Optima AGRICULTURE Growing for the future

CalSap and Cropping by Chris Hourigan (B. Agr. Sc.)

Introduction

CalSap is an alkaline liquid calcium source that provides significant benefits when applied to acidic, sodic and saline soils. CalSap helps remediate the production limiting levels of harmful and toxic elements such as Aluminium and Sodium that can be associated with these soils.

CalSap is a relatively new product (7 years old), which has been subjected to a significant amount of field-testing and industry scrutiny in that time. CalSap has been trialed extensively around Australia since 2005, predominantly in broadacre crops which have shown that CalSap has proven results in improving fertilizer efficiency, reducing levels of sodicity, and acidity, increased root development and remediating soil pH. Since its inception, CalSap has continued to be improved through extensive research & development that now has CalSap leading the market with its levels of soluble calcium and its handling and flowability characteristics', especially when compared against its competitors calcium products.

How does CalSap fit into cropping?

The major benefit of CalSap use in cropping comes from liquid injection at seeding. CalSap offsets acidity, improves root growth and regulates nutrient uptake. It also controls soluble aluminium, sodium and salinity in the root zone. Rates between 5-10 L/Ha have proven to have a very economical return. Costs of application in bulk can be as low as $ 6.50 a hectare. For farmers already set up and injecting UAN (Flexi-N/Easy N), CalSap can easily be mixed with UAN and can be injected at the same time.

CalSap can also be mixed with UAN as a foliar spray throughout the season. Rates between 3-8 L/Ha has been demonstrated to improve nitrogen use by the plant.

CalSap is a versatile product that can and should be applied to most soils to improve production. However, to provide a meaningful perspective, some of the production limiting problems that CalSap can help overcome are:

Low soil pH (root zone)
The availability of macronutrients nitrogen, phosphorus, potassium, calcium and magnesium and most trace elements are affected by soil solution pH. By targeting and improving the pH in the area of soil (not total soil) where early seedlings are establishing, improvements in plant growth are seen, particularly in root growth.

Aluminium Toxicity
Soils high in aluminium and low in pH allow aluminium to become toxic to plants. Root zone soil pH in the range below 4.6 can have toxic levels of aluminium. Aluminium toxicity affects root development and growth, and greatly limits yield. A smaller root system will not take up as much soil moisture and plant nutrients. High nitrogen application in the root zone decreases pH and can make aluminium levels toxic.

Salinity
High levels of sodium chloride limit agricultural production by causing toxic levels of sodium to occur in the plant. Saline water in the root zone also limits the amount of water the plant can take up.

Hard soils and soils high in sodium
On clay soils, production can be limited by a hard crust or lower hard pan, where root growth and water infiltration are limited. Sometimes, high sodium levels can cause these problems. They limit agricultural production by dispersing when wet, and forming a hardpan when dry. Hardpan soils limit nutrient uptake, water infiltration and root development.

This document provides information on trial work performed with CalSap, field observations and the response of plants and soils to CalSap application.

Soil pH amendment in the root zone
CalSap contains liming reagents, but should not be viewed as a liquid lime! There are some products in the market that are liquid limes, but the development of CalSap has been to create a soluble calcium source, that will remain soluble in the soil, and provide a number of benefits over acid neutralization.

CalSap can help increase soil pH in the root zone, as it contains complexed hydroxyl (OH-) ions. This component can neutralize some of the acid in the emerging plants root zone, particularly when injected below the seed at seeding, the area used by the emerging plant. The soluble calcium in CalSap can also outcompete soluble aluminium when seedlings were establishing.

Applications of CalSap at 5-10 L/Ha injected at seeding on cereal crops has demonstrated the ability of CalSap to change soil pH and improve root growth, particularly in areas where ammonium based fertilizers (DAP, MAP) decrease the root zone pH.

Broadacre Trial - Esperance 2007 *(see figure 1.0 below)*
In this replicated trial on wheat in acidic sandy soil in Western Australia, 5 L/Ha of CalSap + 25 L/Ha of UAN were liquid injected at seeding, 5 cm below the seed. In the other treatments only 25 L/Ha of UAN was added.

The trial also included using a NPK mineral fertilizer (WMF @ 80 kg/Ha) and granular acid based NPK fertilizer (M Pro at 2 rates (80 kg/Ha and 65 kg/Ha). The granular fertilizer (M Pro) contained 10 % ammonium nitrogen, which contributes to soil acidity.

The soil pH in the root zone was recorded at seeding and at monthly intervals. CalSap had the effect of maintaining and increasing root zone pH.

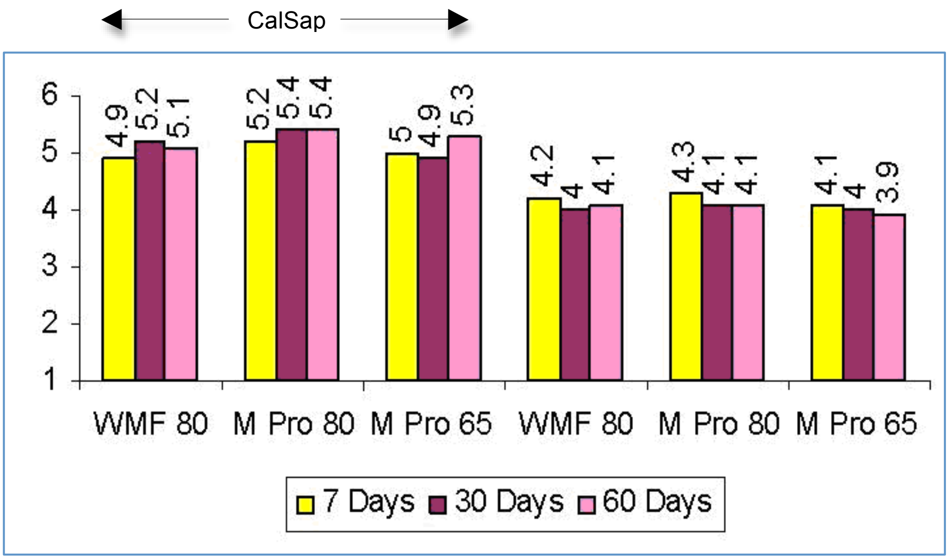


Figure 1.0: pH of root zone soil taken at 20 cm depth at 0, 30, 60 days after planting with and without CalSap at 5 L/Ha injected at seeding, 10 cm under the soil surface. *Source: Injekta 2007*

The increase in soil pH and other effects of CalSap increased the yield of the wheat crop.

