All About Almonds
Fact Sheet 06 – Statistical Analysis of Data from the Almond Optimisation Trial

Welcome to the sixth edition of "All About Almonds", Statistical Analysis of Data from the Almond Optimisation Trial. Fact sheets are distributed to almond growers via email and fax, in addition to being made available for download from the levy payers' access page on the ABA website: www.australianalmonds.com.au (follow links to the login section of the "industry" page).

The information provided in these fact sheets should be kept confidential.

Background

The Almond Board of Australia with the assistance of Horticulture Australia Ltd has undertaken a production based, research and development project entitled "Developing Optimal Nutritional and Irrigation Requirements for Almonds" or "the CT Trial" over the last 7 years. Over that time a large amount of data has been collected. To date only the production data have been discussed in detail. The Project management team has recently engaged a statistician to undertake an analysis of the water, soil chemistry and yield data to provide a **preliminary** summary of the trends over time which will provide the industry with **guidance as** to **the likely effects of the innovative nutritional and irrigation approaches that have been incorporated into the trial,** and which have caused such interest within the Australian almond industry. Due to the nature of the trial, the difficulty in making sense of results obtained with younger trees and the need for several seasons of repeatable data on older trees, it has not been possible to develop "optimum" requirements for a mature almond orchard which can be applied widely. However, the results to date do provide some food for thought and emphasise the sorts of monitoring that will be necessary if the CT Trial management techniques are to be successfully adapted/adopted by the Australian almond industry.

Soil chemistry data were not collected from all treatments so the data presented later were drawn from the three fertiliser treatments listed in Table 1.

The yield data were taken over the production years 2004/2005, 2005/2006, 2006/2007 and 2007/2008 from the following treatments:

		Irrigation Applications	Fertiliser Applications (N:K)
Fertiliser Treatments	1	100% (approx 15-18 ML/Ha)	240kg/ha : 400kg/ha
	2	100% (approx 15-18 ML/Ha)	320kg/ha : 600kg/ha
	3	100% (approx 15-18 ML/Ha)	480kg/ha : 800kg/ha
Irrigation Treatments	4	100% (approx 15-18 ML/Ha)	320kg/ha : 600kg/ha
	5	160% (approx 25-28 ML/Ha)	320kg/ha : 600kg/ha
	6	60% (approx 11-12 ML/Ha)	320kg/ha : 600kg/ha

Table 1. Almond Optimisation Scientific Treatments as of 2007/2008.

Irrigation – Yield responses to increasing application of water

The statistical analysis indicated the economical, optimal water application where the cost of an additional megalitre of water would provide a 100% return on investment in that megalitre of water for the CT Trial was between 13.6ML/Ha and 13.8ML/Ha (Figure 1). The analysis was based on the following assumptions:

- A minimum, seasonal water use figure somewhere between 6ML/Ha would be required to “just” grow a commercial crop and justify harvest,
- 100% value placed on water by assuming 0% water allocation,
- The value of water would be $500/ML,
- Kernel value set at $5.70/kg,
- No consideration of any possible effect of restricted applications on next seasons harvest or other aspects of tree growth or performance, and
- Only considering the theory of diminishing returns of an investment in water and **not** profitability. That is, based on the yields achieved at the CT Trial an estimation of what the Trial could afford to pay for water before the return from yield could not account for 100% of the value placed or spent on water.

