	17.2	44.9	94.8	12.9	23.3	19499	0.8	8.7	4.7
20-September-2009	10.4	17	67.4	96.4	13.2	23.1	14471	2.2	3.8	2.6
21-September-2009	13	18	66.6	87.4	13.4	22.5	13896	5	12	3.3
22-September-2009	5.2	15.8	57.4	94.2	9.4	17.8	14040	1.4	10.6	3.2
23-September-2009	14.5	17.7	56.4	93.9	14.9	23	17525	1	7	3.8

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
24-September-2009	14.8	18.7	65	78.4	14.4	24.7	17254	0	9.9	4.1
25-September-2009	2.1	18.1	57.5	97.1	9.6	21.8	16483	0	7.8	3.6
26-September-2009	7.1	18.1	38.6	85.5	10.3	25.5	23278	0	6.4	5.3
27-September-2009	5	20.9	35.6	91.4	11.4	27.4	24654	0	4.4	5.7
28-September-2009	12	23.7	33.9	94.5	16.3	29	22953	2.8	6.1	5.6
29-September-2009	7.2	16.4	52.8	96.1	12.2	23.5	17571	3.2	6.3	3.7
30-September-2009	4.3	14.1	59.8	94.1	8.9	19.9	15453	2.8	5.5	2.8
01-October-2009	3.5	17.6	42.4	96.7	10.4	24.1	24844	0	5.5	5.3
02-October-2009	5.1	18.5	45.8	97.3	11.4	26.2	24034	0	4.4	5.1
03-October-2009	12.3	20.1	55.4	94.2	16	28.5	23269	3.8	5.4	5.1
04-October-2009	7.4	18.2	47.5	93.2	12.7	27	24135	0	5.3	5.3
05-October-2009	10.8	18.6	53.2	80.7	14	26.6	22023	0	7.3	5.1
06-October-2009	7.7	22.8	43	93.5	14.4	29.3	25672	0	6.9	6.1
07-October-2009	8.9	23	49	95.4	14.6	29.1	24516	0	5.4	5.6
08-October-2009	7.3	22.4	53.1	95.1	14.1	25.5	17368	0	4.9	4
09-October-2009	7.2	20.6	57.8	96.6	15	29.8	24450	0	5.2	5.4
10-October-2009	12.6	20.4	61.4	89.3	17.5	29.8	22471	0	6.4	5
11-October-2009	9.2	19.2	58.8	91.6	14	26.7	19053	0.8	8.2	4.3
12-October-2009	9.5	16.5	50.1	86.3	15	24.3	19507	0	7.2	4.6
13-October-2009	11.7	17.8	53.4	85.2	16.4	25.1	17507	0	6.4	3.9
14-October-2009	8	18.5	54.2	91.5	14	27.7	21746	0	7	4.8
15-October-2009	12	23.4	41.8	82.1	15.5	29.9	26578	0	7.1	6.3
16-October-2009	13.8	27.7	26	67.8	17.2	31.8	27749	0	8	8
17-October-2009	19.7	31.1	22	35.9	20	33.2	27724	0	9.6	9.7
18-October-2009	14.7	38.4	15.6	87.9	21.1	36.4	26305	0	5.5	8.2
19-October-2009	15.8	23.7	64.5	87.5	20.7	32.2	20132	0	6.8	4.8
20-October-2009	9.9	21.2	51.6	83.4	17	31	25100	0	8.2	6
21-October-2009	10.8	21.5	41.7	80.7	16.9	31	27091	0	8.5	6.7
22-October-2009	8	24.9	33.8	93.9	17.2	32.4	28095	0	6.6	6.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
23-October-2009	11.3	23.2	51.8	90.9	18.2	31.3	26553	0	7.4	6.4
24-October-2009	13.7	26.2	41.7	70.9	19	33.1	25367	0	9.9	7.1
25-October-2009	15.6	22	48.2	69.6	18.3	25.9	13766	0	13.4	4.7
26-October-2009	17.7	32.6	27.3	88.5	22	34.5	24516	0	6.1	7.3
27-October-2009	14.9	24	62.8	93.4	19.7	24.9	9518	0.4	4.4	2
28-October-2009	17	26.2	59.3	91.2	21.6	32.7	19986	0.2	5.8	4.9
29-October-2009	11.2	21	57.7	93.3	16.5	25.2	17111	3.8	8.6	3.9
30-October-2009	8.5	20.1	57.2	93	15	26.6	20422	0	6.5	4.5
31-October-2009	12.9	24.1	50	80.4	18	31.3	27987	0	9.5	6.9
01-November-2009	9.5	21	33.9	75	16.4	31.5	29736	0	12.1	7.7
02-November-2009	9.8	24	20.5	74.5	17	32.1	30621	0	10.4	8.9
03-November-2009	11.3	26.4	21.2	70.2	18.2	33.5	30586	0	8.1	8.6
04-November-2009	16.9	31.7	17.7	59.4	20.8	35.9	30094	0	7.7	9.4
05-November-2009	21.1	33.4	14.4	48	23.2	34.3	20913	0	5.7	7.4
06-November-2009	18.3	31.8	31.1	82.2	20.5	31.9	14201	0.8	5.3	3.9
07-November-2009	15.1	26.5	61.3	90.9	20.7	34	23354	0.2	5.6	5.5
08-November-2009	11.5	22.2	58.2	93.1	19.8	31.4	21524	0	5.4	5
09-November-2009	10.4	22.4	46.6	88.1	19.3	35.1	29081	0	7	7.1
10-November-2009	16.7	27.8	41.4	79.8	22.2	36.1	27611	0	6.5	7.4
11-November-2009	13.3	29.2	38.9	95.2	21.6	36.3	23482	0	5.8	6
12-November-2009	19.6	28.6	43.1	89.4	24.2	37.3	23621	0.8	4.6	6.3
13-November-2009	19.6	28.4	54.7	92.7	22.2	30	13424	5.6	6.8	3.4
14-November-2009	17.5	24.3	54.8	76.2	21.9	35.8	27697	0	7.3	7
15-November-2009	10.9	23.4	52.8	95.8	20.4	36.1	28635	0	5.5	6.8
16-November-2009	16.2	25.3	50.4	88.8	23.2	36.7	29583	0	8.3	7.4
17-November-2009	14.1	22.4	54.8	90.9	22.3	35.9	27895	0	7.3	6.7
18-November-2009	16.6	21.7	58.3	92.3	20.4	30.8	17766	10.2	9.2	4.2
19-November-2009	13.6	19	59.7	93.8	16.9	22.5	10838	26.8	11.6	2.4
20-November-2009	10.8	19.4	60.5	91.8	16.4	27.9	27405	0.6	10.8	6.4

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
21-November-2009	10.1	20.5	47.6	88.8	16.6	28.9	24097	0	7.8	5.7
22-November-2009	12.4	21.5	48.1	92.3	18.4	32.7	31130	0	8.2	7.4
23-November-2009	10.4	28.1	27.8	93.8	19	34.6	30308	0	6.5	7.6
24-November-2009	10.8	32.6	21.2	89.4	20.2	37.4	32161	0	5.2	9.5
25-November-2009	13.2	33.4	17	92	22.1	38.4	31667	0	5.7	9.3
26-November-2009	9.4	21.4	48.1	89.4	19.2	34.4	27433	0	10.3	6.9
27-November-2009	7.9	20.6	40.1	85.7	18.2	34.7	31393	0	9.8	7.9
28-November-2009	12.7	22.5	36.4	84.5	19.3	35.1	31675	0	8.5	7.8
29-November-2009	11.9	30	19.7	87.2	20.9	37.4	32521	0	6.3	9.1
30-November-2009	10.3	27.5	28.1	94.5	20.7	38.1	31935	0	7.2	8
01-December-2009	13.8	24.4	43.8	87	22	37.8	31922	0	8.3	8.2
02-December-2009	12.1	23.1	40.5	77.2	21.8	37.1	29968	0	8.7	7.6
03-December-2009	12.8	21.9	36.6	75.2	20.9	37.8	32420	0	10.2	8.4
04-December-2009	15.1	27.1	32	77.2	21.8	38.9	32233	0	9.5	8.8
05-December-2009	19.4	33	27.1	69	24.5	41.2	31660	0	7.5	9.9
06-December-2009	17.9	34.9	23.8	87.6	25.2	43.5	31181	0	6.3	9
07-December-2009	17.2	28.7	40.6	71.9	24.3	42.4	26613	0	10.1	7.7
08-December-2009	12.7	28.9	28.2	70.7	21.9	41.2	30764	0	9.3	9
09-December-2009	13.3	24.7	31.2	76.6	22.2	41.3	32744	0	9.3	8.7
10-December-2009	12.5	28.6	17.9	69.4	21.8	42.9	33190	0	9.2	9.3
11-December-2009	15	25.2	29.2	76.3	22.3	42.6	32626	0	9.3	8.9
12-December-2009	16.4	31.5	17.4	76.1	23.3	43.6	32761	0	8.7	10.2
13-December-2009	13.9	36.4	13.3	71.1	23.8	46	33147	0	6.7	11.1
14-December-2009	13.3	39.8	12.6	93.8	24.3	47.8	32852	0	5.6	10.1
15-December-2009	12.8	28.4	35.3	93.2	22.9	45.5	30951	0	7.8	8.3
16-December-2009	14.7	25.1	48.5	69.3	23.5	42.5	28820	0	12	8
17-December-2009	13	23.3	34.8	68	21.3	39.8	29056	0	11.3	8
18-December-2009	15.5	29.8	20.8	60.4	22.9	43.6	33084	0	8.6	10
19-December-2009	20.8	34.4	17.9	57.4	25.6	47	32786	0	8	10.6

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
20-December-2009	19	36.5	24.7	82.4	25.8	48.5	27878	0.2	5.6	8.5
21-December-2009	19.9	33	36.9	75.2	27.2	48.9	31513	0	7.6	9.4
22-December-2009	18.2	31	36.2	69.5	26.1	48.4	31175	0	9.1	9.5
23-December-2009	15.1	31.4	32.6	78	24	47.3	30050	0	11.8	8.6
24-December-2009	14.1	23.9	39.4	72	22.7	45.2	33190	0	11.1	9
25-December-2009	14.6	27.3	29.7	85	23.3	46.4	31701	0	7	8.4
26-December-2009	15	33.2	21.6	76.8	24.2	45	27692	0	6.1	8.7
27-December-2009	15.5	31.9	23.3	78.4	24.2	47.8	32936	0	7.8	9.4
28-December-2009	18.3	30.2	29.3	85	25.9	47.7	32579	0	9.2	9.8
29-December-2009	24.7	38.8	17.9	61.9	29.6	50.1	25562	0	6.6	8.6
30-December-2009	17.8	34.8	23	81.5	24.7	37.5	14187	0	10.8	4.7
31-December-2009	14.5	24.1	46.5	69.8	22.8	44.1	31359	0	11.2	8.5
01-January-2010	12.8	25.6	34.7	80.6	22.5	45.8	32952	0	9.6	8.6
02-January-2010	17.1	27.6	28.1	68.9	24.1	46.7	33195	0	10.8	9.7
03-January-2010	20.6	37.1	18	72.5	26.3	48.8	32562	0	8.2	10.8
04-January-2010	19.9	38.5	13	61	27.4	50.9	32169	0	8.3	11
05-January-2010	18.5	36.4	19.1	66	26.7	48.6	31599	0	11	10.8
06-January-2010	21.3	37.1	21.5	79.8	28.6	50.7	31517	0	8	10
07-January-2010	15.3	33.3	32.8	92.9	25.2	49.2	29471	0	7.2	7.8
08-January-2010	16.4	26.2	50.1	87.5	25.5	47.4	31511	0	7.9	8.1
09-January-2010	17.8	29.8	34.8	76.2	26.4	48.9	31798	0	7.2	9
10-January-2010	14.9	28.7	36.3	88.1	25.5	49.5	30571	0	8.8	8.3
11-January-2010	12.2	24.6	45	81.2	22.4	42	27474	0	11.4	7.4
12-January-2010	13.9	22.9	37.6	70.8	22.5	45.7	32646	0	10.4	8.8
13-January-2010	14.7	27.8	29	87.9	23.5	46.9	32386	0	7.8	9
14-January-2010	16.7	33.4	20.9	70.1	25.5	48.8	32263	0	7.3	10.2
15-January-2010	16.9	34.3	21.8	79	25.9	50.4	32210	0	9.2	9.7
16-January-2010	15.6	32.7	24.2	67.4	24.8	49.2	32527	0	10.4	10
17-January-2010	21.6	35.5	11.8	44	26.7	48.8	33040	0	10.4	11.9

Date	Minimum temperature (ºC)	Maximum temperature (ºC)	Minimum relative humidity (%)	Maximum relative humidity (%)	Minimum soil temperature (ºC)	Maximum soil temperature (ºC)	Total solar radiation (kJ/m2)	Rain (mm)	Mean wind speed (km/h)	Evaporation (mm)
18-January-2010	21.3	43.6	12	60.6	28.9	52.4	31837	0	5.7	11.4
19-January-2010	27.5	41.9	11.3	44	32.2	54.1	30085	0	7.2	11.3
20-January-2010	19.7	38.9	13.8	90.3	28.2	45.4	18820	0	4.8	6.2
21-January-2010	17.9	29.6	38.7	73.2	27.8	48.7	30410	0	10.2	8.9
22-January-2010	15.8	28.2	28.9	68.9	24.9	49.2	31772	0	9	8.9
23-January-2010	15.9	29.4	28.3	89.5	25.4	49	31369	0	8	8.8
24-January-2010	23.4	32	26.1	69.2	28.4	50	29362	0	8.4	9.3
25-January-2010	19.9	33.8	30.7	90	29.2	51.1	29149	0	7.2	8.4
26-January-2010	20.1	32.2	38.2	72.9	27.5	47.7	26031	0	9.3	7.9
27-January-2010	19.4	33.2	34.1	75.6	27.7	51.1	30231	0	9.6	9.1
28-January-2010	19	34.5	31.6	71.8	27.9	51.9	29955	0	8.9	9.2
29-January-2010	20.4	36.9	24.1	67.7	28.6	51.5	30093	0	8.7	9.9
30-January-2010	21.1	38.8	23.4	77.4	29.7	53.3	29827	0	9.8	10
31-January-2010	14.9	29.1	42	68.5	25.1	49.6	30326	0	12.7	9.3

Appendix 2. Grower 1 bander calibration

Calibration 1 (March 2007)

Speed of travel

Concrete tarmac = 21 m in 6.32 secs (3.32 m/sec)

Field beds (mean of uphill and downhill) = 336m in 92.13 secs (3.65 m/sec)

Bed width covered when banding = 1.65 m (wheel track)

Area covered per second = 3.5 m x 1.65 m = **5.775 m^2**

Test run of bander (stationary at 1700 rpm electric motor)

Output of 2 droppers = 2.35 kg in 20 secs (**117.5 g/sec**)

Rate calculation

$$\text{Time to band 1 hectare} = \frac{10000\ \text{m}^2}{\text{area covered per second}} = \frac{10000}{5.775} = \mathbf{1739\ secs}$$

$$\text{Output per hectare} = \frac{\text{Time for 1 ha x dropper output}}{\text{area covered per second}} = \frac{1739 \times 117.5}{5.775} = \frac{\mathbf{204}\ \text{kg/ha}}{\mathbf{1000}}$$

Since this rate was well below the prescribed rate in our program some adjustments to the bander were required to increase output. A second calibration was done in January 2008.

Test run 1 of bander (stationary at 1500 rpm electric motor)

Output of 2 droppers = 7.1kg in 40 secs (**177.5 g/sec**)

Test run 2 of bander (stationary at 1500 rpm electric motor)

Output of 2 droppers = 8.75kg in 40 secs (**218.75 g/sec**)

Rate calculation before adjustment 1

$$\text{Output per hectare} = \frac{\text{Time for 1 ha x dropper output}}{1000} = \frac{1739 \times 117.5}{} = \frac{\mathbf{309}\ \text{kg/ha}}{\mathbf{1000}}$$

Rate calculation after adjustment 2

$$\text{Output per hectare} = \frac{\text{Time for 1 ha x dropper output}}{1000} = \frac{1739 \times 218.75}{} = \frac{\mathbf{380}\ \text{kg/ha}}{\mathbf{1000}}$$

Appendix 3. Fertiliser practices survey

Introduction form interviewer

Background to the evaluation

We are conducting an evaluation of the Department of Agriculture and Food delivered Horticulture Australia project VG07036 *'Developing guidelines for environmentally sustainable use of mineral fertilisers'* to determine the impact of the project on adoption of the '3PHASE' fertiliser program. We also wish to gather information about irrigation and fertiliser practices and grower information sources. We are doing this to inform planning of future work by DAFWA to support your industry.

Use of survey results

Results of this survey will be presented in the final report to Horticulture Australia for project VG07036 'Developing guidelines for environmentally sustainable use of mineral fertilisers'. Results will also be used for the planning of future projects.