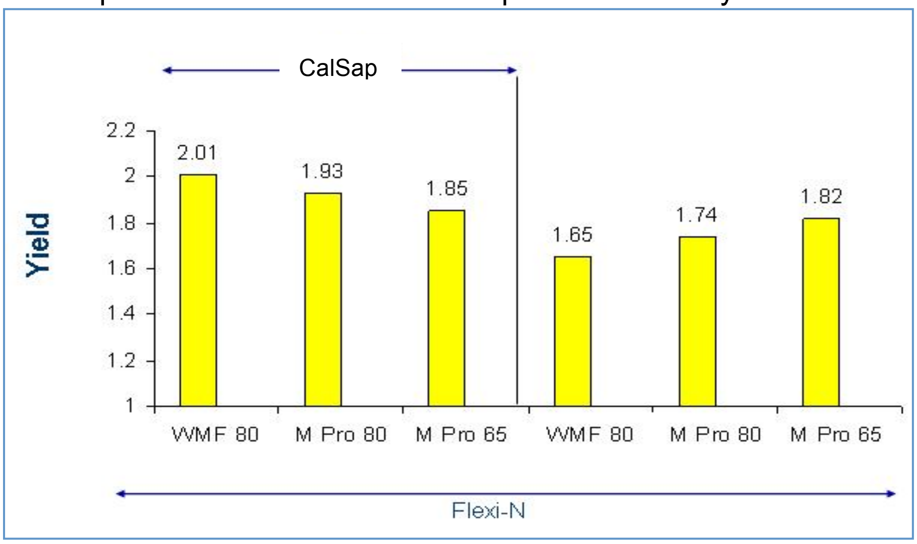


Figure 2.0: **Yield results of Esperance 2007 CalSap trial**

Further trials on soil pH in the root zone are listed below under nitrogen use efficiency, due to how the trial was performed.

Reduction in soluble aluminium in the soil

The other benefit of applying CalSap at seeding below the seed is that it provides an abundance of soluble calcium that stays soluble in the root zone. Supplying and concentrating the higher level of soluble calcium in the root zone can actually buffer out production limiting nutrients in soil, such as aluminium and sodium.

This is where CalSap is set apart from lime and other calcium products on the market. Calcium in traditional sources of lime, like limesand is very insoluble and the majority of that calcium exchanges onto the soil particle (only after being released by acid). Once on the soil particle, the calcium is unavailable for the plant, and the soil solution.

CalSap calcium is complexed, meaning that it will stay soluble in solution, and is available to the plant. It is concentrated in the soil solution (water in soil), yet, because it is complexed, it will remain in the root zone and will not leach out of sandy soils, making the product extremely versatile for ameliorating soil problems.

It is known, yet not widely, that higher rates of calcium in the soil solution can reduce aluminium toxicity without the soil altering (Rengel 1992). If a more available calcium can be applied in a targeted zone where roots will develop (an area containing high amounts of soluble aluminium), then the toxic effects of aluminium can be 'buffered' out.

So CalSap has been designed to 1) Increase soil pH in a targeted area and 2) Provide available calcium to be readily acquired by a growing seedling early in its growth to provide a root system to push through high aluminium zones of soil.

Nitrogen Uptake Increase and pH amendment

CalSap has also been found to improve nitrogen uptake by plants as both a liquid injection application and also as a foliar application. The exact mechanism of how soluble calcium regulates the uptake of nitrogen is not clearly defined, however there is evidence in previous trials. This information is again not widely known in industry.

Addition of soluble calcium sources to N fertilizers have been found to increase the uptake of Ammonium (NH_4^+) nitrogen by plants (Sung & Lo 1990, Taylor *et al.* 1985, Fenn *et al.* 1991, Fenn *et al.* 1986, Fenn *et al.* 1987, Hallmark *et al.* 1997), even on acidic soils that have had a large amount of lime applied as a source of insoluble calcium.

CalSap is now routinely banded below the seed, not only for its buffering ability and pH remediation, but also to improve Nitrogen Use Efficiency (NUE) by seedlings. Independent trials conducted in Western Australia have recorded increased crop yield from applying CalSap with UAN on sandy, acidic soils numerous times, as evidenced by the Beverley and Esperance 2009 results.

Liquid Injection Trials
Esperance 2009
A triple replicated trial was conducted at Esperance in 2009 on wheat, where CalSap was liquid injected at 4 L/Ha on a low pH, low CEC white sand with 30 L/Ha of UAN. Ammonium forms of nitrogen contribute to soil pH. Yield data and average soil pH are recorded in figures 3.0 and 4.0 below.

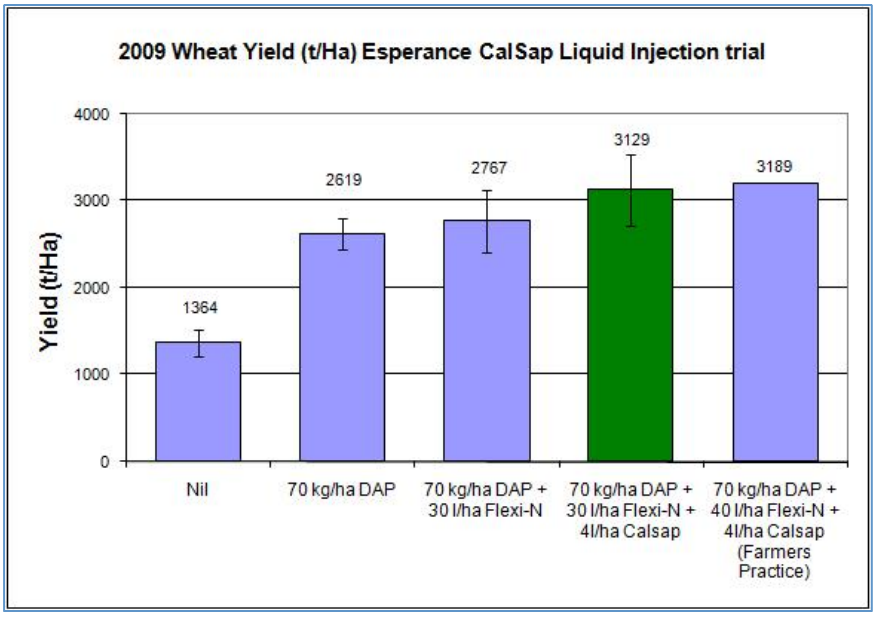


Figure 3.0: Yield results from a trial at Esperance Western Australia on a low CEC white acidic sand (pH_{ca} 4.8). *Source: Injekta 2009.*