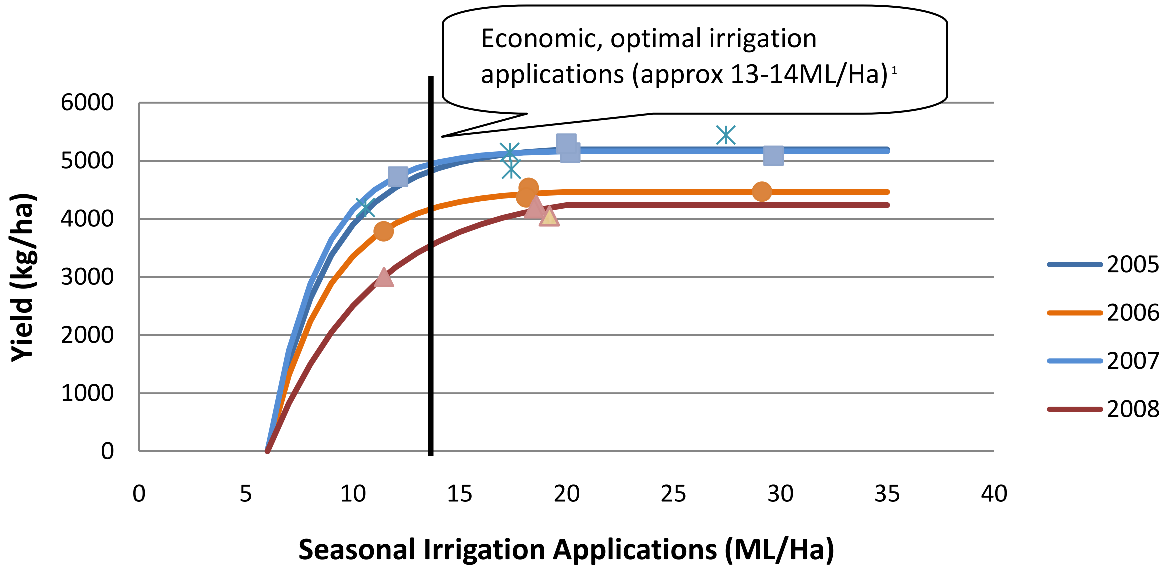

Figure 1. Yield response to varying, seasonal irrigation quantities.

[1] Economic, optimal irrigation application of 13-14 ML/Ha based on the above assumptions. For a more detailed analysis refer to Table 2.

The following sensitivity analysis (Table 2) was also produced. It shows the sensitivity of economic, optimal irrigation rates (these numbers are expressed in the body of the table by a colour scaling) to changes in cost of water and kernel returns. As with Figure 1, Table 2 also considers the theory of diminishing returns of an investment in water, it does **not** take into account profitability. Profitability of each individual property has its own defining circumstances based on interest and principle, depreciation, operational expenses, etc. As an example, if the CT Trial budgeted its long term average yield of approximately 4.5 tonnes/ha and wished to investigate what would the economic optimal irrigation rate be if the budgeted kernel value was $5.00/Kg and the leased water price started at $500/ML and moved to $600/ML. Using Table 2 and its assumptions, $500/ML would suggest 14-16ML/Ha would be the most economic optimal irrigation rate. That is, every dollar spent per megalitre of water would be replaced by the amount of money received ($/Kg) from the orchard and processor. However, using the above scenario, if the price of water increased to $600/ML, the entire cost of 14-16ML/Ha would not be 100% replaced by the money received ($/Kg) from the orchard and processor – but an investment in a water rate of 12-14ML/Ha would be 100% replaced.

	Cost/Value of Water ($/ML)							
Kernel Value ($/kg)	**$300**	**$400**	**$500**	**$550**	**$600**	**$700**	**$800**	**$1,000**
$0.50	[yellow]	[red]	[red]	[red]	[red]	[red]	<6ML/Ha	<6ML/Ha
$1.00	[green]	[yellow]	[yellow]	[yellow]	[yellow]	[yellow]	[red]	[red]
$1.50	[light blue]	[green]	[green]	[green]	[yellow]	[yellow]	[yellow]	[yellow]
$2.00	[light blue]	[light blue]	[green]	[green]	[green]	[green]	[yellow]	[yellow]
$2.50	[light blue]	[light blue]	[light blue]	[green]	[green]	[green]	[green]	[yellow]
$3.00	[dark blue]	[light blue]	[light blue]	[light blue]	[light blue]	[green]	[green]	[green]
$3.50	[dark blue]	[light blue]	[light blue]	[light blue]	[light blue]	[light blue]	[green]	[green]
$4.00	[dark blue]	[dark blue]	[light blue]	[light blue]	[light blue]	[light blue]	[light blue]	[green]
$4.50	[dark blue]	[dark blue]	[light blue]	[light blue]	[light blue]	[light blue]	[light blue]	[green]
$5.00	[dark blue]	[dark blue]	[dark blue]	[light blue]	[light blue]	[light blue]	[light blue]	[light blue]
$5.50	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[light blue]	[light blue]	[light blue]	[light blue]
$6.00	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[dark blue]	[light blue]	[light blue]	[light blue]

- [red] 6 to 8 ML/Ha economic, optimal water use application
- [yellow] 8 to 10 ML/Ha economic, optimal water use application
- [green] 10 to 12 ML/Ha economic, optimal water use application
- [light blue] 12 to 14 ML/Ha economic, optimal water use application
- [dark blue] 14 to 16 ML/Ha economic, optimal water use application

Table 2. Sensitivity of water use figures in relation to changes in water and kernel value. Assumes the long term average yield at the Trial of approximately 4.5 T/Ha, maintenance water of between 3 and 7 ML/Ha to "just" grow a commercial crop and justify harvest, and 100% value placed in water based on 0% allocation.