Confidentiality

Information you provide in this survey will remain confidential. Your responses will be combined with information from other respondents to generate industry representative statistics. Whilst direct quotes may be used to support findings all material provided will remain confidential and no grower names will appear in reporting or attached to any quotes. Once the final report has been written and approved, any links to individuals will be destroyed and raw data archived.

Consent to participate

Participation in this survey is voluntary and you do not have to participate if you don't wish to.

DO YOU WISH TO PARTICIPATE?

At this stage also ask about recording electronically

Further information

All questions regarding this evaluation can be directed to me or Aileen Reid – our contact details have been provided on this sheet.

Industry practice information

1. How do you generally fertilise your crop? – application methods, timing of methods, application rates according to growth stage

2. Have you made any changes to the way you apply fertiliser in the last 3 years? Y/N *(including method of application, timing of application, the way you fertigate)*

   If yes:

   a) Please explain what changes were made
   b) Why did you make these changes (if not explained)

   If no:

   a) Are there any reasons for you not making any changes?

3. Have you made any changes to the total amount of fertiliser you apply to individual crops in the last 3 years? Y/N

   If yes:

   a) Please explain what changes were made
   b) Why did you make these changes (if not explained)

4. Do you apply a pre-plant base dressing (organic or inorganic) before planting your crops?

   If yes:

   a) What do you apply and at what rate?
   b) How many days before planting is this applied?

5. Do or have you ever used chicken manure as part of your fertiliser program? Y/N

   If yes:

   a) What do you see as the benefits of using chicken manure?
   b) Are there any negative aspects associated with the use of chicken manure? Y/N
      If yes, what would this/these be?
   c) If you recently stopped using chicken manure—why did you stop?

6. What proportion of your production costs does fertiliser application account for—as a percentage of each, e.g. lettuce? Costs of fertiliser application for the purposes of this survey include the cost of fertiliser and machinery and labour costs associated with its application

7. When making decisions on fertiliser applications what is your main source of information? *Do you source information from any other areas? (if so where?)*

8. What irrigation system do you currently use?

   a) How do you currently schedule your irrigations?
   b) What scheduled maintenance do you perform on your system to ensure it is operating efficiently?

9. Have you made any changes to your irrigation system or the way you irrigate in the last 3 years? Y/N

   E.g. changes to improve pressure and uniformity of the system, changes to the scheduling of irrigations, use of soil moisture monitoring equipment, use of local weather information (ie SMS service).

   If yes:

   a) Please explain what changes were made
   b) Why did you make these changes?

10. When making decisions on how to run your irrigation system what is your main source of information? Do you source information from any other areas? (If so, where?)

11. Do you think your fertiliser and irrigation practices have an effect on the groundwater around you? Y/N

12. Do you or anyone else monitor nutrient leaching beneath your crops? Y/N

    If yes:

    a) Is this voluntary or enforced?

    If yes, and you are using the 3Phase fertiliser program or aspects of it, has adoption of the program reduced your fertiliser leaching? Y/N If yes by how much has it reduced?

Project impact

1. Are you aware of DAFWA's research into fertilising vegetables on WA's sandy soils without chicken manure 'called the 3Phase fertiliser program'? Y/N

    (You may know it as drench, spray band)

    If yes:

    a) How did you find out about the 3Phase method?
    b) Have you adopted any aspects of the 3Phase fertiliser program? Y/N
    c) Which aspects have you adopted?
    d) Has it helped you to grow a better crop? Y/N. If yes, how has the crop improved? If no, what were the negative effects and why do you think this occurred?
    e) Are you applying less fertiliser using the new program? Y/N. If yes, how much less?
    f) Has it saved you money? Y/N. Can you estimate how much it saved/costed?
    g) What area of your crop have you converted to this new method? What proportion is this of your total crop?

    If no to b):

    a) Why did you decide not to adopt the method? (E.g. not seen aseconomically viable, too risky, capability of staff, time consuming, too complex, lack of support to implement).

Questions specifically for impact of extension material (articles and Farmnotes)

1. Can you recall reading about the 3Phase fertiliser program anywhere? Y/N

    If yes:

    a) What did you learn?
    b) Did you take any further action as a result of what you read?

Questions specifically about impact of field days

1. Did you attend any field days regarding the 3Phase fertiliser program? Y/N

2. Can you remember which field days you attended and tell me about them?

3. Can you think back and tell me what you might have learnt at those / that field day? *Might need to prompt around various aspects of the information provided on the day*

4. Did you feel that you were able to have a good discussion about aspects of the fertiliser program and get your questions answered?

5. Can you recall if you took any further action afterwards as a result of what you learnt on the day? Y/N

    If yes: What was that action?
    If no: Can you recall why you didn't take further action?

Appendix 4. Publications

'HANDS – ON' HELP TO CUT FERTILISER COSTS

By building growers' confidence in new fertiliser practices, the *Developing guidelines for environmentally sustainable use of mineral fertilisers* project aims to ensure that growers adopt more efficient and lower cost fertiliser programs.

Grower fertiliser practices could be made more efficient by ensuring a better match between fertiliser supply and plant demand during crop establishment. On sandy soils, excess fertiliser applied at this time is mostly leached below the root zone before the crop can use it, polluting groundwater used for irrigation.

To address this, the project will employ on-farm demonstrations and extensive one-to-one communication with researchers backed up by topical research to solve transition-phase problems.

An early success has seen adoption of the new practice on 83 hectares of lettuce resulting in fertiliser applications and costs halved and yields increased with an improved environmental outcome.

Project VG07036

For more information contact:
Dennis Phillips, Department of Agriculture and Food, Western Australia
T 08 9368 3319
E dphillips@agric.wa.gov.au

A research station trial comparing new methods from which best practice fertiliser programmes were derived.

The first stage in the adoption process with a DAFWA technician making yield estimates from a small demonstration plot in a grower's crop to provide evidence of yield increase associated with new fertiliser practices.

The next stage where the grower was convinced to try a full bay (between sprinkler lines) of the new practice. After this he did it a number of times on a bigger scale himself.

The final stage 18 months later showing a full lettuce crop grown using the new practice at Nanovich Farm Wanneroo.

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countryman.com.au Thursday, August 7, 2008
Horticulture 5

Vegetables thrive on minerals

Giving young vegetable seedlings a kick-start with extra nitrogen applications can be a winner for both the grower and the environment, Department of Agriculture and Food (DAFWA) research is proving.

After eight years of trials and demonstration plots at the Medina Research Station and on grower properties, project leader Dennis Phillips is confident mineral fertilisers applied regularly and at low doses could effectively substitute for traditional high applications of poultry manure.

"Spraying newly planted seedlings with concentrated urea and potassium nitrate for as little as two weeks after planting has increased yield by up to 300 per cent in some cases," he said.

"We have tried it on seven different vegetables with similar responses but our research effort is most advanced with iceberg lettuce."

The research began with lettuce on a Wanneroo property in 2000, before an industry-wide ban on the use of raw poultry manure. Two Horticulture Australia projects in WA have continued the work since and broadened its scope.

"Keeping the method simple is the way to go," Mr Phillips said.

"For this reason, whether it is broccoli, lettuce, celery or other crops, our standard tank mix since August 2006 has been 20g/L of urea and the same rate of potassium nitrate in 1000L of water sprayed over all crops twice a week from the day of planting."

The nutrient solution is not washed from the foliage and despite it being saltier than seawater, seedling damage is minimal. Any damage is outweighed by the growth response and efficiency gains from applying fertiliser this way.

Carabooda grower Malcolm Nanovich is a recent convert to the new system for his lettuce crop because fertiliser prices had increased sharply in the last year. The method has allowed him to grow the same amount of lettuce at no extra cost than before, and he is now looking to test it on his broccoli crops.

"When we started this work we were warned by many growers that we might get away with it once or twice but wouldn't be able to keep doing it for years without loss of yield," Mr Phillips said. "We listened to the criticism and have been cautious about making premature recommendations to growers."

Growers working with the department adopted an early version of the method in late 2001 and have used it ever since without returning to their previous practice of applying poultry manure before and during every crop.

Brothers Andrew and Mick Tedesco have been more than happy with results over the last seven years on lettuce and Chinese cabbage, and have not experienced any decline in yield or quality.

Some vegetable growers who haven't tried the method have questioned the new recommendations for what they believe is a high labour input.

> Spraying newly planted seedlings with concentrated urea and potassium nitrate for as little as two weeks after planting has increased yield by up to 300 per cent in some cases.
>
> DENNIS PHILLIPS

Mr Phillips said new trials were aimed at finding ways to reduce this. These include spraying less often with more concentrated nutrient solutions and broadcasting granular NPK-based products for crop establishment at the same rate as the sprays. Results of this work are very promising but not yet finished.

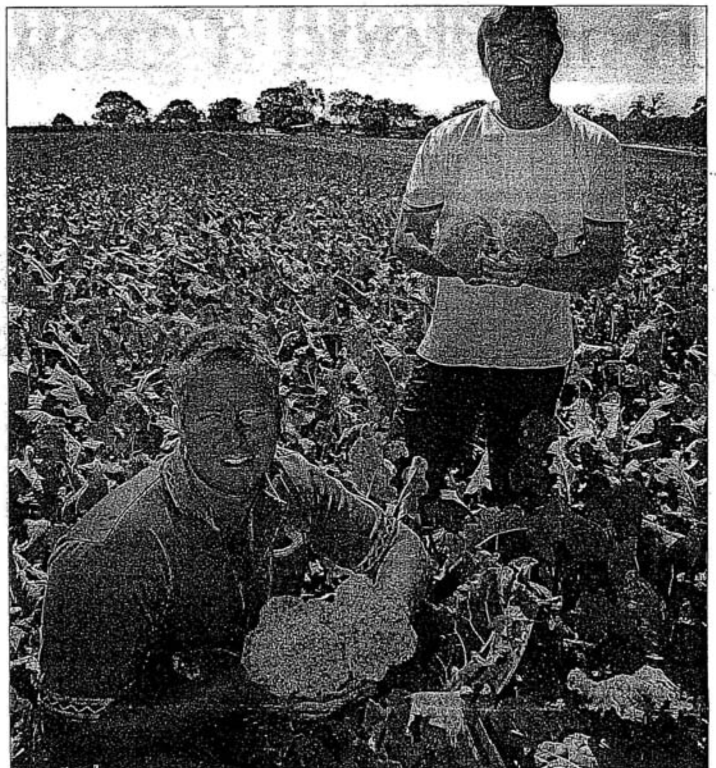
In 2007, the researchers succeeded in making further economies in fertilising iceberg lettuce without adversely affecting yield. By extending the spray application period to four weeks after transplanting in winter, almost 80kg/ha of nitrogen was saved without loss of yield, compared with lettuce that was sprayed for only two weeks and then banded.

"The fallow period between crops can also offer savings in fertiliser costs," Mr Phillips said.

"Management of irrigation during this period is critical to keep nutrients from crop residues within the rooting depth of the following crop. For some crops, such as broccoli, the nitrogen in the crop residue could almost sustain a following lettuce crop if the residue is managed properly."

An added benefit from this method is that it is better for the environment than traditional practices. Nitrate fertiliser leaching into groundwater is significantly reduced because lower fertiliser is applied and the crop uses it much more efficiently when supply matches demand.

"This is a win-win situation with lower costs and better environmental outcomes," he said.



Carabooda broccoli growers Brock Nanovich and uncle Malcom Nanovich.

DAFWA vegetable specialist Dennis Phillips (right) and farm manager Mehdi Dalir inspect lettuce growing at the Nanovich farm at Carabooda.

Two trials at Medina are now comparing 12 different growing methods using only mineral fertilisers.

Any growers, fertiliser suppliers or consultants interested in learning more about these methods should contact Dennis Phillips (9368 3319), Aileen Reed (9368 3393) or Medina Research Station (9414 2908) to view the trials.

MEDIA MONITORS

Kwinana Courier
Friday 28/8/2009
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Region: Western Australia Circulation: 43,114
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Size: 293.98 sq.cms.
Frequency: —F--

Index: 1.11
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Veggie tour sprouts knowledge

Always learning... horticultural development officer Aileen Reid with Baldivis vegetable grower Sam Calameri. Picture: Neil Mulligan d307545

VEGETABLE farmers and potato growers from around the south-west converged on Medina and Baldivis for a Vegetables WA tour last week.

Farmers got the opportunity to see the latest sustainable farm practices and environmental techniques to reduce their impact on the environment and included visits to the Medina Research Station and Baldivis market gardens..

Vegetables WA project manger Gavin Foord said the purpose of the trip was to raise awareness of a range of sustainable farm practices that link productivity with a good environmental outcome.

Mr Foord said that Baldivis Market Garden, run by Sam Calameri, was a good example of programs run by industry and government, which focused on sustainability.

The Medina Research Station and the Department of Agriculture and Food showed the latest fertiliser strategies designed specifically for the sandy soils in the region.

Mr Foord said that the practices were in line with Vegetables WA policy. One that deems any practice which provides farmers with a viable crop with limited impact on the environment, is a good practice.

The tour group was shown ways to save money, improve production and advised about the latest research in soil improvement and efficient fertiliser use.

Fertiliser

Nitrogen Fertiliser management - *getting it right*

Peter O'Malley, Dennis Phillips and Rohan Prince, Department of Agriculture and Food, WA

Monitoring soil nitrogen allows correct timing of fertiliser

As part of the HAL/AUSVEG supported project 'Increasing water and nutrient use efficiency in vegetable production on sandy soil', we have used soil nitrate testing and lysimeters to monitor fertiliser practices. The aim of this activity has been to examine fertiliser efficiency and then to demonstrate where improvement might be possible.

Our results show that soil levels of plant available nitrogen fluctuate widely in response to applied fertiliser nitrogen, mineralisation of plant residues and existing soil reserves, plant uptake and irrigation and drainage. Achieving good nutrition of your crop without excessive losses requires a dynamic approach which aims to apply the nutrients when needed, fully accounts for all available sources and minimises losses.

The simple monitoring of soil nitrogen has allowed us to demonstrate the fertiliser value of crop residues and to improve the timing of fertiliser applications. Fertiliser applications should be adjusted to meet expected crop uptake and take into account the quantity of nitrogen present in the soil at the time of application.

Using lettuce as an example, transplanting into soil with a nitrate-nitrogen content equivalent to more than 40 kg N/ha in the top 30 cm of soil is wasteful and will normally result in a large amount of nitrogen being leached (see Figure 1). During the cooler months maximum growth over the first four weeks can be achieved with a fertiliser application or uptake from the soil of 20 to 25 kg N/ha. In summer when growth rates are faster, higher rates of nitrogen may be required for optimum early growth. Weekly fertiliser application should then increase progressively to a weekly maximum of 60 kg N/ha being applied as the crop approaches its peak demand for nitrogen.

The '3Phase' approach to fertilising vegetable crops which involves spray applications of nitrogen and potassium in the early stages of the crop is proving a very effective approach to fertilising vegetables on sand, resulting in high yields and low leaching. The 3Phase method involves optimum fertiliser strategies during each of three key crop developmental stages: establishment, rapid growth and approaching maturity. This method has been developed by Dennis Phillips and his team at DAFWA.

With good irrigation and fertiliser control soil nitrate content will increase to the equivalent of around

Fertiliser

80 kg N/ha and then should be allowed to fall as the crop approaches harvest (see Figure 2).

Excessive leaching caused by poor irrigation scheduling or rainfall may mean a soil content of 80 kg N/ha can not be achieved but weekly fertiliser applications of greater than 55 kg/ha of nitrogen are seldom needed. Higher application rates and soil reserves of more than 80 kg N/ha in the top 30 cm exceed the amount most crops can absorb in a week and increase the risk of excessive loss.

For further information on fertiliser management for vegetable crops contact:
Rohan Prince on 0429 680 069 or Dennis Phillips on 9368 3333.