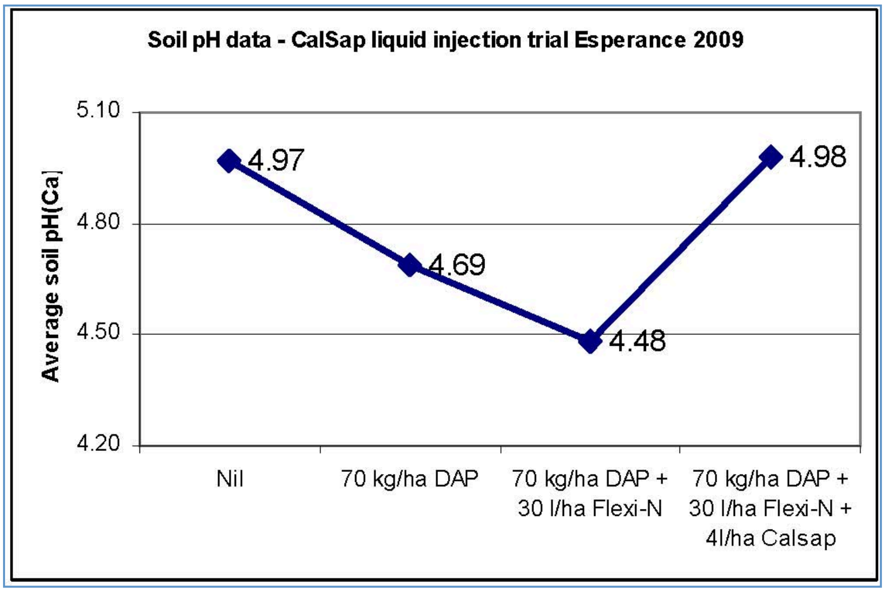


Figure 4.0: Average soil pH of soil collected from area 5 cm under the seed for each treatment.

Beverley WA 2009

A four block replicated trial was conducted at Beverley in 2009 on wheat, where CalSap was liquid injected at rates between 5-10 L/Ha on a low pH sandy loam soil. Variable rates of UAN and potassium humate were also liquid injected with the CalSap. Yield data and average soil pH are recorded in figures 5.0 and 6.0 below.

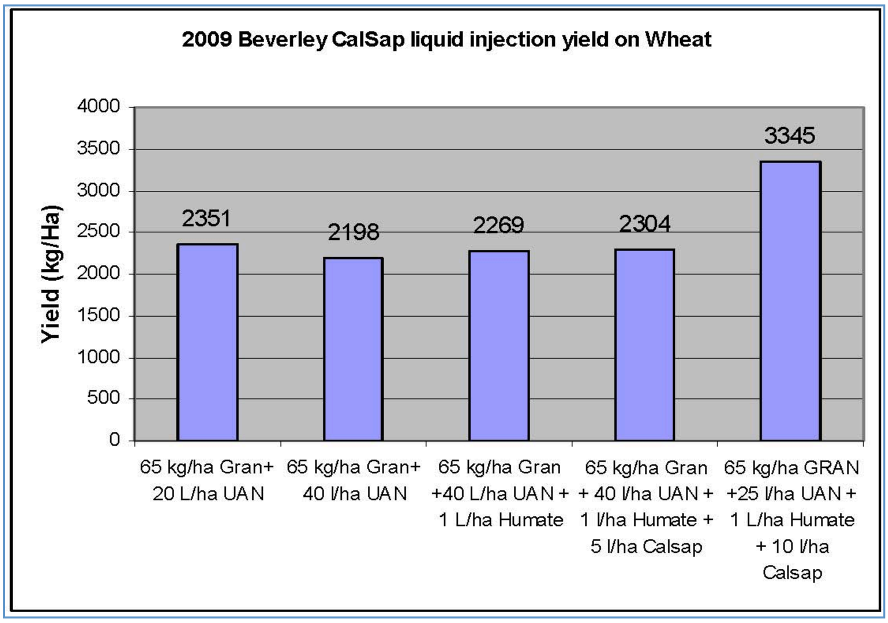


Figure 5.0: Yield results from a trial at Beverley Western Australia on an acidic sand (Starting soil pH_{ca} 5.0). *Source: Injekta 2009.*

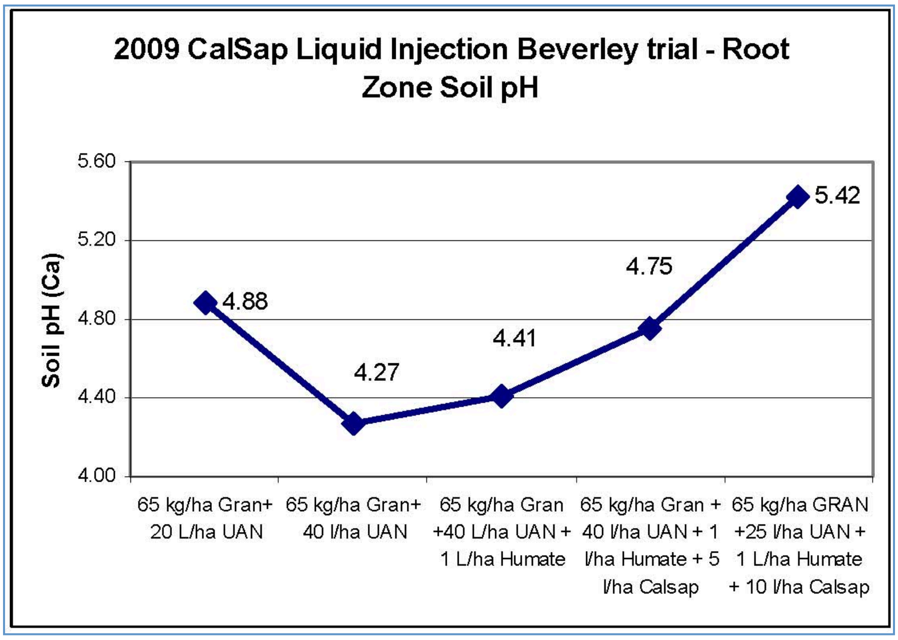


Figure 6.0: Average soil pH of soil collected from area 5 cm under the seed for each treatment.