Soil Chemistry

A first look at the impact of different management strategies on the chemistry of the soil (sampling position of 20cm from the dripper) indicated the following trends. The graphs depicted below are examples which best illustrated the trends in soil chemistry. Whilst the graphs are only of an individual treatment and depth range, the trends were consistent across all water and fertiliser treatments involved in the sampling procedure.

Soil pH

Firstly, significant soil acidification has occurred in the topsoil during the life of the Trial (Figure 2). Acidification is expected when nitrogen fertilisers which contain ammonium or urea are applied, particularly where there may be loss of nitrogen through the rootzone to drainage. It can be more serious where “point source” irrigation or intensive, drip irrigation systems are used. The acidification has predominantly occurred in the last two seasons where despite applications of lime to the soil surface, the soil pH has continued to decrease (become more acid). The likely cause of the sudden drop in soil pH depicted in Figure 2 is the exhaustion of the soil buffering capacity. This will occur faster in a sandy soil than in one that contains a higher percentage of clay and soil buffering capacity.

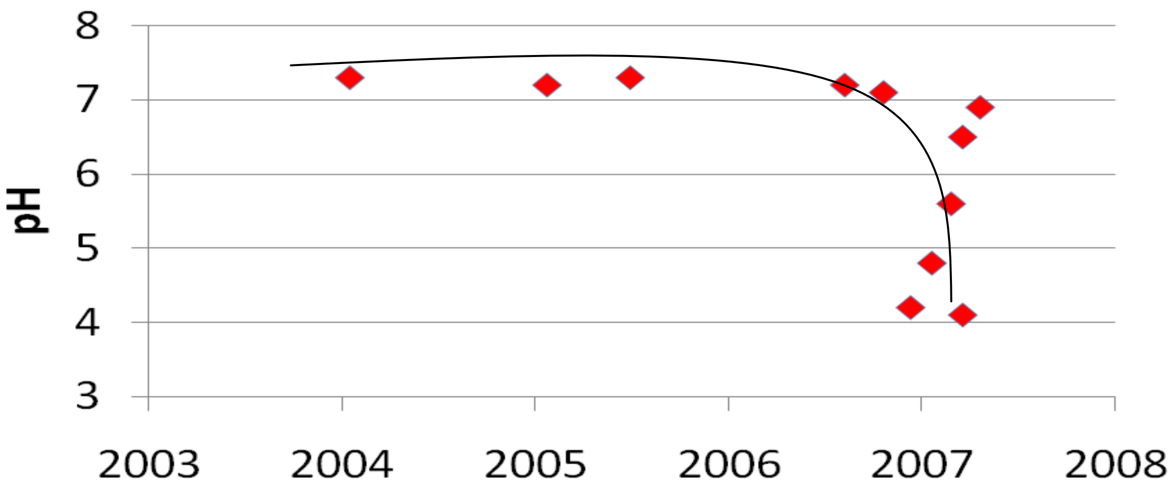

Figure 2. Treatment 2, 12.5-20cm.

Soil Salinity

Secondly, there has been an increase in soil salinity levels below 50cm (Figure 3) – this is a common feature of drip irrigation in low rainfall areas and with water sources that contain natural salts. To keep the rootzone free of damaging salinity it is necessary to build in a “leaching fraction” to move the salinity past the root zone.