Department of Agriculture and Food

Vegetable R&D Your national vegetable levy at work

HAL Know-how for Horticulture™

AUSVEG

Figure 1. Chart demonstrating poorly timed fertilisation of Cos lettuce

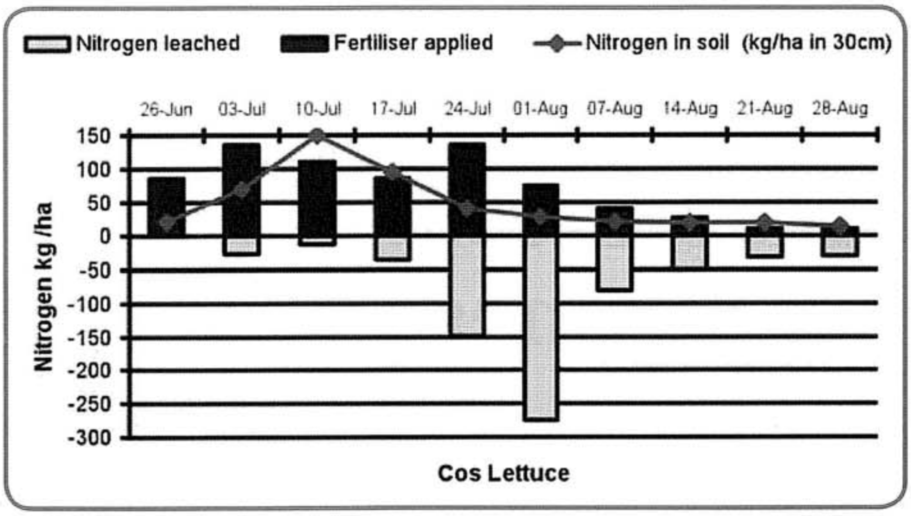
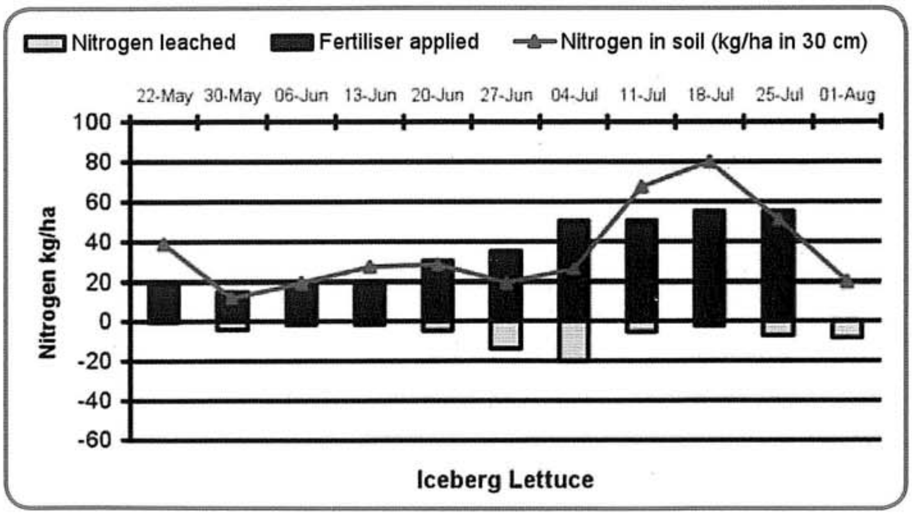


Figure 2. Chart showing good fertiliser scheduling of Iceberg lettuce



4 Thursday October 2 2008 countryman.com.au

Horticulture

Efficiency helps water down costs

Frank Smith speaks to a vegetable grower who has turned to strict supervision to keep the family business viable

Broccoli benefits: Malcolm Nanovich, right, with nephew Brock Nanovich.

Malcolm Nanovich has brought a new approach to a traditional industry.

Trained as an architect, he returned to the family vegetable growing business after his father died and a brother was killed in an accident.

Malcolm's great grandfather started with 20 hectares, and now Nanovich Farms, run by Malcolm, a brother and an uncle, grows broccoli, lettuce, cabbage and celery on 110ha of tuart sand at Carabooda, between Perth and Yanchep.

"Farming is not easy; the industry is doing it tough," Malcolm said.

"We are restricted by high costs and low prices. We can't pass on extra cost to the consumer and as a result we can't afford to invest in high-tech equipment."

Nanovich Farms sells most produce direct to Woolworths, but at the same price received through Canning Vale Markets.

"Fertiliser costs have risen 200 per cent over the past six months," Malcolm said. "Potassium nitrate was $900 per tonne but it is now $2800."

The Nanovichs are faced with finding another $600,000 to meet their fertiliser bill, so they are trying to make ends meet by savings in water and fertiliser use.

Two years ago Malcolm began trials aimed at improving water and fertiliser efficiency.

"We are not saving water, just using it more efficiently," he said. "We have been doing that for the last 12 months.

"We use it differently so that it stops leaching nutrients out of the root zone."

Malcolm uses precision water application so the crop gets enough to grow optimally, but not so much that excess water drains down the soil profile, out of the relatively shallow root zone of vegetables.

Controlled watering also ensures soluble nutrients such as nitrogen and potassium remain in the root zone where they are accessible to plants.

Every morning Malcolm receives an SMS from VegetablesWA giving him data from the Wanneroo weather station on the previous day's temperature, humidity, wind speed and evaporation rate.

He plugs that data into a table on the VegetablesWA website available only to members. He adds in the crop factor for each crop at its particular stage of growth and from that he can work out the exact amount of water to apply that day.

"We used to control irrigation by time," Malcolm said. "Now we do it by volume. We have tested every sprinkler and calculated the volume of water each puts out every hour."

So he knows how many millimetres of water to apply and from that, how long to run each sprinkler.

"If the calculation comes to 6mm of water and the sprinkler delivers 20mm an hour we run them for 20 minutes."

If it rains that day, he deducts the rainfall from the amount of irrigation water applied.

"If the calculations say lettuce needs 6mm today and it rains 4mm we apply just 2mm.

> We don't have enough water allocation, so more efficient water use helps us meet the Waterwise water guidelines.
>
> MALCOLM NANOVICH

"You have to give vegetables enough water. Lettuce won't grow with 6mm if it needs eight."

All water is applied by sprinkler because drippers cannot be used on vegetables.

Although Malcolm aims to keep water in the root zone, some leaching is necessary to remove excess chloride and sulphate ions, which come along in the fertilisers.

Timing of water application is also critical.

He irrigates early in the day in summer to reduce evaporation losses and not later than 2–3pm in winter to prevent plant diseases developing under cool, moist conditions.

"On 40 degree days vegetables need a good drink later in the day to stop them burning or you will lose the crop," he said.

"A crop can be lost in just three hours if a bore breaks down. We only use what we need to use — a minimum of millimetres."

While Malcolm says his major objective is to improve water use efficiency he does save water overall.

"We don't have enough water allocation, so more efficient water use helps us meet the Waterwise water guidelines," he said.

"The Government has hit on the industry to reduce water use, not on mum and dad's garden plots, although the industry grows food for the same mums and dads."

All the water comes from a series of bores and is of excellent quality, except for one that has to be treated to reduce its high iron content.

The Nanovichs are also trying to reduce their fertiliser use.

They are trialling different growth methods for lettuce in a cooperative research program with Department of Agriculture and Food scientists, Dennis Philips and Rowan Prince.

After completing six to eight trials on lettuce Malcolm is moving on to broccoli and later celery.

"It takes 5–6 plantings to get it right," he said.

The main changes are to apply fertiliser in bands in the root zone and to use foliar sprays where possible.

Phosphate cannot be applied by foliar spray because phosphorus is absorbed and bound by the plant cuticle, but nitrogen, potassium and trace elements can be applied that way.

He is reducing his use of fertigation because while it is an efficient way of providing plant nutrients he needs to keep sprinklers going for 20 minutes to water the fertiliser in.

Malcolm would like to invest in three or four lysimeters on each farm to measure the amount of leaching, but cannot afford the investment at present produce prices.

He has one lysimeter, which is used by external consultants to provide data on leaching.

"They come twice a week and tell us what we need to replace," he said.

Malcolm pointed out that in addition to cost savings there were environmental reasons to limit fertiliser use and more efficient water use reduced strain on the aquifer.

"We have to change the way things were done 20 years ago," he said.

But adopting more efficient ways to use water and fertiliser is unlikely to be enough to save the industry. Unless prices improve many growers will be forced out of business.

Web-based watering system

A new web-based irrigation scheduling system developed by the Department of Agriculture and Food with VegetablesWA is boosting efficiencies for growers.

The Vegetable Irrigation Scheduling System, or VISS, is the final stage of a system that has been available by daily SMS service for the last year, but now provides far more customised information.

Both the department's horticulture staff and VegetablesWA are enthusiastic about the final results of several years work.

"It is free and gives growers more information than the SMS evaporation service," VegetablesWA industry development officer, David Ellement, said.

"Reliable scheduling contributes to more efficient use of groundwater resources, improved water use efficiency in production and reduced loss of nutrients to groundwater."

Leading potato and carrot grower Sam Calameri, from Baldivis Market Garden, has set up three farm blocks and two lease blocks using VISS.

"This system is very useful," Mr Calameri said. "It is taking a bit of getting used to, turning on the computer first thing in the morning, but it's so useful to get a summary of run times to make sure my crops are getting the right amount of water.

"It proved its worth for my potatoes during the incredibly dry August and I can see it becoming indispensable in the warmer months."

VISS has been designed to guide irrigation of vegetable crops on sandy soils and is funded by the Premier's Water Foundation, which is administered by the Department of Water.

VISS uses evaporation data from the Department of Agriculture and Food's live weather station network, which uses six stations throughout the State. Growers can use the built-in crop factors for 28 vegetable crops or can easily adjust them to better suit their own situations.

A demonstration version of VISS can be viewed on the VegetablesWA website at www.vegetableswa.com.au. Just go to scheduling and then to view our working demonstration. No manual calculations are required. The water requirements of each crop are displayed on one computer screen.

"Once the system is set up by entering farm details, bed layout and irrigation shifts, daily irrigation run times are displayed in both minutes and millimetres of water for each crop and planting," Mr Ellement said.

Users simply enter the planting date into the web-based system and the daily crop water requirements will be waiting on the computer at the start of the day.

Growers already using the SMS evaporation service can continue to do so, but will obtain more detailed information on irrigation needs for individual crops by going to the website.

For assistance on getting started, contact Rohan Prince at the Department of Agriculture and Food on 0429 680 069 or David Ellement at VegetablesWA on 0408 941 318.

Countryman
Horticulture
ovember 6, 2008
Western Australia's leading industry resource

INSIDE

Growers reclaim markets
Australian horticulture capitalises on Chinese food safety scares and the falling Aussie dollar. Report, page 3

Hot tomatoes
Australia's biggest tomato processor wants to use the Ord River region to expand its operations. See page 5

Sweet bounty
WA stone fruit growers say this season's crop will be memorable. Report, page 5

Way to grow

In the wake of rising farm input costs, the Department of Agriculture and Food is conducting research into new methods of fertiliser application, which will produce more for less. Report, page 8

Cost-saving boost

Sarah Quinton

While many growers are finding it hard to move away from the traditional use of poultry manure to fertilise their lettuce and broccoli crops, research at the Department of Agriculture and Food has proven methods of reducing fertiliser while halving the costs.

Growers are invited to view the trials on the 3Phase method of fertilising lettuce and broccoli at the Medina Research Station, which has seen yields increase by 300 per cent, with the dual aims of reducing fertiliser leaching into groundwater and reducing production costs.

The 3Phase method involves specific fertiliser strategies for each of the three key phases of the crop: establishment, rapid growth and approaching maturity.

Spray applications of nitrogen and potassium in the establishment phase of crop growth have proven to be effective for all these crops, replacing the traditional, inefficient use of chicken manure which can leach large amounts of nitrogen into the groundwater.

Only 20 to 25 kg of nitrogen/ha and 15 to 20 kg of potassium a week has been shown to produce optimal growth in all these crops when applied by spraying.

"There have been some exceptions to this rule, with better results for some crops achieved by broadcasting mixed granular fertiliser in this phase in winter when leaching can be heavy," DAFWA development officer Aileen Reid said.

"If you look at broccoli, we have to do something after the broadcasting. A few weeks ago this crop closed over and we couldn't broadcast between the rows because fertiliser falls on the leaves and damages it. After row closure we have a dilemma of how do you handle it.

"With lettuce you don't have to, but with some of the other crops like broccoli and the longer-term crops like celery and cabbage, you have to do something, and you can't stop fertilising the crop at what is about halfway through its life.

"Now we're starting to look at other substitutes for these treatments here, because of the cost of potassium nitrate being so high. We really desperately need to do something about that."

It is in the next two phases of crop growth that DAFWA senior development officer Dennis Phillips and his team have been concentrating their efforts to reduce costs.

Current trials at Medina on lettuce and broccoli have been testing some cheaper options to commonly used banded fertilisers, such as NPK Blue Special, in the rapid growth phase.

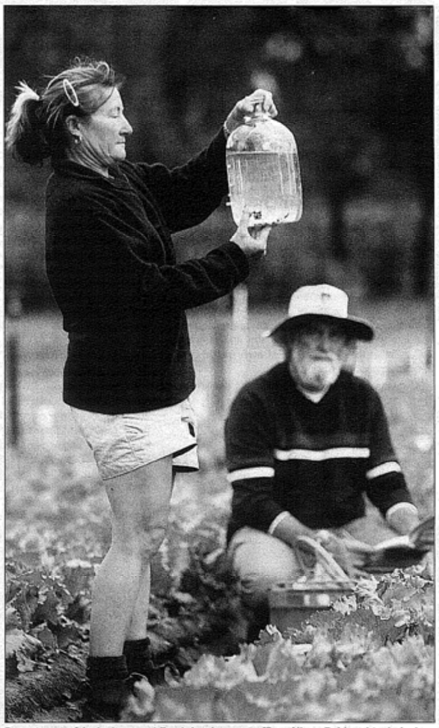
"There may be opportunities to reduce rates in this phase, while cheaper products such as Turf Special at half the cost per hectare of NPK Blue Special are showing great promise," Ms Reid said.

"With potassium nitrate tripling in price in 18 months, other sources of potassium in the third growth phase after row closure are also being evaluated.

"For some crops such as broccoli and celery, this latter phase comprises a substantial part of the total fertiliser program, while for lettuce, fertiliser rarely needs to be applied in this phase, contrary to common grower practice," she said.

Any growers, fertiliser suppliers or consultants interested in learning more about these trials or wishing to view them should contact Dennis Phillips (9368 3319) or Aileen Reid (9368 3393).

Broccoli is being used as part of a fertiliser trial at the Department of Agriculture and Food's Medina Research Station.



Department of Agriculture and Food development officer Aileen Reid and technical officer Dave Gatter record lysimeter leachete volumes as part of fertiliser trials.
PHOTOS: DANELLA BEVIS

Build on drought report with action

Peak horticulture organisation Growcom has welcomed the final report from the Federal Government's review of the social impacts of drought.

Chief advocate Mark Panitz said Growcom was supportive of the review, because social issues had not received adequate attention in the past.

"Dialogue on these issues must continue beyond the panel's report. We look forward to the Government's response and an agenda to turn the recommendations into actions," said Mr Panitz.

"Growcom is strongly supportive of the expert panel's recommendation seeking government commitment to a strong, healthy, vibrant and sustainable rural Australia. An overarching supportive national food security policy would go a long way to improving confidence and hope among growers who have spent years battling drought."

Mr Panitz said drought was well known to the horticulture industry.

"Horticulture is the mainstay of many rural communities and the impact of drought can have huge social and economic impacts for many years. This has flow-on effects on the whole community, with less economic activity generated, reduced demand for labour, people leaving the community to find work and a drop in the number of backpackers/seasonal workers to an area due to a lack of seasonal work opportunities."

Mr Panitz said the review made the point that farm families, rural businesses and communities would need to continue to adapt to manage changes in climate.

"However, current policy settings and programs are not appropriate for this goal," Mr Panitz said.

"The report has reflected the key message driven by Growcom and industry – that government drought policy must be forward thinking, incorporating preparedness, self-reliance and risk management. Current programs discriminate against those who do prepare," he said.

"Growcom is supportive of the panel's view that government policy should focus on early intervention to counteract the worst effects of drought and to provide incentives to adopt new practices.

"The priority for all levels of government, in collaboration with peak industry organisations and non-government support agencies, must be to extend, co-ordinate and deliver the information and tools necessary to help farm families, rural businesses and communities to help them respond to the challenges of living with future climatic events. We look forward to the Government's response to the report and to working with government to deliver the recommendations."

Thrips take a trip to Hills

Apple dimpling bug is proving very persistent this season, with some Donnybrook and Manjimup growers applying multiple sprays to control the insect.

Department of Agriculture and Food development officer Martine Combret sampled several orchards in the Donnybrook, Capel, Kirup and Balingup areas, where growers were applying sprays and follow-up applications.

DAFWA technical officer Dave Cousins said there had also been an increase in the number of thrips in the Perth Hills recently.

"There were high numbers of thrips about this week on fruit trees and weeds, species were many and varied including plague thrips, tomato thrips, western flower thrips and onion thrips. Plague thrips did seem to be els of beneficial insects with brown lace wings and transverse ladybirds being the most common, and growers should consider this when applying chemicals," he said.

"I also saw very low-level damage of what looked like heliothis grazing on the fruit, but no actual larvae."

Moth numbers in southern areas of the State are much higher, with reports from Manjimup of heliothis armigera numbers averaging 20 per trap and those for heliothis punctigera at 50 per trap

It is proving to be a light season so far for light brown apple moth (LBAM) and western fruit moth (WFM). More WFM are being trapped in the South-West than LBAM, with LBAM more common in the

fieldtalk

To have your say email gfv@ruralpress.com

Nanovich farm manager Mehdi Dalir and DAFWA vegetable specialist Dennis Phillips inspect lettuce growing at Carabooda, near Perth.

Going in hard and early yields results

GIVING young vegetable seedlings a kick-start with extra nitrogen applications can be a winner for both the grower and the environment, Department of Agriculture and Food WA research is proving.