Esperance 2007

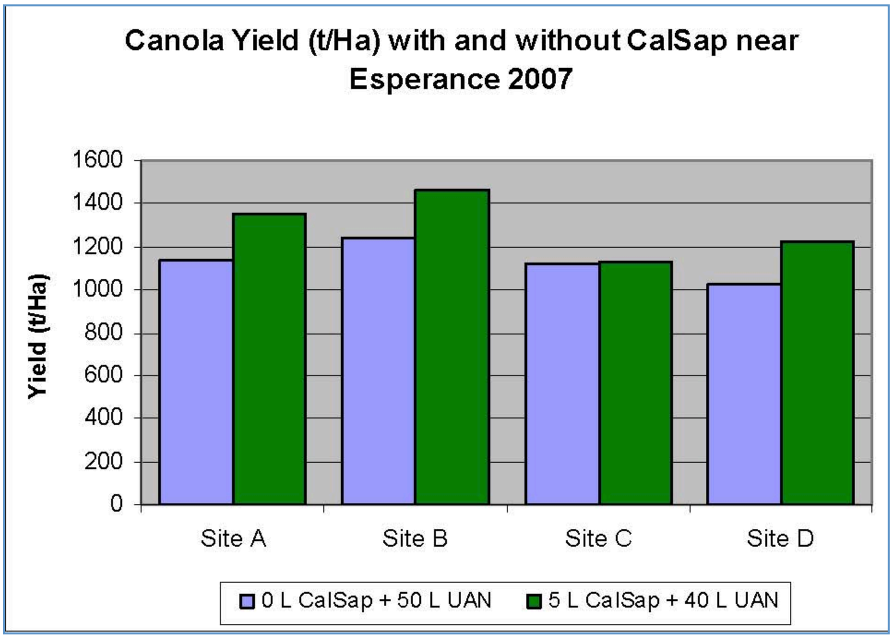


Figure 7.0: Yield results of Canola from a farmer done/performed trial on acidic sand near Esperance WA 2007. *Source: Optima Agriculture 2007*

Goomalling WA 2008

CalSap was liquid injected with UAN on a triple replicated trial near Goomalling WA. The trial area was hit by frost, yet small increases in yield were seen where CalSap had been applied. Plant Sap tests taken in spring displayed higher levels of nitrogen in the plant sap, demonstrating improved nitrogen uptake with CalSap application.

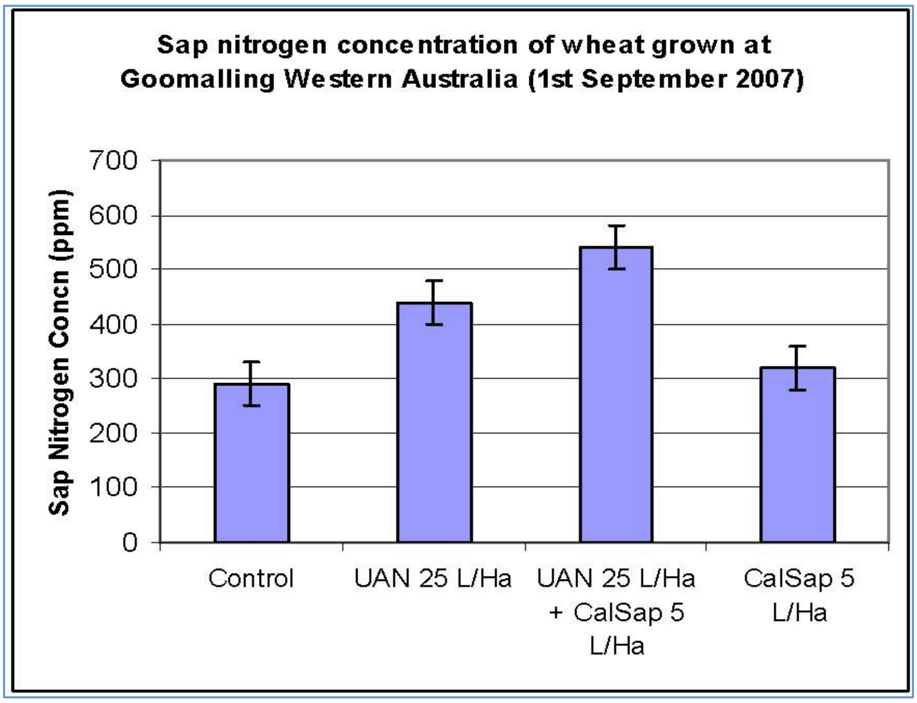


Figure 8.0: Nitrogen sap concentrations of wheat trial grown on acidic sands. Trial was hit by frost, yet small yield increase on UAN + CS plot. *Source: Injekta 2007*

CalSap applied as a foliar with Nitrogen
CalSap is also routinely added with UAN in boom sprays, as a foliar N application throughout the growing season. Independent trials conducted in Western Australia have recorded increased yield on Barley of UAN with CalSap application.

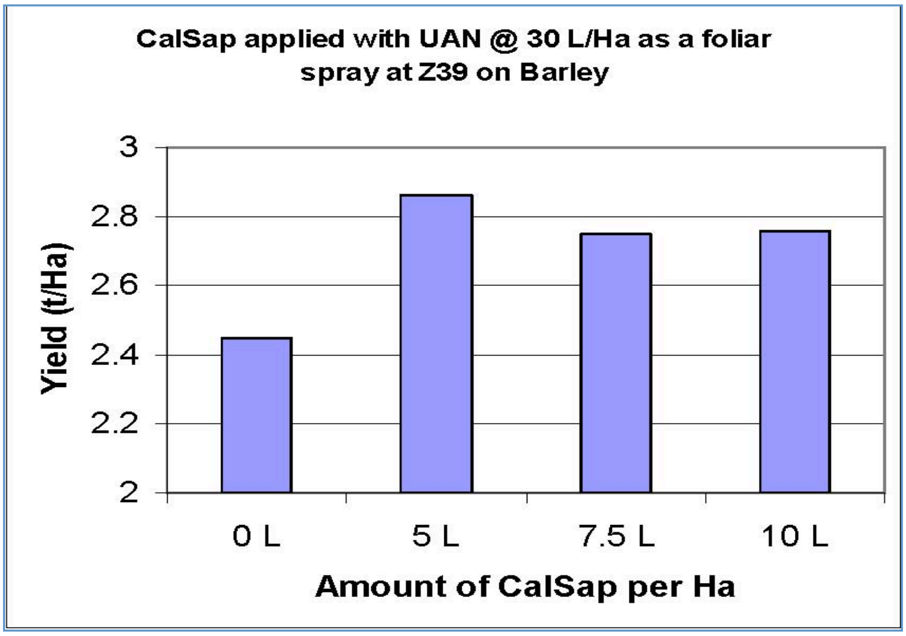


Figure 9.0: Yield results of CalSap applied at variable rates with 30 L/Ha of UAN as a foliar spray on malting barley, Greenhills WA 2008. *Source: Living Farm*

Improved utilization of ammonium Nitrogen by the plant (without being toxic) has been stated as a major area to improve nitrogen use in broadacre cropping (Ruan & Johnson 1999). Why? Improving ammonium absorbtion by the plant actually reduces the amount of energy used by the plant to convert N to protein by ¾. This leaves additional energy for carbohydrate production and grain filling. When in the plant, the plant requires 5 ATP mol^{-1} to convert ammonium N to protein against 20 ATP mol^{-1} for conversion of nitrate N to protein.