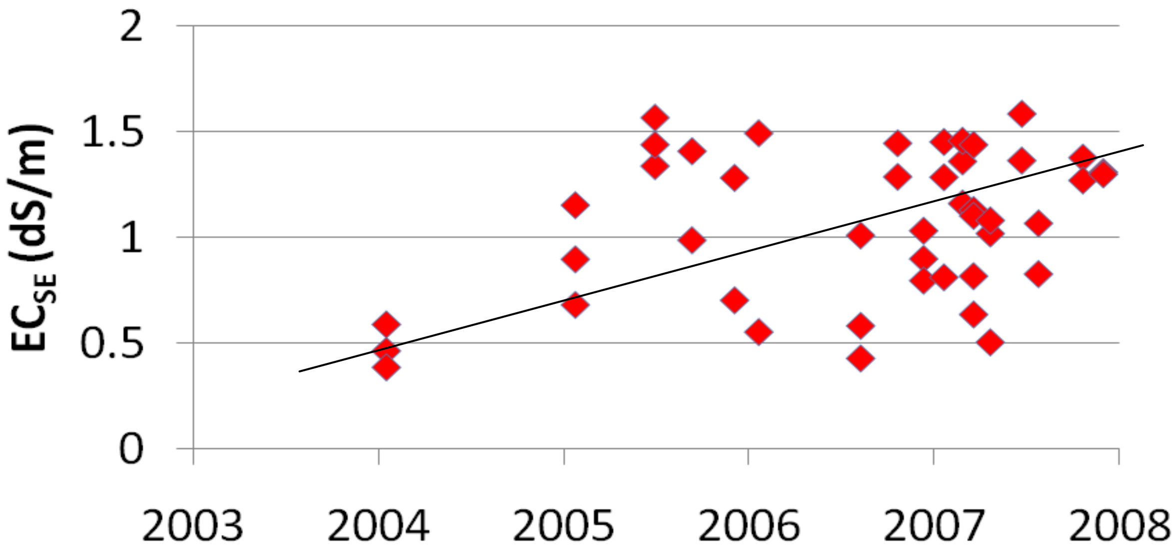

Figure 3. Treatment 1, 20-51cm.

Soil Nitrate Nitrogen

Thirdly, there has been a significant increase in the concentration of nitrate nitrogen below 50cm (Figure 4) – this is of concern to an orchard manager as it represents a waste of a resource and an unnecessary cost. In addition, it poses a risk to the environment and may mean that such a management system is unsustainable.

The movement of nitrate nitrogen through the soil profile is often a feature of irrigated horticulture. Nitrate nitrogen has a negative charge, urea is neutral and consequently neither are held up by the negatively charged exchange sites of the soil. The movement may also be attributed to an imbalance between the amount of nitrogen-containing fertilisers **applied** and the amount **required** by the trees. However, an analysis of the inputs (i.e. fertiliser quantities) in comparison to the outputs (i.e. crop removal of nitrogen) suggests a neutral to slightly negative nitrogen balance in the Trial. Consequently, the movement of nitrate nitrogen is more likely to be due to leaching rather than excessive applications of nitrogen fertilisers.

It is worth noting however, that a perfect nitrogen balance is very difficult to achieve and often only a 50% nitrogen use efficiency is achieved.

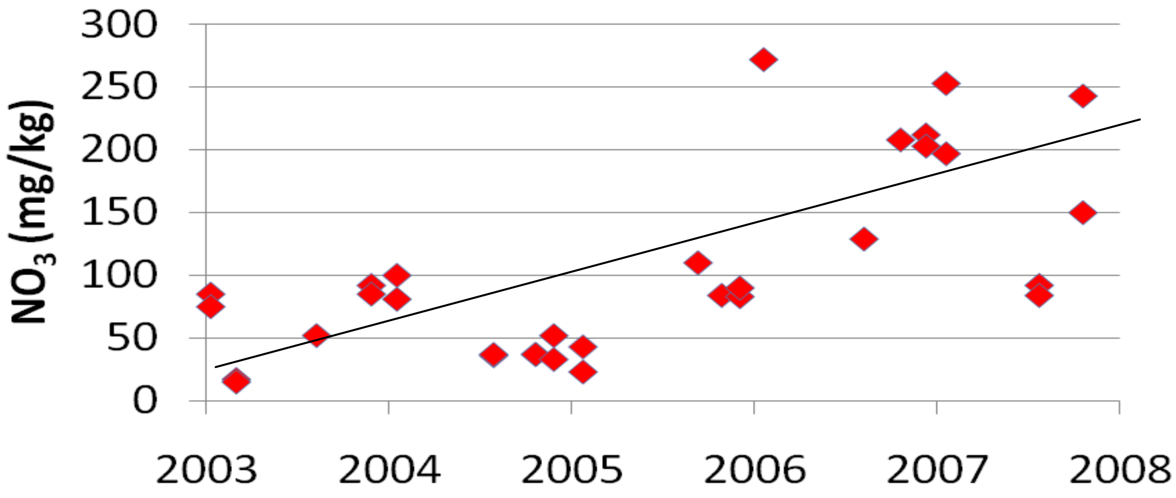

Figure 4. Treatment 1, 100-151cm.