After eight years of trials and demonstration plots, both at Medina Research Station near Perth and on grower properties, project leader Dennis Phillips is confident that mineral fertilisers applied regularly and at low doses can effectively substitute for traditional high applications of poultry manure.

"Spraying newly planted seedlings with concentrated urea and potassium nitrate for as little as two weeks after planting has increased yield by up to 300% in some cases on infertile sandy soils," he said.

"The unsprayed plots only missed out on small quantities of nitrogen for two weeks of their whole lives, but at this critical stage it was enough to severely reduce final harvest yields.

"We have tried this method on seven different vegetables with similar responses but our research effort is most advanced with iceberg lettuce."

The research began with lettuce on a Wanneroo property in 2000 before an industry-wide ban on the use of raw poultry manure. Two Horticulture Australia projects in WA have continued the work since and broadened its scope.

"Keeping the method simple is the way to go," Mr Phillips said. "For this reason, whether it is broccoli, lettuce, celery or other crops, our standard tank mix since August 2006 has been 20 g/L of urea and the same rate of potassium nitrate in 1000 L of water sprayed over all crops twice a week from the day of planting."

The nutrient solution is not washed from the foliage and despite it being very concentrated, seedling damage is minimal. Any small amount of leaf

> Keeping the method simple is the way to go.

damage is outweighed by the growth response and efficiency gains from applying fertiliser this way.

Wanneroo grower Malcolm Nanovich is a recent convert to the new system for his lettuce crop because fertiliser prices have increased between two and threefold in the past year.

The method has allowed him to grow the same amount of lettuce at no extra cost than before, and he is now looking to test it on his broccoli, celery and cabbage crops.

"When we started this work we were warned by many growers that we might get away with it once or twice but wouldn't be able to keep doing it for years without loss of yield, because there is no organic component to the fertiliser programs. We listened to the criticism and have been cautious about making premature recommendations to growers," Mr Phillips said.

Growers with whom the department started working in 2000 adopted an early version of the method in late 2001 and have used it ever since without returning to their previous practice of applying poultry manure before and during every crop.

Andrew Tedesco and his brother Mick have been more than happy with results over seven years on lettuce and Chinese cabbage, and have maintained high yields and quality.

Some growers remain sceptical about what they believe is a high labour input due to the number of sprays required on these highly leaching sands.

Mr Phillips said new trials aimed at finding ways to reduce this. These include spraying less often with more concentrated nutrient solutions and broadcasting granular NPK-based products for crop establishment at the same time as the sprays. Results of this work are very promising but not yet finished.

In 2007 the WA researchers succeeded in making further economies in fertilising iceberg lettuce without adversely affecting yield. By extending the spray application period to four weeks after transplanting in winter, almost 80 kg/ha of nitrogen was saved without loss of yield compared with lettuce that was sprayed for only two weeks and then banded.

"The fallow period between crops can also offer savings in fertiliser costs," Mr Phillips said.

"Management of irrigation during this period is critical to keep nutrients from crop residues within the rooting depth of the following crop." GF&V

Trouble doesn't go on hols

WITH Christmas not far away, now is the perfect time to make contingency plans for the holiday period when many businesses shut down.

What would you do if you had a major disease or insect problem over this period?

For example, what would happen if you did not have a sufficient amount of the correct product to protect your crops?

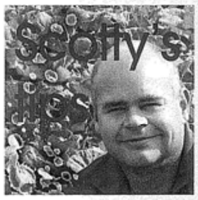
It is heart-breaking to lose a crop at any time, let alone at Christmas.

At the very least, it is sage advice to either plan your requirements based on past experience, or to find out which resellers will be open over the holiday period and to leave their contact details (including after hours) in your diary or on a calendar.

It wouldn't be Christmas if I didn't give you a recipe. I'm a lover of the traditional Christmas pudding. I wait all year to sit down and tuck into the pudding, smothered with warm brandy custard.

However, we live in a lucky country that is blessed with so many fabulous fresh summer fruits, so let's forget the pudding this year and just go with the fruit.

My tip is more of a challenge – to get as many colours into a fruit salad as possible. Start with mangoes, papaya, kiwifruit, strawberries, plums, passionfruit, cherries, bananas and nectarines – just to name a few. Now, because of the great post-harvest initiatives, you can add oranges, apples, blueberries ... the list goes on.



Information to help you get the very best from your crops

I am very proud to work with Syngenta, a company that works hand-in-hand with growers every day to help them achieve quality produce.

So, when I sit down to eat my colourful Christmas dessert this year, I will take a moment to admire the quality fruit that we grow in Australia. I hope you do, too.

TIP: Take some time to relax and enjoy the company of family and friends over the festive season. Normally, I remind you to seek professional advice for your specific situation – but hopefully this will not be needed.

Merry Christmas and have a happy New Year!

Scotty

● For more information, please call the Syngenta technical product advice line on 1800 067 108 or visit www.syngenta.com.au GF&V

Tools for growers online

by **ALISON TURNBULL**
natural resources and climate manager

HAL *Know-how for Horticulture™*

HORTICULTURE growers can now access the on-farm manual for environmental management, 'Guidelines for Environmental Assurance in Australian Horticulture', online free of charge at the new-look Horticulture for Tomorrow website, www.horticulturefortomorrow.com.au

Horticulture for Tomorrow is an across-horticulture environmental management project managed by Horticulture Australia Limited (HAL) on behalf of industry.

Horticulture for Tomorrow was established in 2004 to help growers link production targets to their care for the environment as an integral part of daily business management.

The website was relaunched in November. In a new section of the site, 'For Growers', visitors can download copies of the EA guidelines, the Horticulture Natural Resource Management Strategy which enables horticultural industries to address environmental issues and communicate their successes, and the Freshcare Environmental Code of Practice.

The code of practice (the 'green code') was developed in conjunction with the Guidelines for Environmental Assurance (EA) in Australian Horticulture.

The green code complements the EA guidelines by providing a practical, grower-friendly mechanism through which compliance against environmental elements can be demonstrated.

Freshcare, the national on-farm assurance program for the fresh produce industry, and HAL are now facilitating the certification of growers to this system.

Growers can also access grower case studies and follow links to catchment specific information across Australia. GF&V

GOOD FRUIT & VEGETABLES **December 2008** 21

3Phase counters climbing costs

By Aileen Reid and Dennis Phillips DAFWA

3Phase approach to fertilising

The price of fertilisers commonly used for vegetable production is continuing to climb rapidly. A team of researchers at the Department of Agriculture and Food has been working with the 3Phase approach to fertilising brassica, lettuce and celery crops now for about 8 years with the aims of reducing fertiliser leaching into groundwater and reducing production costs. Big rises in fertiliser prices during 2008 however, prompted us to review the work and increase emphasis on reducing fertiliser costs.

A crop of iceberg lettuce and one of broccoli concluded our work for 2008. The latest trials both consisted of 12 treatments, the only major difference between the treatments for lettuce and broccoli being the application of fertiliser after row closure for broccoli. The trial site has been in continuous cropping now for two years and soil testing has shown that phosphorus and potassium levels remain at good levels so no preplant applications of P or K are required at the moment.

Several treatments used a preplant broadcast application of granular NPK fertiliser on the day of planting, found to be beneficial in previous trials. This was followed by either:

- weekly or twice weekly applications of granular NPK fertiliser or
- weekly or twice weekly spray applications of potassium nitrate and urea

for the first three weeks. This was followed by banding with granular NPK fertiliser until row closure. Only the broccoli crop then received further fertiliser in the form of a simulated fertigation of urea and potassium nitrate.

Superimposed over these were:

- two treatments which tested lower rates of banding (300 or 400 kg/ha instead of 500 kg/ha)
- two treatments which utilised lower cost options of granular NPK fertiliser (Turf Special® and Hort Special®)
- one treatment which tested the application of fresh phosphorus just prior to planting.

For the broccoli only, there were also two treatments which shifted the timing of potassium applications so either more was applied in the first three weeks or in the last four weeks.

Results – lettuce

The crop grew well with few major differences between treatments. It harvested in 52 days from planting in mid September.

- All treatments produced a commercially acceptable yield (52-68 t/ha) with the best treatments all in excess of 60 t/ha.
- All treatments that performed best had Nitrophoska Blue Special® broadcast at planting time. Yield increased by about 8 t/ha for a cost of about $270 dollars.
- We found we were able to reduce the rate of banding to 400 kg/ha without yield reduction thus saving about $410/ha.
- The application of fresh phosphorus up front did not prove beneficial and was substantially inferior to those treatments which had Nitrophoska® broadcast at planting.
- Both Hort Special® and Turf Special® produced 4-6 t/ha less than the comparable Nitrophoska® treatment. More testing is needed to determine whether these yield reductions are real - in which case the treatments are not cost effective, or simply due to experimental variation.

Growers visiting Medina trial sites in July/August 2008

Results - broccoli

All treatments grew well but some treatments matured quicker than others. In the last two weeks of the trial some signs of nutrient deficiency (probably nitrogen) were becoming apparent in the older leaves of some treatments.

The crop was harvested over two days, 63 and 69 days after transplanting. Close to half the crop was picked on each date.

We decided that analysis of the first harvest was most important since the better treatments would be those that yielded best, earliest. At that time, there were substantial differences between treatments. The four best treatments all had over half the crop picked on that first day whilst the remaining treatments were all well under half. The four best treatments all had granular NPK fertiliser broadcast prior to planting and then for the first 21 days, had either:

- twice weekly sprays of urea and potassium nitrate (20g/L of each at 1000 L/ha)
- twice weekly broadcasting of Nitrophoska® (200 kg/ha)
- twice weekly broadcasting of Turf Special® (200 kg/ha) (this treatment was preceded with Turf Special broadcast at planting), or
- weekly banding of Nitrophoska® (200 kg/ha)

The use of fresh phosphorus up front was not beneficial.

There was no effect of any of the fertiliser treatments on incidence of disease or faults such as purpling or irregularly shaped heads.

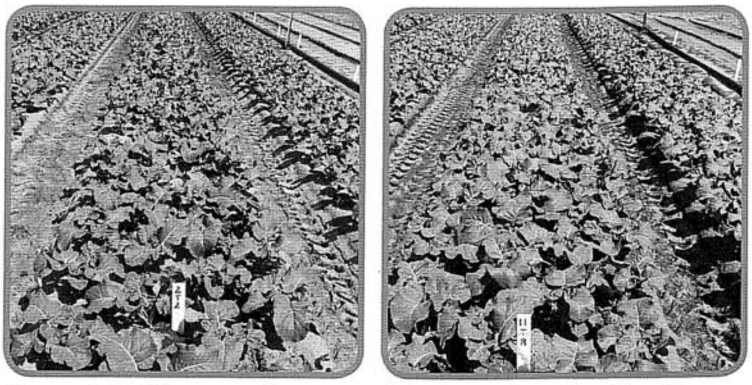
The results with Turf Special are particularly interesting for broccoli since the actual plot weight harvested was not the lowest of the four (second lowest) and this treatment represents a cost saving of about $1000/ha ($2939 versus ~$3969).

The main findings from this trial are:

- there is a big impact from the use of a granular NPK fertiliser broadcast at planting at 200 kg/ha
- the timing of potassium applications for broccoli is not important.
- banding rates need to be 500 kg/ha for either Turf Special or Nitrophoska

The team have now moved on to fine-tuning previous work on celery and cabbage. Two trials were planted in mid January. Growers wishing to view these trials should contact either Dennis Phillips on (08) 9368 3319 or Aileen Reid on (08) 9368 3393.

Figure 1a-d. Comparison of growth in selected fertiliser treatments in a spring lettuce crop 19 days after transplanting.



Figures 2a,b The range of crop growth in this trial was less than for previous crops. T2 (left) seemed less advanced than T8 (right).

GOVERNMENT OF WESTERN AUSTRALIA
Department of **Agriculture** and **Food**

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FIELD TRIP

Friday 21 August 2009

Field walks featuring trials at MEDINA RESEARCH STATION and on-farm improvements at BALDIVIS MARKET GARDEN

Hear about good practice and better returns from:
Sam Calameri - making changes , saving money
Rohan Prince - small changes making a big difference
Bob Paulin - improving soil performance
Dennis Phillips and Aileen Reid - busting fertiliser myths with 3Phase

Starting 1:30pm and finishing at 4:30pm
Medina Research Station, 60 Abercrombie Road

Courtesy bus departing Wanneroo Tavern 12:30pm, returning 6:00pm
Bookings by Tuesday 18 August are essential

For more information contact Horticulture House
Phone: 9481 0834 or email foord@vegetableswa.com.au

All Welcome

This project is supported by vegetablesWA, through funding from the Australian Government's Caring for our Country, the Department of Agriculture and Food WA and Horticulture Australia Ltd.

CARING FOR OUR COUNTRY

Department of Agriculture and Food

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Field Trip First of Three

Good Practice Field Trip *By Gavin Foord*

About forty people attended the first of three Good Practice field trips planned for the lead-up to summer. vegetablesWA and the Department of Agriculture and Food WA (DAFWA) were out in force to ensure growers were provided with a good learning environment to view and discuss a range of practices aimed at a sustainable WA vegetable industry.

This trip focused on practices implemented at Baldivis Market Garden on Eighty Rd Baldivis and on innovative fertiliser trials at Medina Research Station. DAFWA specialists Rohan Prince and Bob Paulin were on hand to support Sam Calameri discussing a commercial view on the benefits of improving irrigation systems and soil performance. At Medina, Dennis Phillips and Aileen Reid showed the group the latest in a series of trials.

BALDIVIS MARKET GARDEN

Baldivis Market Garden was established in 1974 and is a family owned business located in Baldivis, approximately 50 kilometers south of Perth. The business originally grew onions, cauliflowers, carrots and potatoes. They now specialise in carrots for the export market and potatoes for the local ware market. The market garden covers 55ha of irrigated land and crops 110ha per year.

Sam Calameri is the owner and manager of Baldivis Market Garden.

Sam's reputation as an industry leader comes from his continued support to grower committees and his commitment to research and development. Baldivis Market Garden has been offered as a demonstration site for a range of activities over the years, allowing research to be put into practice on a commercial scale. This is again demonstrated through his participation in the project, Good practice and better environmental outcome in vegetable production.

Making positive changes

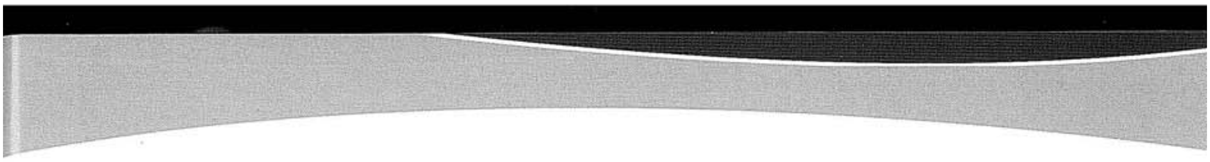
Through participation in Water Wise on the Farm, Sam made adjustments to his irrigation system, resulting in a vast improvement in his irrigation system performance. "When we had a close look at our irrigation system I was surprised that our uniformity was not as good as it could be." said Sam "With a few, relatively small and inexpensive changes, we were able to improve our distribution uniformity so that it exceeded international standards. This not only saved us water, it meant that our system was uniform enough for us to start fertigating with confidence that we were keeping more of our water and fertiliser in the rootzone. This has been a positive change for us, we are growing a more even crop and continue to see improvements in our yield and quality."

Rohan Prince provided the following Top Tips for a good irrigation system:

- Check the pressure at your sprinklers. There should be no more than 10% difference from the valve to each end of the lateral line.
- Check the pressure at the pump. If it's considerably more than the pressure at the sprinklers there may be an issue.
- Test your uniformity so you know your application rate and wetting pattern - Refer to the Good Practice Guide, Water Management chapter for details.
- A well designed, installed and maintained irrigation system is an asset that will make you money.
- A poorly designed system is a liability. It will increase your water use and cost you more in fertiliser and electricity.

Improving soil improved yield and quality

It has long been acknowleged that the sandy soils of the Swan Coastal Plain



leave a bit to be desired in terms of water holding capacity and nutrient retention. In recent years, Baldivis Market Garden has been the site of a number of trials aimed at using compost to improve soil performance. Sam has worked with DAFWA and Custom Composts to commercially put research into practice.

"We got involved in compost work because we were concerned about the condition of our soil" said Sam "We have a more intensive cropping program now, growing crops all year round. We need to maximise our returns from the same area of land and minimise issues with declining soil and water quality.

The benefits we gained in cauliflowers were better yield and quality and improved uniformity. Our soil organic matter more than doubled, which gave us improved water and nutrient holding capacity and disease suppression. Better uniformity meant fewer harvests and reduced harvest costs. The disease suppresion was an added bonus, saving on the cost of fumigation."

For details on how to improve your soil performance see the Soil management chapter of the Good Practice Guide and the DAFWA Compost Bullettin 4746.