The data below shows sap nitrate and ammonium concentrations of wheat given combinations of UAN, CalSap and a control.

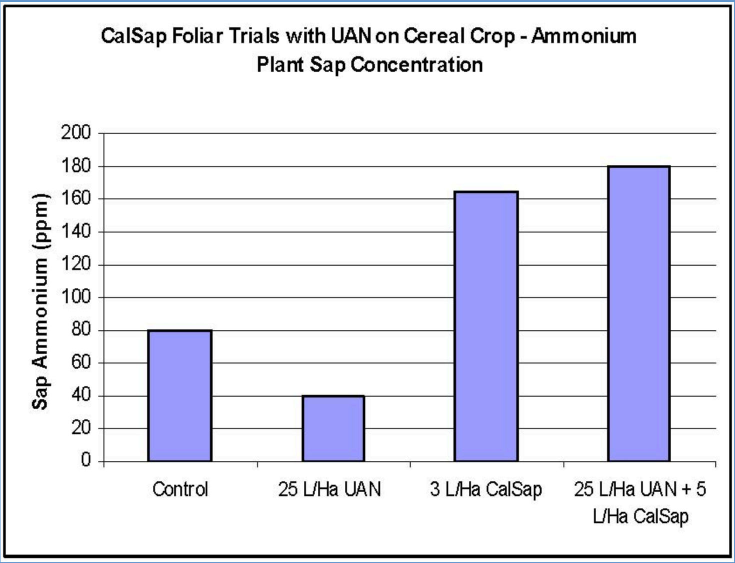


Figure 10.0

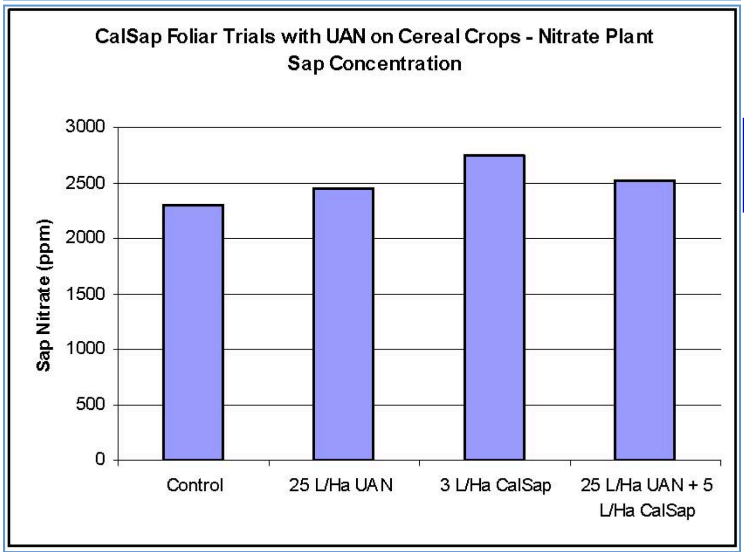


Figure 11.0

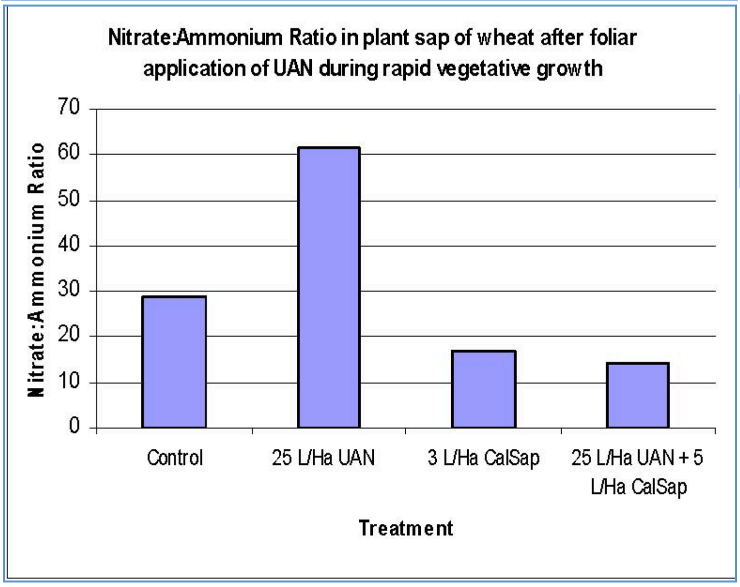


Figure 12.0

Figures 10.0, 11.0 & 12.0: Plant sap concentration of nitrate, ammonium and the nitrate: ammonium ratio of wheat treated with a foliar spray of 25 L/Ha UAN, 3 L/Ha CalSap and a combination of both. *Source: Injekta 2007*

CalSap and salinity
CalSap application has been noticed to improve plant growth when applied after irrigation with saline water in turf and horticulture. It has also been trialed on soils naturally high in salinity in broadacre farming, with results being better plant growth. Below is information from soil tests that indicate a reduction in sodium and chloride in side by side and also before and after results.