Soil Potassium

Fourthly, the data indicates a significant increase in available potassium below 50cm (Figure 5) – this is also of importance to growers who may wish to adapt or adopt the strategies trialled at CT Farms. Movement of potassium through the soil profile and below the rootzone is not a common feature in irrigated orchards as potassium is positively charged and is more likely to bind with the negatively charged soil particles rather than be leached away. An analysis of the inputs (i.e. fertiliser quantities) in comparison to the outputs (i.e. crop removal of potassium) suggests a neutral to positive balance of available potassium in the Trial. Consequently, the movement of potassium could be attributed to an out of balance supply, leading to an increase in soil solution concentrations of potassium (i.e. available potassium) and the movement through the soil profile brought about by slight over application of irrigation water at some times in the season.

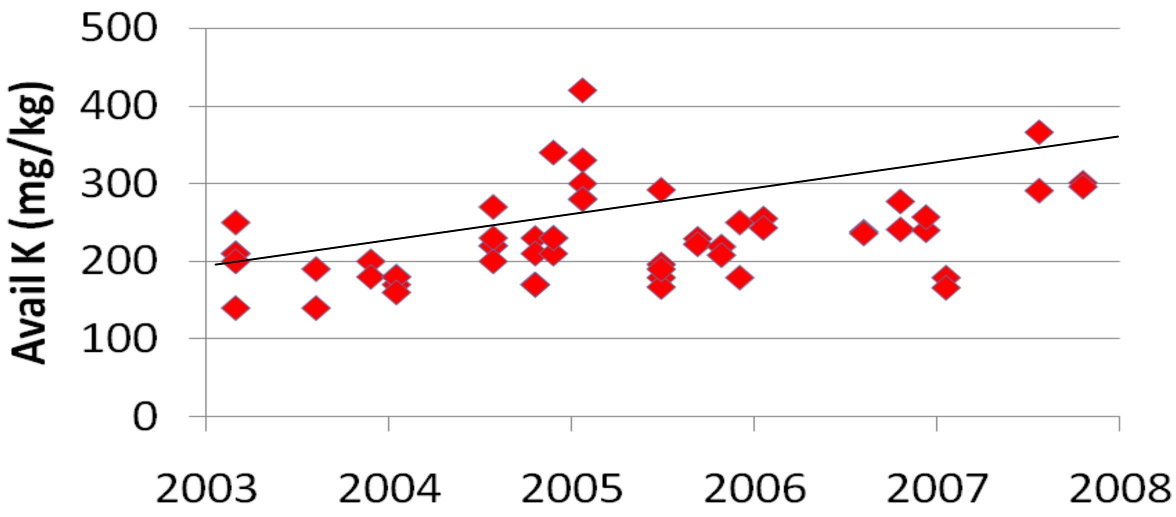

Figure 5. Treatment 1, 51-100cm.

Future Directions

The questions raised by the detailed examination of the soil chemical data have pointed out that management of the movement of water and nutrients such as nitrogen and potassium under an intensive, pulse irrigation regime are not fully understood. Both on the trial site and on any sites where the experience at the Trial is being adapted for commercial use, constant analysis of water movement through the soil profile and measurement of changes in soil chemical values will be needed if the system is to be sustainable. It is to address these issues that new features have recently been introduced to the CT Trial. These include:

a) The installation of soil solution extractors to monitor soil pH, nutrient movement, nutrient concentrations and nutrient uptake. It is hoped that this work will identify when losses to leaching occur and define the extent of such losses. It will also show how serious the build up in salinity below the rootzone might be and whether there will be risks to future tree health and crop production.
b) A closer investigation of the crop factors and associated irrigation quantities for the 100% irrigation treatments. It is hoped that this work will make it possible for orchard managers to control (not prevent) the losses of water below the rootzone.
c) A more detailed investigation of a nutrient balance between inputs (i.e. fertiliser applications) and outputs (i.e. crop removal of nutrients). This will mean better nutrient use efficiency and lowered production costs.

Monitoring is important

For further information on appropriate sampling procedures where components of the CT Trial are being tested on commercial orchards contact Ben Brown, Industry Liaison Manager. It is obvious that pH changes in the soil occur slowly and nutrient losses through the rootzone are not at this stage too serious. However, an annual monitoring program could help define risks and point to management changes in time to forestall development of more serious problems.

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