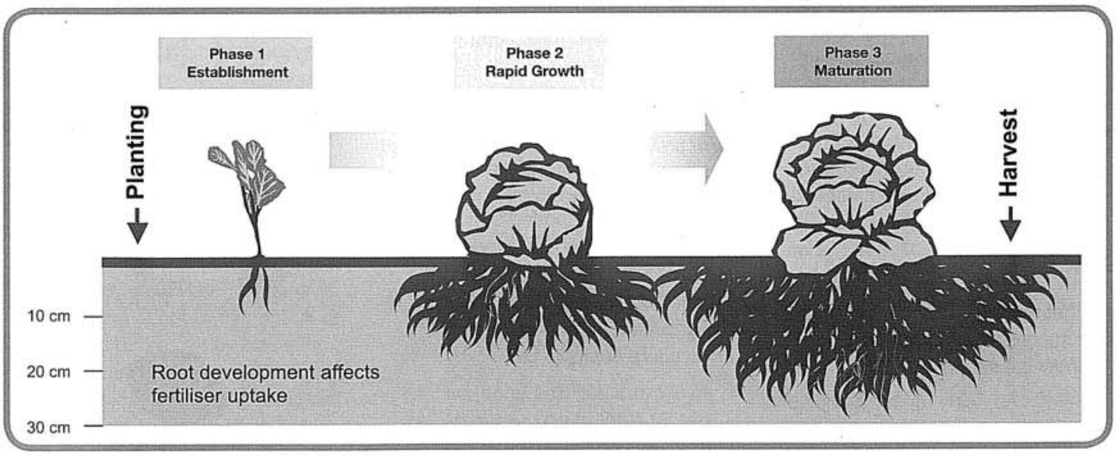
MEDINA RESEARCH STATION

Medina has been a key site for DAFWA's horticultural research since the closure of the Churchlands Horticultural Station in 1963-64. Forty five years on, work conducted by a research team led by Dennis Phillips is focused on developing vegetable fertiliser programs that:

- Maximise the efficiency of fertiliser use
- Minimise loss through leaching
- Maximise return on the dollars spent on fertiliser.

This work builds on the development of successful programs for broccoli and lettuce detailed in two new DAFWA publications:

1. Farmnote 375, The 3Phase method for growing broccoli on sandy soils 2009
2. Farmnote 377, The 3Phase method for growing lettuce on sandy soils 2009



Busting fertiliser myths with 3Phase

Dennis Phillips and Aileen Reid (DAFWA) showed growers through cabbage and celery trials that test the effectiveness of this new approach to applying fertiliser, locally known as the 3Phase program.

"Fertiliser and cost savings are achieved in the '3Phase' method by making informed choices about fertiliser type, application rates, application methods and the timing of applications—matching fertiliser application to crop demand" said Dennis. "To achieve this, the life of the crop is considered in three phases: establishment, rapid growth and maturation. Different fertiliser strategies are used to optimise growth in each of these phases."

So what myths are we busting?

- That there is only one way to grow a successful crop and only you know the secret
- You can't grow a successful crop without poultry manure
- You can't do it any cheaper than you are now and grow a good crop
- You won't get a marketable crop if you don't pile on the potash close to harvest

Two more field trips before summer

Two more field trips are planned as part of this project, one in September visiting demonstration sites at Gingin and Gingin West. The other in October will visit properties at Myalup. These are great opportunities to network while looking at sustainable farm practice where it happens, on the farm.

This project is supported by vegetablesWA, through funding from the Australian Government's Caring for our Country, the Department of Agriculture and Food WA and Horticulture Australia Ltd.

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Disappointing C'man Hort Supp

C'man Hort Supp 1/10/09 P2

Fertilising a three-way system

Providing fertiliser when and how vegetable plants can gain most advantage will become easier, following research by the Department of Agriculture and Food (DAFWA).

The 3Phase fertiliser method for sandy soils sets benchmark levels of nitrogen; potassium and phosphorus for crops according to growth stage, and includes advice on placement, products and low-cost application methods.

DAFWA development officer Aileen Reid said detailed work had been completed for lettuce and broccoli, and other popular crops would be completed over the coming seasons.

"The department's work on the Swan Coastal Plain has shown for short rotation vegetable crops, there are three phases," Ms Reid said.

"The new recommendations are a refinement of work over about eight years. Several leading growers are already using the system, after adapting it slightly to suit their own conditions."

The 3Phase fertiliser method for sandy soils sets benchmark levels of nitrogen, potassium and phosphorus for crops according to growth stage.

Besides saving growers money by only applying fertiliser to the level it can be used by growing plants, the 3Phase system has ronmental benefits by reducing the ar of nitrogen leached into groundwater.

In phase one, growers may either s mixture of nitrogen and potassium o twice a week or broadcast granular NP tiliser weekly. Broadcasting works be rainy periods.

For lettuce and broccoli, phase one take less than two weeks in summer bu ly four weeks in winter. It takes this lo the roots to become extensive enough tercept nutrients placed anywhere exc the soil surface.

Much higher fertiliser rates are app phase two, when growth is most rapid. ly banding until row closure is recomm with granular NPK fertiliser. In su some crops don't require any more fe after this stage.

Department of Agriculture and Food
Farmnote
Note: 375
July 2009

The 3Phase method for growing lettuce on sandy soils 2009

Dennis Phillips, Aileen Reid and Helen Ramsey

The 3Phase fertiliser schedule presented here is based on eight years of fertiliser trials on iceberg lettuce grown on the sandy soils of the Swan Coastal Plain with sprinkler irrigation. This schedule gave the highest yields and best quality throughout the year, while being practical to apply and economical with labour.

The schedule is also suitable for cos lettuce with small changes to application timings and has been successfully adapted by growers for use on other leafy and heading lettuce crops. Boom spray applications recommended in phase 1 however, are not suitable for use on some soft-leaved types such as Green Festival and Buttercrunch.

The sandy soils of the coastal plain provide a free-draining, easily worked growing medium for a variety of vegetable crops. The nature of this soil allows nutrients to be freely available in the soil solution for uptake by plants. Some nutrients are therefore also highly mobile and easily lost through leaching. Nitrogen in the form of nitrate is particularly susceptible to leaching in this soil and is a major groundwater pollution concern.

Careful attention must be paid to fertiliser application to:

- maximise the efficiency of fertiliser use
- minimise loss through leaching
- maximise return on the dollars spent on fertiliser.

The schedule outlined here is based on research conducted on some of the least fertile sandy soils in the region. It aimed to develop cost-effective strategies for maximising yield in a 'worst case' situation. Trial sites had no previous vegetable cropping history and irrigation water did not contain nutrients from past cropping activities. We did not use soil amendments such as compost and manure.

Fertiliser and cost savings are achieved in the 3Phase method by making informed choices about fertiliser type, application rates, application methods and the timing of applications—matching fertiliser application to crop demand. To achieve this, the life of the crop is considered in three phases: establishment, rapid growth and maturation (see Figure 1). Different fertiliser strategies are used to optimise growth in each of these phases.

It takes approximately two weeks in summer and four weeks in winter for the root zone of a lettuce crop to become extensive enough to intercept nutrients placed everywhere on the soil surface. By maturity, the roots of a lettuce plant can access water and nutrients from the top 20–30 cm depth of soil.

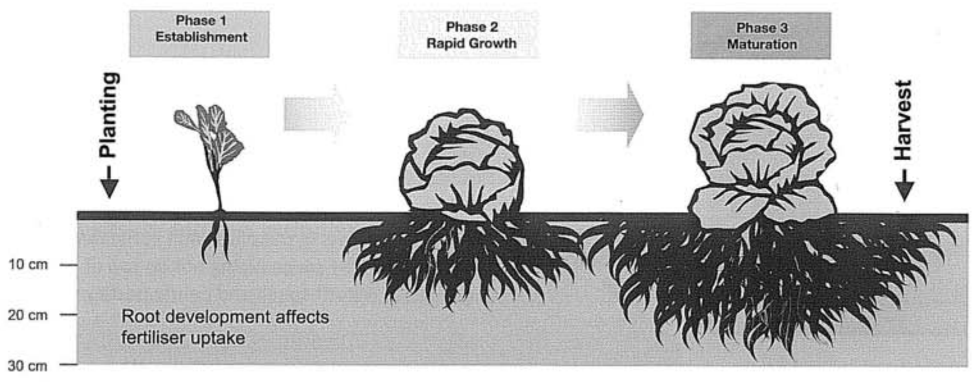

Figure 1 Growth phases from planting to harvest.

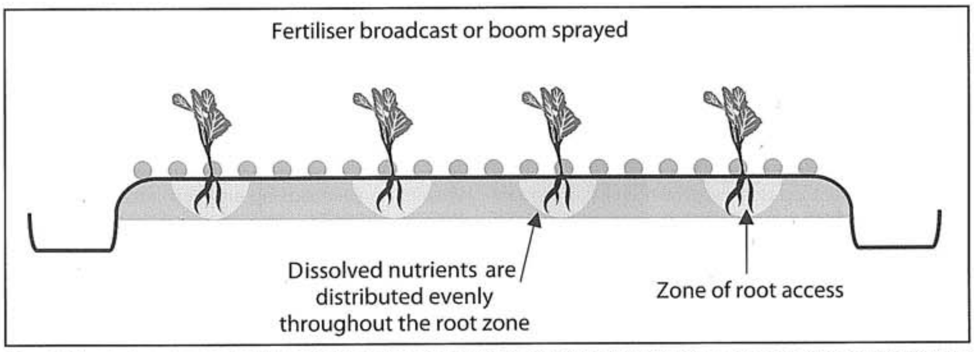

Figure 2 Broadcast or spray applications of fertiliser during crop establishment place nutrients in the zone where young developing roots have access.

Phase 1 – crop establishment

Good growth in the first two to four weeks of crop life is critical to crop performance. Growth achieved in this time has a major impact on final yield and the number of days from planting until harvest—one that cannot be made up in later growth phases.

To maximise crop nutrition and growth in the establishment phase it is important to keep fertilisers in the zone where young roots are growing.

Trials showed that twice weekly broadcast or boom spray applications of fertiliser (containing low rates of nitrogen) during crop establishment have big yield benefits and shorten the time to harvest. Both methods place enough fertiliser within the reach of roots to maximise crop growth without excessive loss to the environment (see Figure 2). Research has shown that an initial application of granular NPK fertiliser, applied to the soil surface on the day of planting, is also important for achieving maximum yields whichever fertiliser delivery method is used later.

Phase 2 – rapid growth

Once the root system is established, fertilisers are most effectively applied weekly by banded application (see Figure 3). Fertigation or broadcasting can be used in this phase, however, it is difficult to apply the required rates of fertiliser with these methods without unnecessary water use or the risk of leaf burn from undissolved or lodged fertiliser granules. Banding with compound granular fertilisers is most suitable as it minimises waste and allows the required rate of nitrogen, phosphorus and potassium to be applied in one pass.

Phase 3 – maturation

After row closure, the head or other marketable part of the crop fills out, drawing accumulated nutrients from the frame developed in earlier stages as well as from the soil. Continued application of nitrogen is usually only required if the maturation period is longer than two to three weeks.

From early spring to early autumn (September to March) no further fertiliser is usually required after row closure for iceberg and cos lettuce. In the cooler months when growth is slower, weekly fertigation with nitrogen and potassium is recommended up until one week before harvest.

The 3Phase fertiliser strategy

A 'year round' fertiliser strategy for iceberg lettuce grown on the sandy soils of the Swan Coastal Plain is shown in Figure 4. This strategy combines the methods

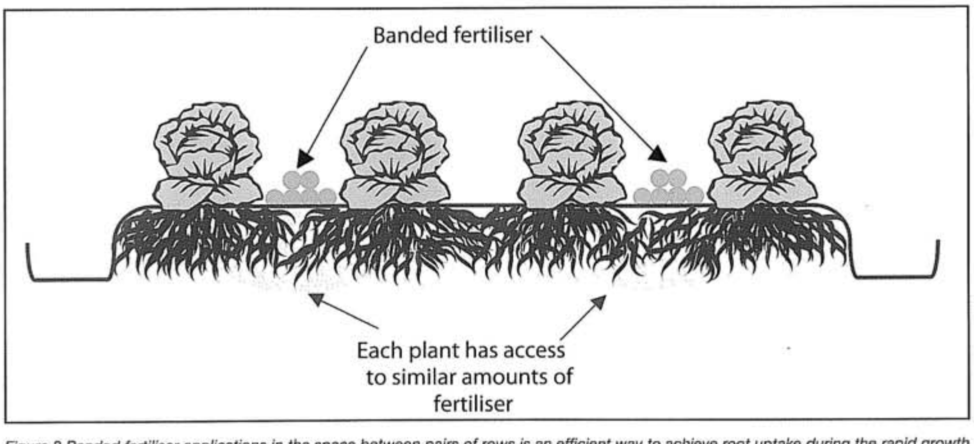

Figure 3 Banded fertiliser applications in the space between pairs of rows is an efficient way to achieve root uptake during the rapid growth phase.

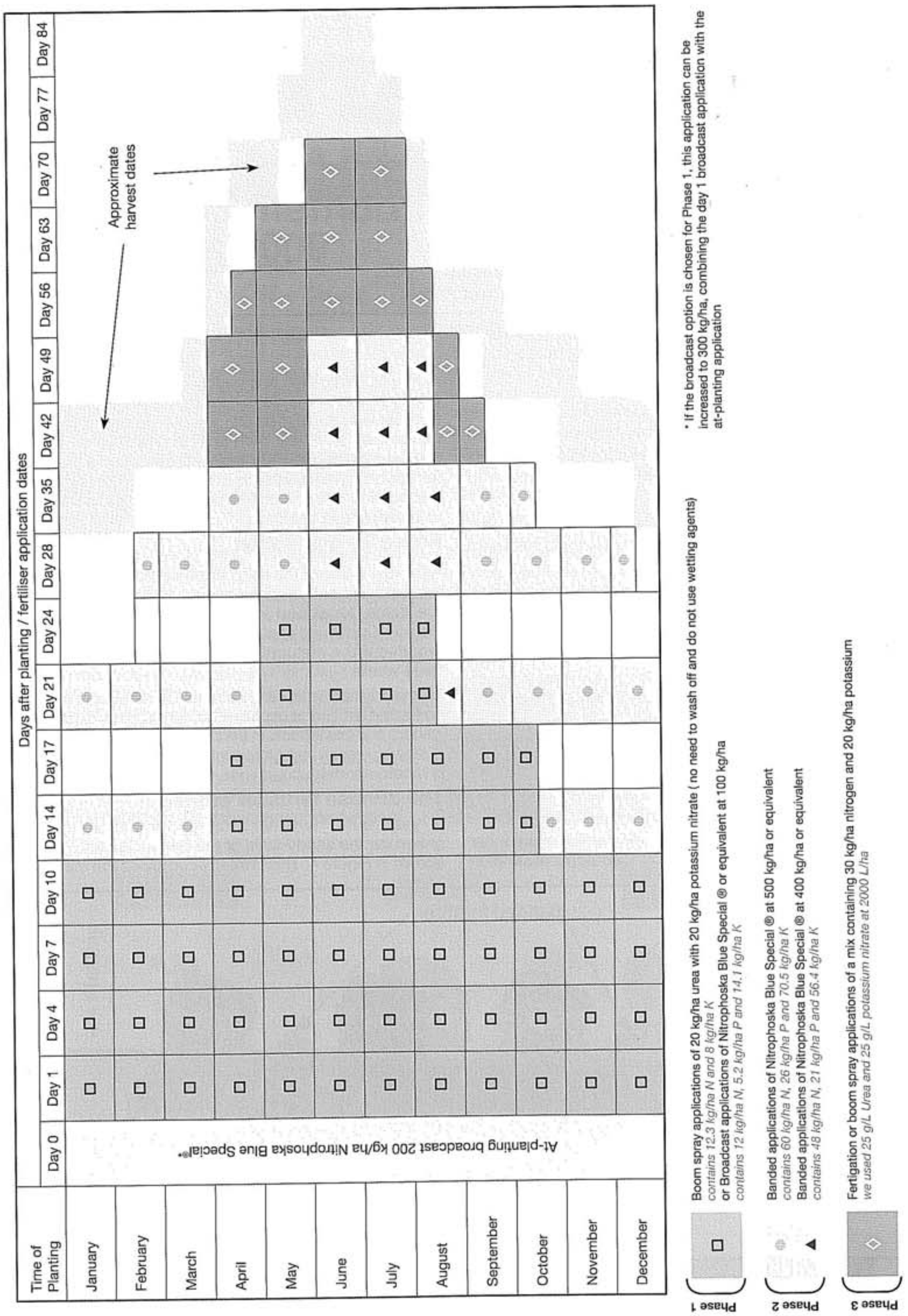

Figure 4 3Phase annual fertiliser strategy for iceberg lettuce according to planting date. Planting dates are shown at fortnightly intervals in some months to account for rapidly changing temperatures, rainfall and sunshine hours.

outlined above with recommended rates and preferred products based on current research results. Products, timing and rate recommendations may change subject to the results of future research.