Meningie, South Australia

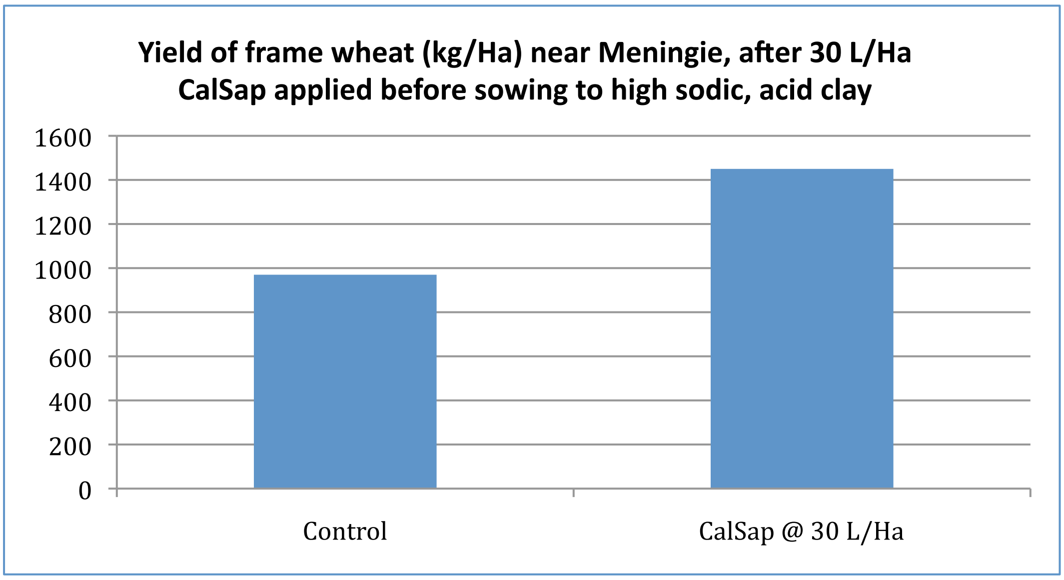


Figure 13.0: Average yield of wheat after CalSap was applied to high sodium, high magnesium dispersed clay soil at Meningie SA. Fertilizer was 80 kg/Ha MAP. *Source Injekta 2008*

ID	N (as NO3)	P	K	Ca	Mg	Na	S	B	Cu	Zn	Mn	Fe	Al	Cl	pH	ORP	Ece
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	mg	mg	mg	mg/kg	mg/kg	ppm	ppm		mv	dS/m
WITH 30 Ltrs	98.4	2.2	89	144	66	488	73	0.92	na	0.21	0.47	3.58	7.2	199	5.6	362	2.75
NO CalSap	65.1	0.97	69.5	197	86	982	197	0.89	na	0.01	0.47	8.01	13.6	489	5.5	366	4.47

Table 1: Soluble Ion Paste Test conducted on soil by Australian Perry Agricultural Labs, South Australia. The soil samples were taken from pasture at Meningie South Australia, where CalSap was applied at 30 L/Ha CalSap and a control plot. Source: Injekta 2007

There was a reduction in soluble sodium and chloride after CalSap was applied at 30 L/Ha to bare soil with a boom spray before a crop was planted, compared to the control. The soil pH was almost identical between treatments.

Lara, Victoria
CalSap was applied via boomspray to bare soil at 30 L/Ha, in autumn 2008 to dryland cropping paddock. There was a massive reduction in sodium and chloride in soil rests taken pre and post application. There are certainly plenty of evidence at higher rates of application mitigate the effects of salinity on the growing plant. Research is continuing on the effects of CalSap on salinity.

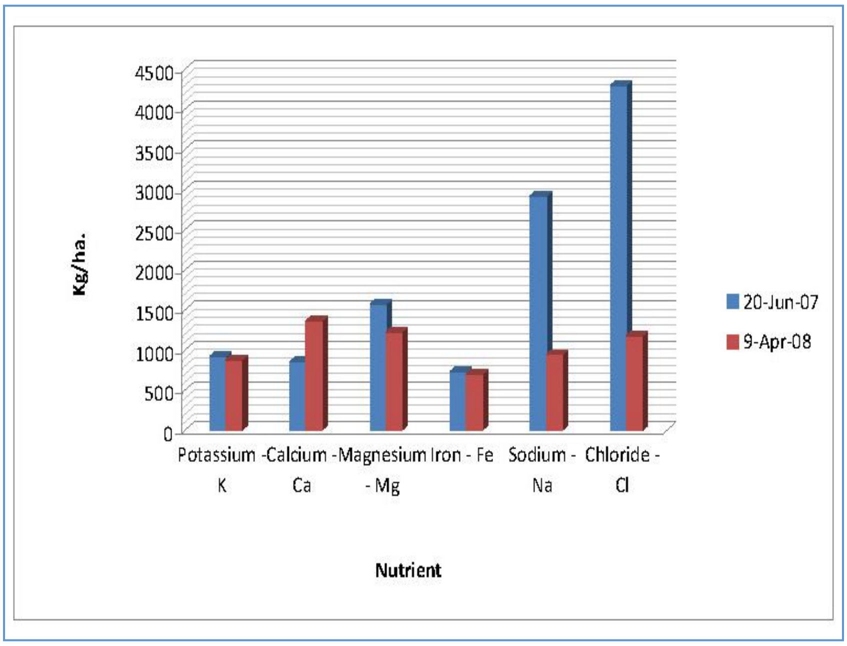


Figure 14.0: Change is sodium chloride levels in soil near Lara VIC, before and after CalSap application @ 30 L/Ha in autumn. *Source: Injekta 2008.*