Important notes on the 3Phase program

- Nitrophoska Blue Special® has been the most effective product tested for broadcast and banding in trials to date, from the perspectives of efficacy and labour saving. This fertiliser contains 12 per cent nitrogen, 5.2 per cent phosphorus and 14.1 per cent potassium. Other equivalent compound (granular) fertiliser products with similar analysis may also be suitable but need to be tested.
- Broadcast or spray applications in phase 1 can be applied once a week (at double rates) with a small reduction in final yield. Twice weekly applications are recommended when rainfall is expected or irrigation requirements are high.
- If fertiliser applications in phase 3 are applied by boom spray, residue must be washed off the foliage to prevent fertiliser burn as higher rates of fertiliser are applied at this time compared to phase 1.
- Urea may not always be a suitable source of nitrogen in phase 3 in the coldest months as temperatures may be too cool for its conversion into ammonium and nitrate.

Nitrogen application benchmarks

Figure 5 shows the levels of nitrogen that give maximum yield over the life of a lettuce crop grown on the sandy soils of the coastal plain. The totals are reported according to planting time.

If your current fertiliser application rates exceed those outlined in Figure 4 and Table 1 you are applying too much and losing an unacceptable quantity of nutrient to the environment. Future research is expected to lower these benchmarks even further.

Trace elements should also be considered in your fertiliser program. Maintenance of soil pH with regular liming and the use of supplementary magnesium products should provide adequate calcium and magnesium. An annual broadcast application of complete trace elements is also good practice for all crops grown in rotation.

Irrigation

Individual applications of water should not exceed 3 mm at any time during the crop establishment stage (phase 1). Daily water requirements are best broken up into multiple irrigations of 3 mm or less, limiting the loss of nutrients from the developing root zone. Water applications can be increased to 6–8 mm at a time in later growth stages when the crop root zone is fully developed. An irrigation system with good uniformity is required to achieve the best results.

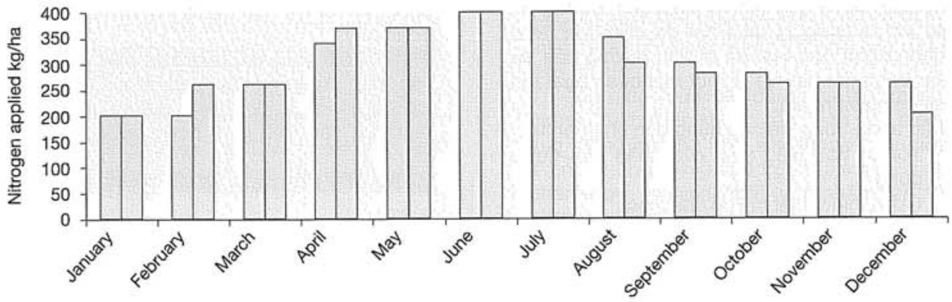

Figure 5 Nitrogen application benchmarks for the life of a crop in kg/ha according to the time of planting

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Department of Agriculture and Food
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Farmnote

The 3Phase method for growing broccoli on sandy soils 2009

Dennis Phillips, Aileen Reid and Helen Ramsey

The 3Phase fertiliser schedule presented here is based on four years of fertiliser trials on broccoli grown on the sandy soils of the Swan Coastal Plain with sprinkler irrigation. This schedule gave the highest yields and best quality throughout the year, while being practical to apply and labour saving.

The sandy soils of the coastal plain provide a free-draining, easily worked growing medium for a variety of vegetable crops. The nature of this soil allows nutrients to be freely available in the soil solution for uptake by plants. Some nutrients are therefore also highly mobile and easily lost through leaching. Nitrogen in the form of nitrate is particularly susceptible to leaching in this soil and is a major groundwater pollution concern.

Careful attention must be paid to fertiliser application to:

- maximise the efficiency of fertiliser use
- minimise loss through leaching
- maximise return on the dollars spent on fertiliser.

The schedule outlined here is based on research conducted on some of the least fertile sandy soils in Australia. It aimed to develop cost-effective strategies for producing high yield in a 'worst case' situation. Trial sites chosen for this research initially had no previous vegetable cropping history and irrigation water did not contain nutrients from past cropping activities. We did not use soil amendments such as compost and manure, but trials were grown in rotation with lettuce and celery crops and there was some carryover of nutrients from crop residues after each crop, as there is in commercial vegetable production.

Fertiliser and cost savings are achieved in the 3Phase method by making informed choices about fertiliser type, application rates, application methods and the timing of applications—matching fertiliser application to crop demand. To achieve this, the life of the crop is considered in three phases: establishment, rapid growth and maturation (see Figure 1). Different fertiliser strategies are used to optimise growth in each of these phases.

It takes approximately two weeks in summer and four weeks in winter for the root zone of a broccoli crop to become extensive enough to intercept nutrients placed everywhere on the soil surface. By maturity, the roots of a broccoli plant can access water and nutrients from the top 20–30 cm depth of soil.

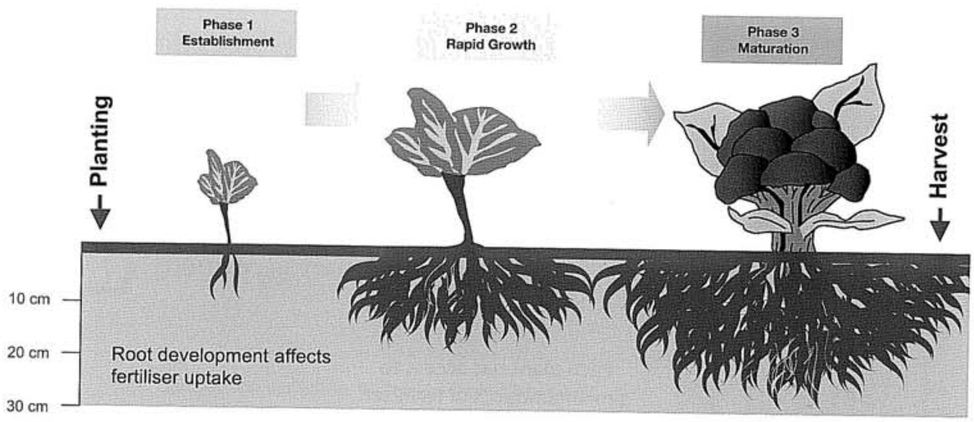

Figure 1 Growth phases from planting to harvest.

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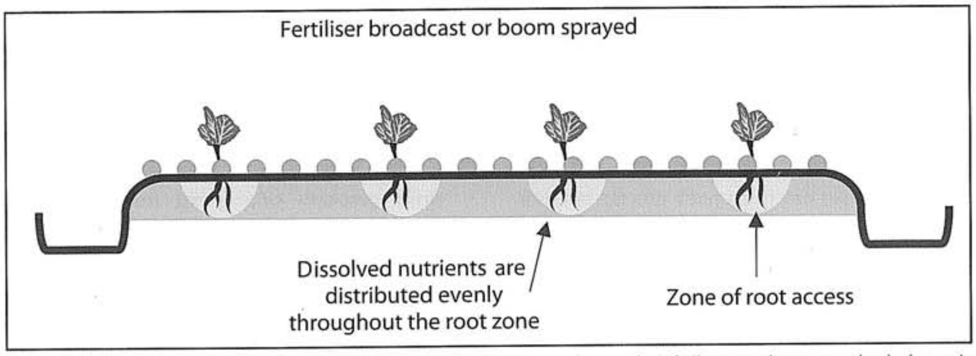

Figure 2 Broadcast or spray applications of fertiliser during crop establishment place nutrients in the zone where young developing roots have access.

Phase 1 – crop establishment

Good growth in the first two to four weeks of crop life is critical for achieving high marketable yields. Maximising growth rates in this phase not only has a major impact on final yield but also the number of days from planting until harvest. These benefits cannot be made up in later growth phases if early growth is inadequate.

To maximise crop nutrition and growth in the establishment phase it is important to keep fertilisers in the zone where young roots are growing.

On sandy soils, twice weekly broadcast or boom spray applications of fertiliser (containing low rates of nitrogen) during crop establishment are required to shorten the time to harvest and maximise yields. Both methods place enough fertiliser within the reach of roots to maintain a steady nutrient supply without excessive loss to the environment (see Figure 2). Our research showed that an application of granular NPK fertiliser, applied to the soil surface on the day of planting, is critically important for achieving maximum yields whether spraying or broadcasting is used for following applications.

Phase 2 – rapid growth

Once the root system is established, fertilisers are most effectively applied weekly by banded application (see Figure 3) until row closure. Fertigation or broadcasting can be used in this phase. However, it is difficult to apply the required rates of fertiliser with these methods without unnecessary water use or the risk of damaged foliage and heads from undissolved or lodged fertiliser granules. Banding with compound granular fertilisers is most suitable as it minimises waste and allows the required rate of nitrogen, phosphorus and potassium to be applied in one pass.

Phase 3 – maturation

After row closure, the head and frame fill out, drawing accumulated nutrients from the frame developed in earlier stages as well as from the soil. Continued application of nitrogen and potassium is required in the three to five week period between row closure and harvest.

Weekly fertigation with nitrogen and potassium is recommended up until the week of harvest.

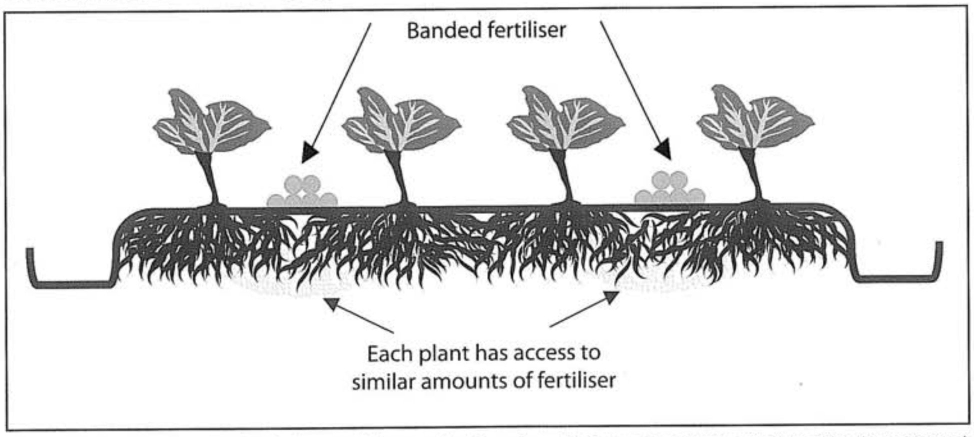

Figure 3 Banded fertiliser applications in the space between pairs of rows is an efficient way to achieve root uptake during the rapid growth phase.

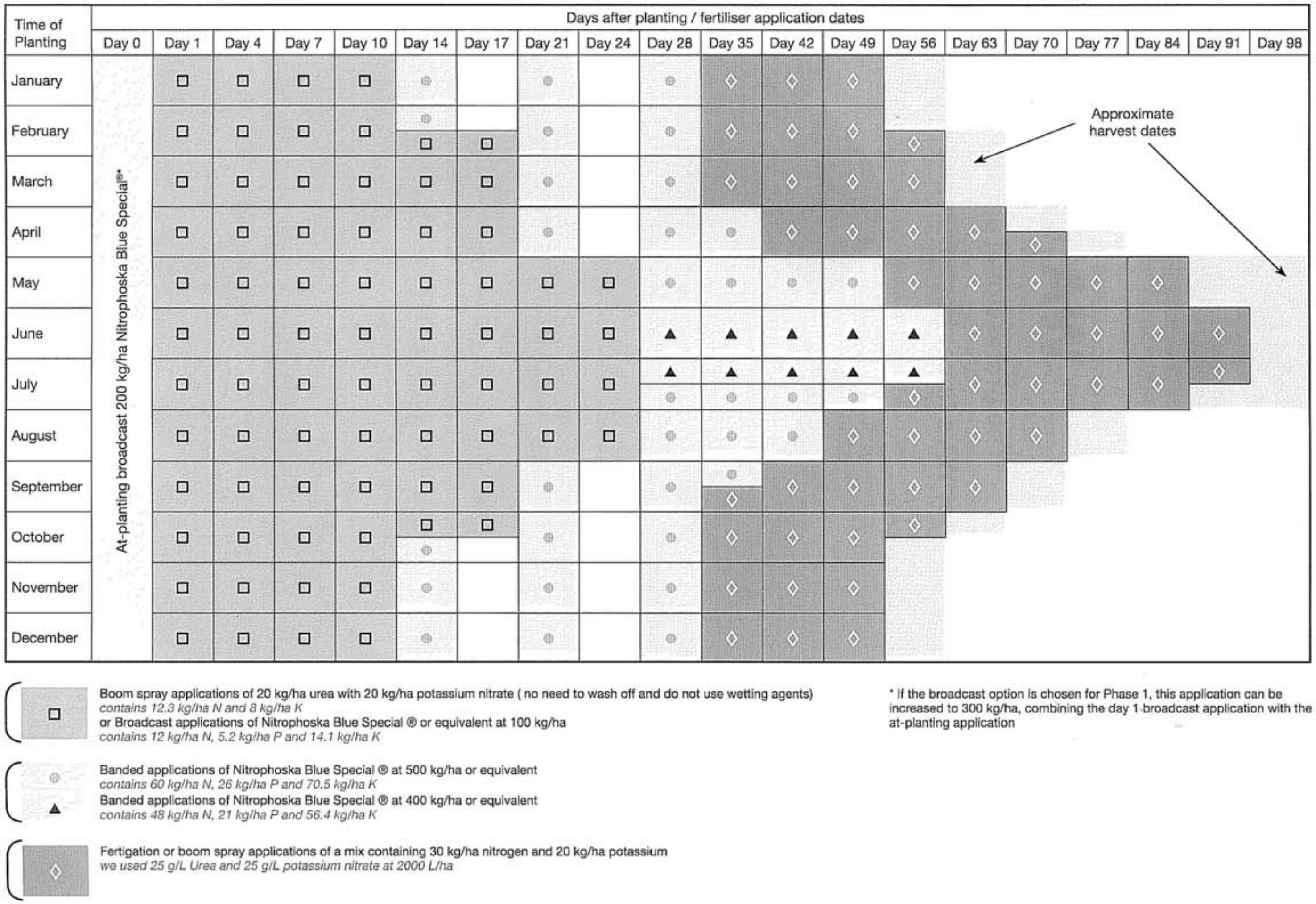

Figure 4 3Phase annual fertiliser strategy for broccoli according to planting date. Planting dates are shown at fortnightly intervals in some months to account for rapidly changing temperatures, rainfall and sunshine hours.

The 3Phase fertiliser strategy

A 'year round' fertiliser strategy for broccoli grown on the sandy soils of the Swan Coastal Plain is shown in Figure 4. This strategy combines the methods outlined above with recommended rates and preferred products based on current research results. Products, timing and rate recommendations may change subject to the results of future research.

Important notes on the 3Phase program

- Nitrophoska Blue Special® has been the most effective product tested for broadcast and banding in trials to date, from the perspectives of efficacy and labour saving. This fertiliser contains 12 per cent nitrogen, 5.2 per cent phosphorus and 14.1 per cent potassium. Other equivalent compound (granular) fertiliser products with similar analysis may also be suitable but need to be tested to confirm this.
- Broadcast or spray applications in phase 1 can be applied once a week (at double rates) with no to small reductions in final yield depending on the time of year. Twice weekly applications are recommended when rainfall is expected or irrigation requirements are high.
- If fertiliser applications in phase 3 are applied by boom spray, fertiliser residue must be washed off the foliage to prevent fertiliser burn as higher rates of fertiliser are applied at this time compared to phase 1.
- Urea may not always be a suitable source of nitrogen in phase 3 in the coldest months as temperatures may be too cool for its conversion into ammonium and nitrate. Work is still being done to better define this risk.

Nitrogen application benchmarks

Figure 5 shows the levels of nitrogen that give maximum yield over the life of a broccoli crop grown on the sandy soils of the coastal plain. The totals are reported according to planting time.

If your current fertiliser application rates exceed those outlined in Figure 4 and Table 1 you are applying too much and losing an unacceptable quantity of nutrient to the environment. Future research is expected to lower these benchmarks even further.

Trace elements should also be considered in your fertiliser program. Maintenance of soil pH with regular liming and the use of supplementary magnesium products should provide adequate calcium and magnesium. An annual broadcast application of complete trace elements is also good practice for all crops grown in rotation, while a fertigated application of Borax at 15 kg per hectare at row closure is recommended as a precaution against boron deficiency.

Irrigation

Individual applications of water should not exceed 3 mm at any time during the crop establishment stage (phase 1). Daily water requirements are best broken up into multiple irrigations of 3 mm or less, limiting the loss of nutrients from the developing root zone. Water applications can be increased to 6–8 mm at a time in later growth stages when the crop root zone is fully developed. An irrigation system with good uniformity is required to achieve the best results.