Cucurbits - Virginia, South Australia

Figure 15.0

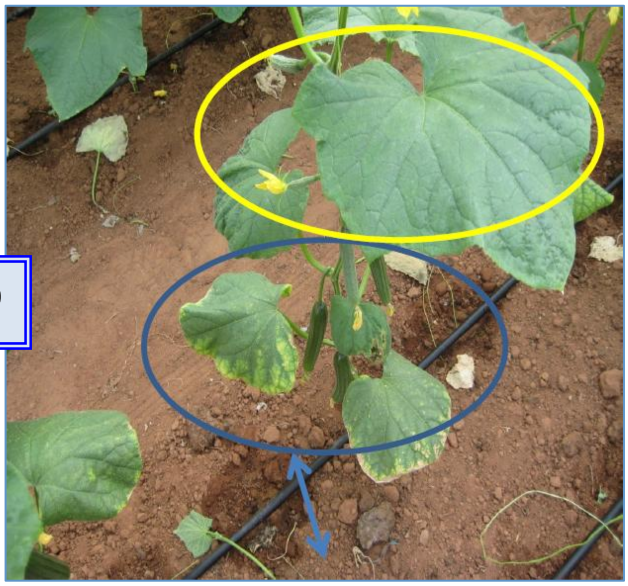


Figure 16.0

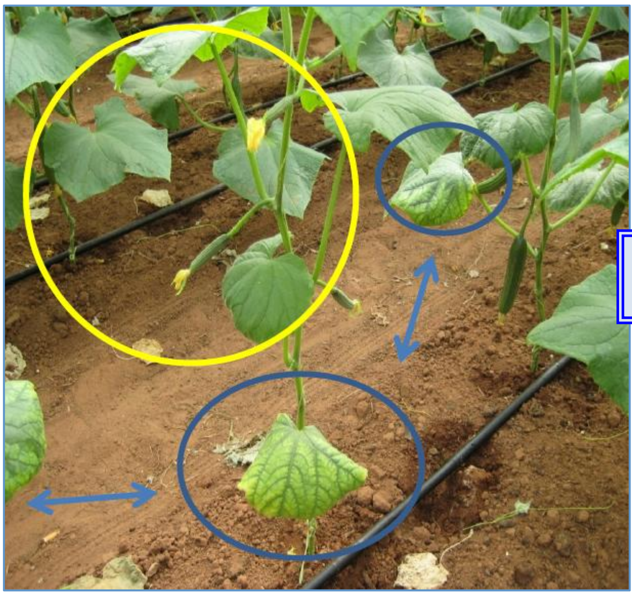
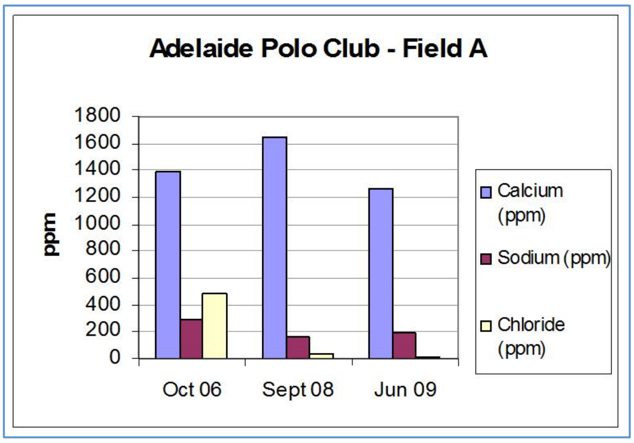
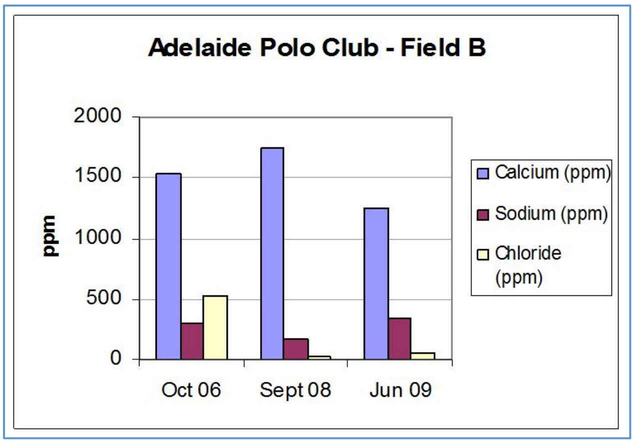


Figure 17.0

Figure's 15.0, 16.0 & 17.0: Lebanese cucumbers 21 days after CalSap application @ 50 L/Ha. Saline water used in drippers caused damage to the growing plant near Virginia, South Australia. Irrigation water salinity was approx 4300 ppm. *Source: Seasol International*





Figures 18.0 & 19.0: Reduction in salinity on turf irrigated with saline water, before (October 2006) and after (Sept 08 and Jun 09) applications of CalSap. The data is soil tests, there was a massive decrease in chloride in the soil. *Source: Injekta 2009*

Figure 20.0: Picture of the Adelaide polo club turf during summer, where salinity levels in water are higher.

Increasing Potassium Uptake

Potassium uptake on low pH soils is a problem because pH limits availability and a low CEC on sandy soils limits the ability of potassium to 'sorp' and remain in soil throughout the growing season. CalSap has been found to improve potassium uptake in plants.

Increases in solution calcium concentrations have resulted in a number of observed changes that have benefited growing plants, resulting in increased yields and more nutrient dense plants (Jacobson *et al.* 1960). An increase in the calcium content of epidermal root cells has been shown to increase and allow for selective uptake of potassium (Leggett and Gilbert 1967). Calcium is taken up in plant roots by cells just behind the growing root cap. By applying CalSap, increases in potassium uptake as a total % of dry matter have been recorded. Statistically significant increases in potassium content in potatoes have also been observed.

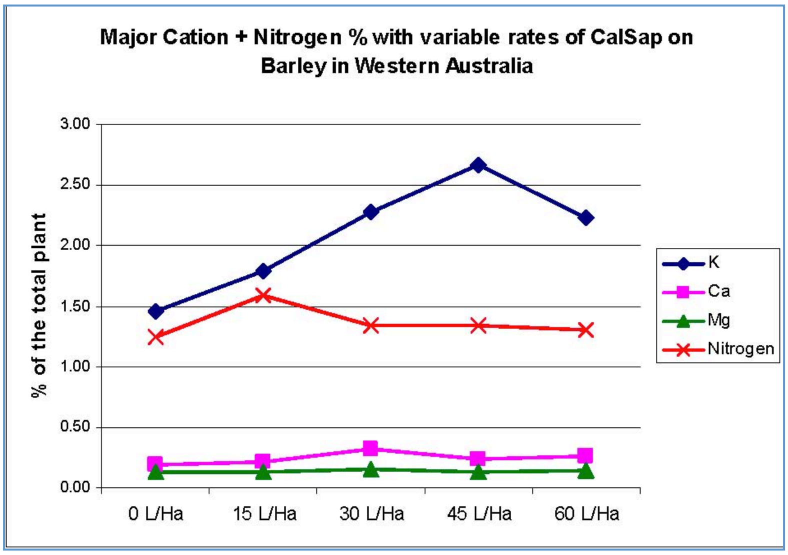


Figure 21.0: Dry matter % of major cation makeup of Barley plant from variable rates of CalSap applied 2 weeks after seeding (2 July 2009). Samples were taken 20 October 2009 Source: Optima Agriculture

Root Development

Increased root development has been observed with CalSap. On an acidic (pHCa 4.8) sandy soil, significant increases in root weight were recorded with CalSap application at Goomalling WA (Injekta 2007).

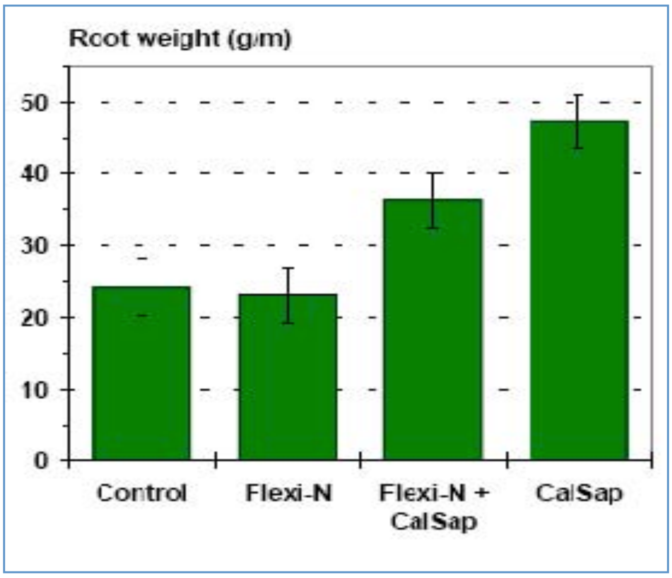


Figure 22.0: Root weight of wheat plant (grams per meter of root) recorded with UAN (Flexi-N), UAN + CalSap and CalSap injected 5 cm below seed at planting at Goomalling WA 2007.