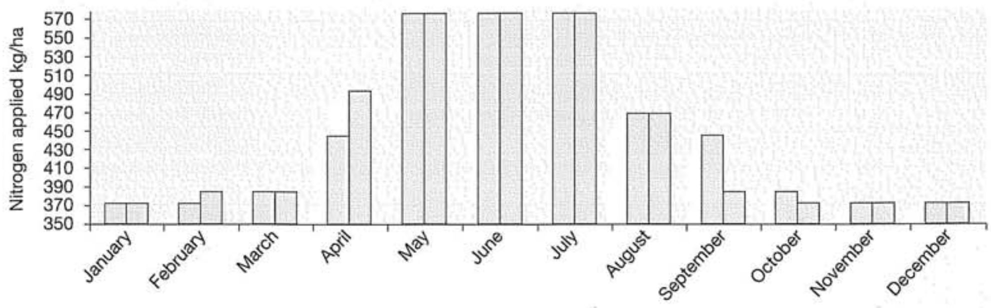

Figure 5 Nitrogen application benchmarks for the life of a crop in kg/ha according to the time of planting

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Bộ Nông Nghiệp và Thực Phẩm

Bản: 375
Tháng 07 năm 2009

Farmnote

Phương pháp 3Phase (3Giaiđoạn) trồng rau diếp trên đất cát năm 2009

Dennis Phillips, Aileen Reid và Helen Ramsey soạn viết

Kế hoạch phân bón 3Phase (3Giaiđoạn) trình bày ở đây dựa trên tám năm thử nghiệm phân bón cho sà lách iceberg trồng trên đất cát của Đồng Bằng Ven Biển Swan với hệ thống tưới tiêu. Kế hoạch này mang đến sản lượng cao nhất và chất lượng tốt nhất suốt cả năm, trong khi vẫn thực tiễn để áp dụng và tiết kiệm sức lao động.

Kế hoạch cũng phù hợp cho rau diếp lá dài với các thay đổi nhỏ về thời điểm bón và đã được thích nghi thành công bởi người trồng để sử dụng cho cây rau diếp có phần đầu và các loại cây rau rậm lá khác. Tuy nhiên, phương pháp bón phun được khuyến nghị trong giai đoạn 1 không phù hợp để sử dụng cho các loại cây rau lá mềm như Green Festival và Buttercrunch.

Đất cát của đồng bằng ven biển cung cấp một phương tiện trồng không cần thoát nước, dễ hoạt động là một môi trường trồng cho nhiều loại cây rau cải. Bản chất của đất này cho phép chất dinh dưỡng có sẵn và rộng rãi trong thành phần của đất cho cây hấp thụ. Vì vậy một số chất dinh dưỡng rất di động và dễ dàng bị thiệt hại do chiết lọc. Nitơ dưới dạng nitrat đặc biệt dễ bị ảnh hưởng của sự chiết lọc trong đất này và là một mối quan ngại lớn về ô nhiễm nước ngầm.

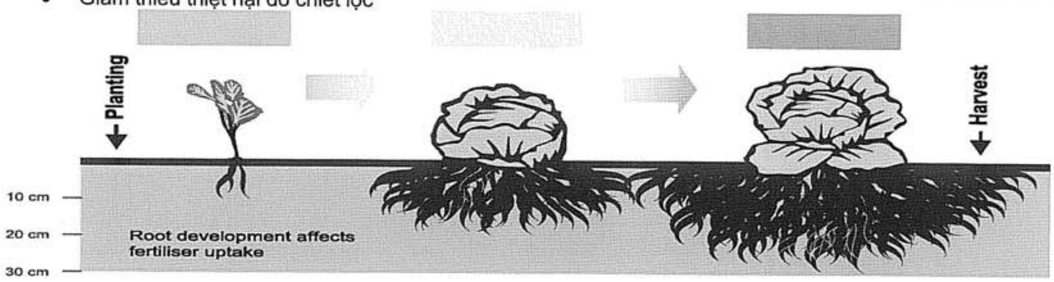
Phải thận trọng trong việc áp dụng bón phân nhằm:

- Tối đa hóa hiệu suất của phân bón được dùng
- Giảm thiểu thiệt hại do chiết lọc
- Tối đa hóa lợi nhuận từ tiền đầu tư phân bón

Kế hoạch trình bày ở đây dựa trên nghiên cứu được tiến hành ở một vài vùng đất cát ít màu mỡ nhất trong khu vực. Nó có mục đích phát triển các chiến lược sinh lợi cho việc tối đa hóa sản lượng trong một bối cảnh "tình huống tồi tệ nhất". Các khu vực của cuộc thử nghiệm chưa từng trồng rau cải trước đây và nước tưới tiêu không chứa các chất dinh dưỡng từ các hoạt động trồng trọt trong quá khứ. Chúng tôi đã không sử dụng các chất bổ sung cho đất như phân trộn và phân bón.

Phương pháp '3Phase' giúp quí vị bón phân và giảm chi phí của nó qua những lựa chọn có đầy đủ thông tin về loại phân, tỉ lệ bón, phương pháp bón và thời gian bón – làm cho cách bón phân phù hợp với nhu cầu cây trồng. Để đạt được điều này, đời sống của cây được xem xét thành 3 giai đoạn: bắt đầu, sinh trưởng nhanh và trưởng thành (xem Hình 1). Các chiến lược phân bón khác nhau được sử dụng để tối ưu hóa sự sinh trưởng trong mỗi giai đoạn này.

Phải mất khoảng hai tuần vào mùa hè và bốn tuần vào mùa đông cho khu vực rễ của cây rau diếp đủ lớn để bắt được chất dinh dưỡng bỏ khắp nơi trên mặt của đất. Đến giao đoạn trưởng thành, rễ của cây rau diếp có thể hấp thụ được nước và chất dinh dưỡng từ ở trên xuống 20-30cm độ sâu của đất.



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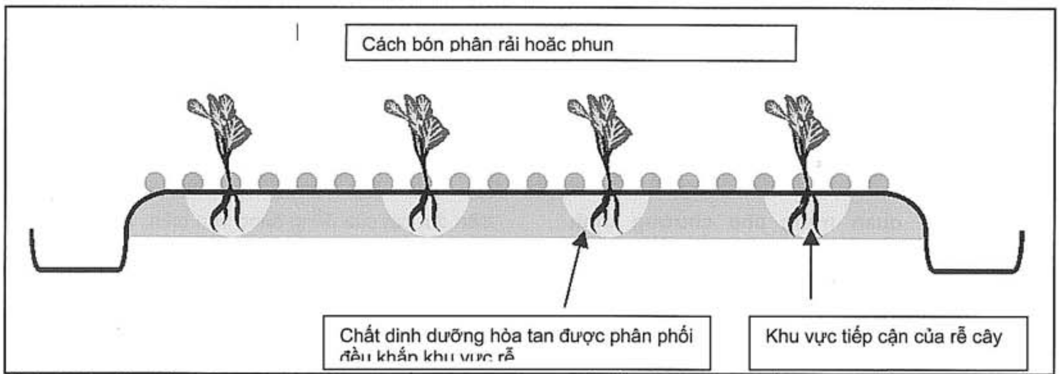


Hình 2 Bón phân bằng phương pháp rải hoặc phun trong giai đoạn bắt đầu của quá trình trồng sẽ giữ chất dinh dưỡng trong khu vực mà rễ cây non đang phát triển có thể tiếp cận.

Giai đoạn 1 - bắt đầu trồng

Sinh trưởng tốt trong hai đến bốn tuần đầu tiên của đời sống cây trồng rất quan trọng đối với năng suất cây trồng. Sự sinh trưởng đạt được trong thời gian này có tác động lớn đến sản lượng sau cùng và số ngày từ khi bắt đầu trồng cho đến khi thu hoạch - điều không thể bù đắp qua các giai đoạn sinh trưởng sau này.

Nhằm tối đa hóa chất dinh dưỡng và sự sinh trưởng cho cây trồng trong giai đoạn bắt đầu, điều quan trọng là giữ cho phân ở trong khu vực nơi rễ non đang phát triển.

Các thử nghiệm cho thấy nếu áp dụng phương pháp rải hoặc phun phân bón hai lần một tuần (chứa tỉ lệ nitơ thấp) ở giai đoạn bắt đầu trồng có lợi ích lớn về sản lượng và rút ngắn thời gian đến khi thu hoạch. Cả hai phương pháp cung cấp đủ phân ở nơi mà rễ có thể tiếp cận được nhằm tối đa hóa sự sinh trưởng của cây trồng mà không gây quá nhiều thiệt hại cho môi trường (xem Hình 2). Nghiên cứu cho thấy dùng phân NPK dạng hạt lúc đầu, cho vào mặt trên của đất vào ngày trồng, cũng quan trọng cho việc nhằm đạt được sản lượng tối đa bất kể phương pháp bón phân nào được sử dụng sau này.

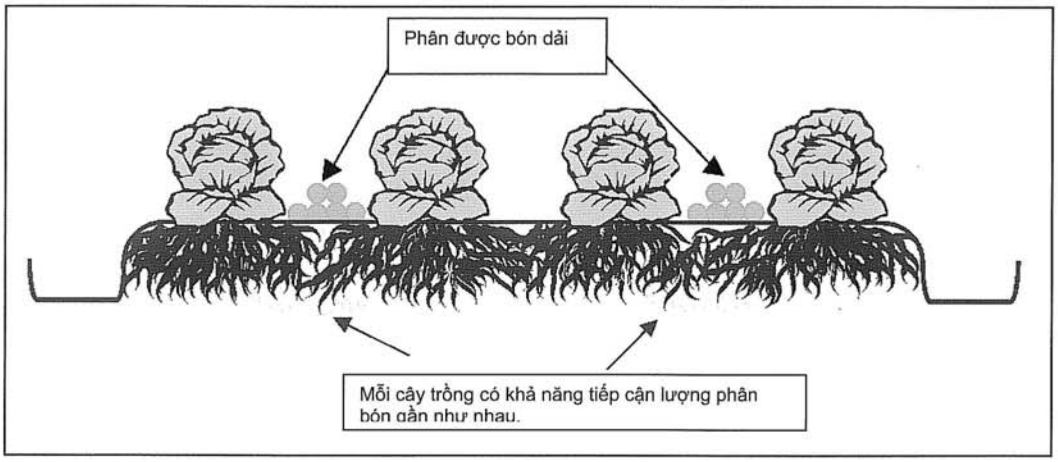
Giai đoạn 2 - sinh trưởng nhanh

Một khi hệ thống rễ đã hình thành, hiệu quả nhất là bón phân hàng tuần bằng phương pháp bón dải (banded application) (xem Hình 3). Phương pháp tưới hoặc rải phân có thể sử dụng ở giai đoạn này, tuy nhiên, khó áp dụng tỉ lệ phân bón yêu cầu với các phương pháp này mà không sử dụng nước một cách vô ích hoặc và tránh được rủi ro cháy lá do các hạt phân không hòa tan hoặc bị giữ lại. Bón dải với phân dạng hạt hợp chất là thích hợp nhất vì sẽ giảm thiểu phí phạm và cho phép mức nitơ, phốt pho và kali cần thiết có trong cùng một lượt.

Giai đoạn 3 - trưởng thành

Sau khi vun luống, đầu và những phần bán được của cây trồng mọc ra, hút chất dinh dưỡng tích lũy từ khung được phát triển trong các giai đoạn trước cũng như từ đất. Việc bón tiếp nitơ thường chỉ cần thiết nếu giai đoạn trưởng thành kéo dài hơn hai đến ba tuần.

Từ đầu mùa xuân đến đầu mùa thu (tháng 09 đến tháng 03) thường không cần phân bón thêm sau khi vun luống cho sà lách iceberg và rau diếp lá dài. Trong những tháng mát trời hơn khi sự sinh trưởng chậm hơn, khuyến nghị tưới phân hàng tuần với nitơ và kali cho đến một tuần trước thu hoạch.



Hình 3 Phương pháp bón dải ở giữa hai luống là cách hiệu quả để cho rễ hấp thụ trong suốt giai đoạn sinh trưởng nhanh

Chiến lược phân bón '3Phase'
Chiến lược phân bón "quanh năm" cho sà lách iceberg được trồng trên đất cát của Đồng Bằng Ven Biển Swan được trình bày trong Hình 4. Chiến lược này kết hợp các phương pháp trình bày ở trên với tỉ lệ được khuyến nghị và các sản phẩm ưa chuộng hơn dựa trên những kết quả nghiên cứu hiện có. Các khuyến nghị về sản phẩm, thời điểm và tỉ lệ có thể thay đổi theo các kết quả nghiên cứu trong tương lai.

Các ghi chú quan trọng cho chương trình "3Phase"

- Nitrophoska Blue Special® là sản phẩm hiệu quả nhất được thử nghiệm cho phương pháp bón rải và bón dải trong các thử nghiệm cho đến ngày nay, nhìn từ viễn cảnh hiệu quả và tiết kiệm lao động. Phân bón này chứa 12% nitơ, 5,2% phốt pho và 14,1% kali. Các sản phẩm phân bón (dạng hạt) hợp chất khác tương đương qua phân tích tương tự cũng có thể phù hợp nhưng cần được thử nghiệm.
- Bón phân rải hoặc phun trong giai đoạn 1 có thể áp dụng mỗi tuần một lần (ở tỉ lệ gấp đôi) với sự giảm thiểu một chút sản lượng cuối cùng. Khuyến nghị bón hai lần một tuần khi biết là sẽ có mưa hoặc nhu cầu tưới tiêu cao.
- Nếu bón phân trong giai đoạn 3 bằng phương pháp phun, phải rửa sạch cặn khỏi tán lá để tránh cháy do phân khi áp dụng tỉ lệ phân cao hơn ở thời điểm này so với giai đoạn 1.
- Urê không luôn là một nguồn nitơ thích hợp trong giai đoạn 3 vào những tháng lạnh nhất vì nhiệt độ có thể quá thấp cho việc chuyển hóa nó thành amoniac và nitrát.

Mốc chuẩn bón nitơ
Hình 5 cho thấy các mức độ nitơ mang đến sản lượng tối đa trong đời sống của cây rau diếp trồng trên đất cát của đồng bằng ven biển. Tổng số được báo cáo theo thời điểm trồng.
Nếu tỉ lệ bón phân hiện tại của quý vị vượt quá mức trình bày trong Hình 4 và Bảng 1, quý vị đang bón quá nhiều và đang số lượng dinh dưỡng bị mất cao đến mức không thể chấp nhận được chất dinh dưỡng cho môi trường. Các nghiên cứu trong tương lai mong đợi sẽ còn hạ thấp các mốc chuẩn hơn nữa.
Các nguyên tố vi lượng cũng nên được xem xét trong chương trình phân bón của quý vị. Việc duy trì độ pH của đất bằng cách bỏ vôi định kỳ và sử dụng sản phẩm magiê bổ sung sẽ cung cấp đủ can-xi và magiê. Việc bón rải hàng năm các nguyên tố vi lượng đầy đủ cũng là thực hành tốt cho tất cả cây trồng luân canh.

Tưới tiêu
Mỗi lần tưới nước không nên quá 3 mm vào bất kỳ thời điểm nào trong giai đoạn bắt đầu trồng (giai đoạn1). Tốt nhất nên chia nhu cầu tưới hàng ngày thành nhiều lần tưới mỗi lần 3 mm hoặc ít hơn, hạn chế sự mất chất dinh dưỡng từ khu vực rễ đang phát triển. Có thể tưới tăng lên đến 6-8mm mỗi lần ở các giai đoạn sinh trưởng sau khi khu vực rễ của cây trồng đã phát triển đầy đủ. Cần có một hệ thống tưới tiêu có khả năng tưới đều để đạt được kết quả tốt nhất.

See page 44 for Figure 4

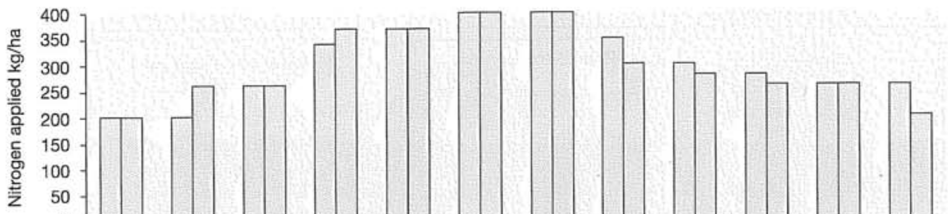


Figure 5 Nitrogen application benchmarks for the life of a crop in kg/ha according to the time of planting

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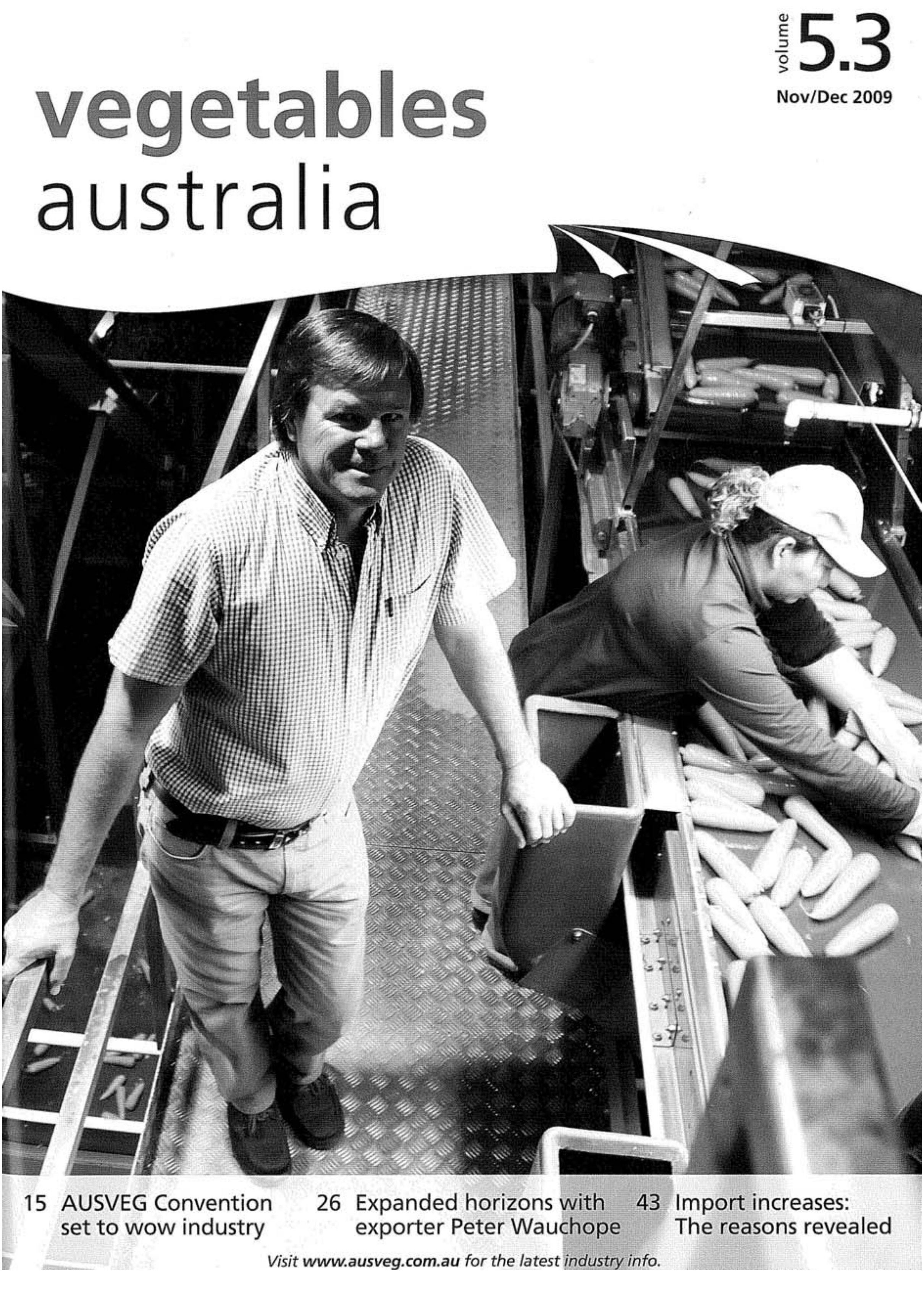

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3Phase beats nitrogen leach

Mineral nitrogen could see the end of poultry manure's costly nitrogen leaching—and its polluting after-effects—writes Angela Brennan.

For years Western Australian vegetable growers have been bombarded with complaints about the excessive number of flies due to the use of raw poultry manure to fertilise crops. Recent concerns include groundwater pollution from fertiliser nitrates. After nearly a decade of research to resolve these problems a solution is being offered to growers.

A team of Department of Agriculture and Food Western Australia (DAFWA) researchers, led by Dennis Phillips, has developed fertiliser strategies called "3Phase" that replace manure with mineral nitrogen for use on leafy and brassica vegetable crops.

Consistent results

Results of this research have been consistently positive. Mineral fertilisers, applied regularly and at rates that match plant growth, can provide an effective substitute to poultry manure. They supply less nutrients while improving uptake, reducing costs, increasing yield, maintaining quality, and significantly reducing pollution and fly breeding.

The research targets growers of lettuce, broccoli, cabbage and celery on the infertile sandy soils of the Swan Coastal Plain near Perth, but the principles are applicable in most other production areas of Australia.

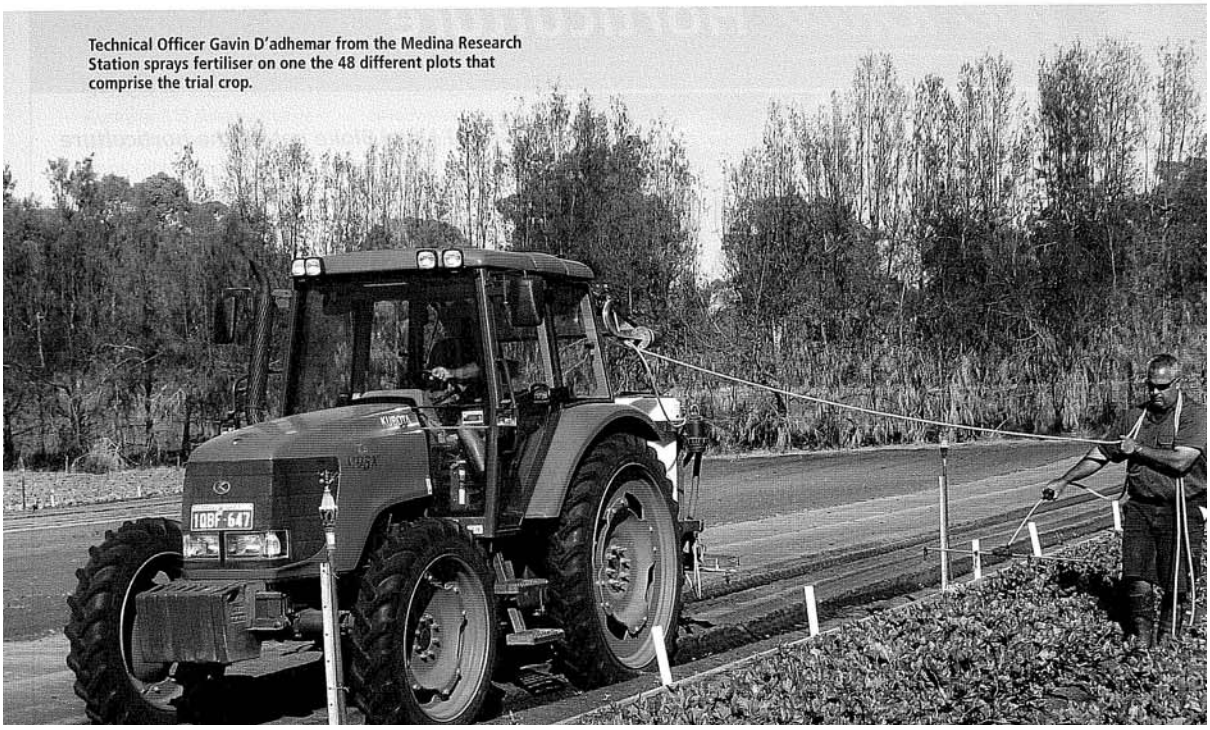
The recommendations set benchmark levels of nitrogen, potassium and phosphorus for these crops.

"We've tested these on possibly the least fertile soils in Australia, using only mineral fertilisers and limited residues from preceding crops. Trials consistently produced high yields of good quality," said Dennis Phillips.

"For higher-quality soil types we have set upper limits for nitrogen and potassium that should never need to be exceeded to grow successful crops."

At this stage of the project, the research team is keen to help growers adopt the 3Phase methodology with minimal upheaval to growers' current farm management systems.

"With 3Phase we are producing 'recipe style' blueprints that pay particular attention to the importance of early growth, while minimising the number of products, any need for special-



Technical Officer Gavin D'adhemar from the Medina Research Station sprays fertiliser on one the 48 different plots that comprise the trial crop.

ised equipment and changes to machinery settings as the crop grows. Commercial realities are also fully considered," said Mr Phillips.

"If you follow it to the letter, you can't go wrong—even if you get unexpected rainfall."

Rewarding change

Andy Tedesco and his brother Mick grow iceberg lettuces and Chinese cabbage on a small farm in Wanneroo. The brothers adopted 3Phase seven years ago.

"Change is very difficult. You are asking people to change from a system they have been using for 40 years. You need to be certain the new system is going to work better. At first we were laughing at [Mr Phillips] because his new system didn't look feasible, but gradually his research started to look better than our fertilising program so we gave it a go," said Andy Tedesco.

"At first, our previous system with manure seemed easier. But we'd put the whole lot on at the start of a crop and by the time the plants matured a lot of that nutrition had leached away. There was no benefit to the crop and it was getting into the water. This is our drinking water," he said.

"3Phase is more precise and costs less because we use everything that goes onto the crop. We've been using this method since 2002 and we have not lost any production."

Leave nothing to chance

"Growers need significant reasons to make fundamental changes to the way they grow crops," said Dennis Phillips.

"The dramatic rise in the price of some fertilisers in the past year has been one driver for change, but issues such as groundwater pollution have not been enough to convince everyone, and there is a risk that many growers won't change until the situation reaches crisis point."

Pollution was not what stirred Damien Rigali to adopt 3Phase on his farm. "I simply didn't get the quality I needed using my father's

Growers inspect trials at Medina with Project Leader, Dennis Phillips [left]. Images supplied by Dennis Phillips.

I'm teaching him," said Mr Rigali.

"The old system was too risky. You could lose an entire crop's fertiliser in one heavy downpour. Now I leave nothing to chance. It's not cheaper at the outset, but it's more efficient and savings are made at the end. I have more control and more certainty; the quality is better, there is more growth."

> "3Phase is more precise and costs less because we use everything that goes onto the crop."

Mr Rigali had his soil tested and nitrates on his property were down to 14ppm (parts per million), compared with 140ppm on nearby properties still using poultry manure.

"We save on irrigation, fertiliser and our own time. Our only problem is labour. But I've done my figures and I still make more even though I have had to take on another worker," said Damien.

Soil health considerations

Many growers argue against the

health. Dennis Phillips does not agree, and queries some practices that are put out to promote soil health.

"Compost and cover cropping can play an important role in improving the efficiency of plant nutrition but they work best in an environment where there is a good understanding of the crop's mineral nutrient needs," he said.

"There is still a lot of work to do and future funding is subject to the outcomes of the current project and the levels of grower uptake.

"A number of growers have used the research results to cut their fertiliser rates and costs. Others will benefit from the information we can provide when poultry manure is banned for use in 2011. In the long term, the two key outcomes will be less pollution and more cost efficient production. It's a win-win for

THE BOTTOM LINE

- 3Phase fertiliser strategies have been developed to promote early crop growth. They also minimise product numbers and reduce the need for changes to machinery settings as the crop grows.
- Growers who have adopted 3Phase have found it successfully fertilises crops and reduces nitrogen leaching.
- Labour costs may increase with the 3Phase methodology, but savings are made on irrigation and fertiliser costs.

For more information contact:
Dennis Phillips, Director Horticulture Industries Development, Department of Agriculture and Food WA
Email: <dennis.phillips@agric.wa.gov.au>
Phone: 08 9368 3319
or visit www.ausveg.com.au/levy-payers
Project number: VG07036
Keywords: Mineral fertilisers

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New fertiliser practices

A project to develop fertiliser practices using only mineral fertilisers has coined the term '3Phase' to describe the new methods.

Year-round production guidelines for lettuce and broccoli using 3Phase have been published and similar guidelines for celery and cabbage will be released soon. Benchmark rates of nitrogen on sandy soils established through this research are also relevant as upper limits for the same crops grown elsewhere in Australia on better soils.

Leaching studies confirm poultry manure as the major source of nitrate loss to groundwater. This, together with recent press about groundwater pollution and the forthcoming 2011 ban on poultry manure use, are driving increased adoption of 3Phase.

New research this year has shown broadcast granular NPK fertilisers to be better than sprays in the crop-establishment phase when rainfall or irrigation rates are high. The high cost of potassium nitrate is now leading researchers to focus on the third phase, where optimising fertigation will greatly reduce costs.

Project VG07036

For more information contact:
Dennis Phillips, DAFWA
T 08 9368 3319
E dennis.phillips@agric.wa.gov.au

Trials require customised methods to apply fertilisers on a plot-by-plot basis

Trial field day

Best practice farm programs for IPM and pesticides

Five 'best practice programs' have been developed for vegetable growers and researchers, providing detailed, practical information on various fungicide-control options for specific vegetable diseases.

The two-year project is in its final year and programs have been developed for:

- Sclerotinia (individual reports for lettuce and beans)
- Downy mildew
- Powdery mildew
- Fusarium, Pythium and Rhizoctonia.

The programs list current pesticides available and provide critical comments on their reported effectiveness, their impact on beneficial insects and other biocontrol agents, the impact on the grower, consumers and the environment, their resistance potential and future availability for each target disease.

Each of the programs has been through several reviews involving growers, government agencies, consultants and retailers. The reviews are now being completed with final versions to be issued soon.

The programs provide practical information that growers can implement on their farms for a sustainable and IPM-compatible production system.

Project VG07109

For more information contact:
Peter Dal Santo, AgAware Consulting
T 03 5439 5916
E pds@agaware.com.au

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Department of **Agriculture** and **Food**
Government of **Western Australia**

Malcolm Nanovich
Nanovich Farms
PO Box 384
Wanneroo WA 6065

Your Ref:
Our Ref: 45-0041
Enquiries: D. Phillips
Date: 2 July 2008

Dear Malcolm,

Further to our discussion today, please accept my thanks for the effort that you and your staff, particularly Mehdi and Max have put in to the adoption of new high efficiency fertiliser practices for lettuce.

It is very gratifying to be told that these new practices have been recognised by your produce buyer for the superior quality lettuce they produce. From the work that we have done together on this, you now know that high quality crops can be produced with significantly less fertiliser than was used in the past. More efficient use of fertiliser has never been more important than it is now with recent sudden and dramatic increases in fertiliser costs. It is pleasing that this new production method has allowed you to stabilise your total fertiliser bill for lettuce in the face of these rising costs with no loss of yield or quality.

As well as producing a juicy and tasty product that represents good value for consumers, this new method has a number of other advantages in the marketplace. The risk of microbiological contamination of the product should be greatly reduced compared to conventional production because no manures or organic waste products are used at any stage and little, if any, fertiliser is applied in the last few weeks of the crop's life. Because fertiliser rates are significantly reduced with this method, it is more environmentally friendly than conventional production methods, reducing the potential for excess fertiliser to leach into precious groundwater. This is good for you and should also have some appeal for consumers of your product.

This method for growing lettuce, using highly concentrated nitrogen sprays in the establishment phase followed by banding of mixed fertiliser from establishment to row closure has been developed in stages over the last 8 years by Department researchers with funding from Horticulture Australia Limited (HAL) and the vegetable industry levy. We are now in our third project since 1999 and this most recent project aims to ensure widespread adoption of the method for transplanted vegetable crops grown on sandy soils. Lettuce is the first of these, with broccoli and celery to follow.

These projects and techniques have had a good deal of coverage in the Horticultural press since 2004, with reports in the *WA Grower*, *Good Fruit and Vegetables*, *Vegetables Australia* and the *Australian Vegetable Review 2007*. However, there is no substitute for demonstration work on growers' properties to get adoption, and we need growers like you to take some risks to prove that we can do things better. We welcome the support of your produce buyer to encourage other growers in WA to explore these methods on their farms to ensure that we get a payoff for the money that the vegetable industry has already spent on this research.

3 Baron-Hay Court, South Perth Western Australia 6151
Postal address: Locked Bag 4, BENTLEY DELIVERY CENTRE WA 6983
Telephone: (08) 9368 3201 Facsimile: (08) 9368 3846 E-mail: dphillips@agric.wa.gov.au

- 2 -

I look forward to adapting this method for broccoli production on your farms with your ongoing support.

Yours sincerely,

Dennis Phillips
SENIOR DEVELOPMENT OFFICER
DEPARMENT OF AGRICULTURE AND FOOD WA

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at

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- When to starting and stop fertiliser application – timing is all important
- Replacing fowl manure with nitrogen sprays
- Granular vs liquid products for top-dressing

Come and inspect these trials at a time convenient to you!

Ring
Dennis Phillips (08) 9368 3319 (0404819621)
or
Aileen Reid (08) 9368 3393
To arrange a time (before July 25th)

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- in the public carpark at the corner of Sutton and Gibson streets
- in unmarked bays in the carpark opposite the PWC corner Sholl and Gibson streets
- on the roof of the Rivers Superstore (entrence off Tuckey Street)

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Lettuce and Broccoli growers

Save serious money on fertiliser with the '3Phase' method

Growers, consultants and suppliers are invited to view new lettuce and broccoli trials at Medina Research Station at a time convenient to you from now to November 30

Location: Medina Vegetable Research Station, 60 Abercrombie Road, Medina

Contact: Dennis Phillips P: 9368 3319 M: 0404819621 E: dphillips@agric.wa.gov.au
Aileen Reid P: 9368 3393 E: areid@agric.wa.gov.au

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