Use of CalSap of Alkaline soils

CalSap has been used extensively in alkaline soils in Australia. The predominant soil types where CalSap is used are sodic and saline soils. CalSap is being used to displace sodium from soil exchange sites, encourage nitrogen efficiency, reduce chloride levels, stabilise salt EC (conductivity) and stimulate root growth with soluble plant available calcium. Alkaline soils can have high levels of sodium, which can create hard pans, limiting root growth and water penetration. Although not limited to alkaline soils, high sodium and magnesium soils share the common hard soil problem.

CalSap effect on sodium in soil and on hard setting soils

Hard soils limit plant growth by reducing the water infiltration when wet, and limit root growth. High sodium and to a lesser extent, high magnesium in soils have been scientifically known to cause this problem. However, some soils are also hard due to physical compaction that has occurred over time, even though a soil test indicates there are no underlying chemical problems. CalSap has been applied to both soils high in sodium and also to hard soils in general, with the result being improved soil structure and more friable soil, capable of improved water infiltration and water holding capacity.

CalSap's effect on hard clays

Observations on applying CalSap to dispersed hard soil through the drippers to an apple tree at Shepparton, Victoria 2007.

Water movement through profile was significantly better (350 % increase). Tensiometer readings indicate improved water penetration and storage. The estimated saving on water application because of better soil infiltration rates and depth of water movement was 27% in 2007 year. A very significant cost saving and far more effective use of water.

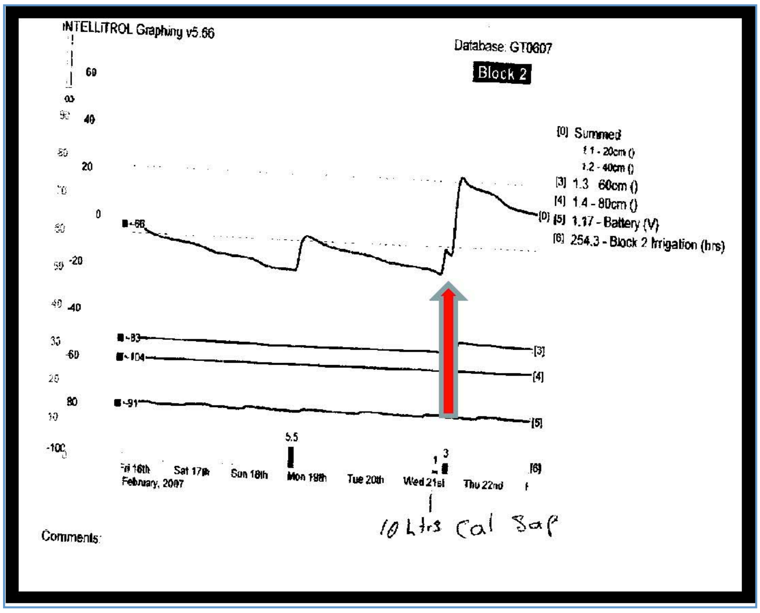


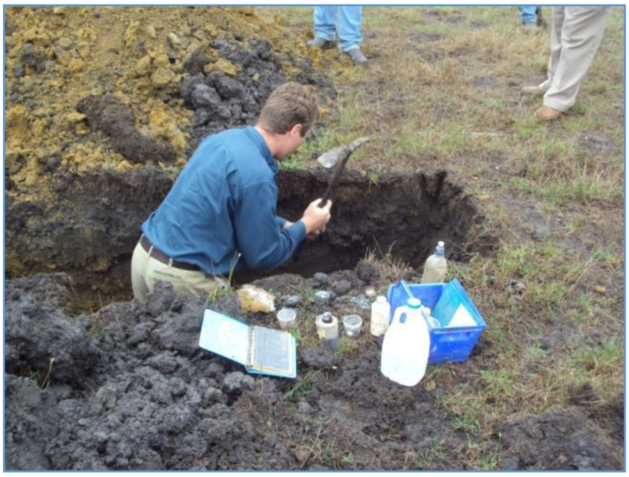
Figure 23.0: Effect of CalSap on water infiltration applied to a dispersed clay as measured with tensiometers

Western Victoria

Improved soil structure has resulted in improved water drainage and storage in Western Victoria.

Below are photos of soil pits dug on heavy acidic, high magnesium clay. The two paddocks are neighboring paddocks, however CalSap has been applied at 40 L/Ha for 4 years on one paddock, compared to traditional fertilizer practices on another.


Figures 24.0 & 25.0: Control paddock. Picture taken in March 2010 after a dry summer where water infiltration was limited and drained off the surface. This soil also has water pooling on it in the wetter months.



Figures 26.0 & 27.0: Picture taken 100 m away on the same day (over treeline in figure 25). Improved soil structure, resulting from CalSap application has allowed for water and air to penetrate soil during spring, decreasing waterlogging, and also water to be retained through the dryer parts of the year. Improved root growth is also noted. 'Softening' and improvements in soil structure have been noted on several soil types by users of CalSap.

Improved root development was observed on acidic clay soils also in Ashbourne, South Australia

Figure 28.0: Canola roots of CalSap treated (left) and control (right) on acidic, sodic clay soils.

Figure 29.0: Barley roots of CalSap treated (right) and control (left) on acidic, sodic clay soil.

Sodium reduction in soils

Traditionally, hard soils have been associated with a high sodium content (>6 % Exchangable sodium) in soils. CalSap has demonstrated an ability to reduce sodium % in soils. CalSap has been used extensively in the turf industry for sodium displacement, where sodium is a production problem.

Ballarat Golf Course

The 10th fairway at the Ballarat GC was soil sampled in March 08. CalSap was applied @ 40 L/ha and another soil sample was taken in the 10th fairway 2 months after application.

The July soil sample clearly shows the dramatic drop in Sodium Base Saturation from 33% to 16% and the significant rise in Calcium Base Saturation levels.

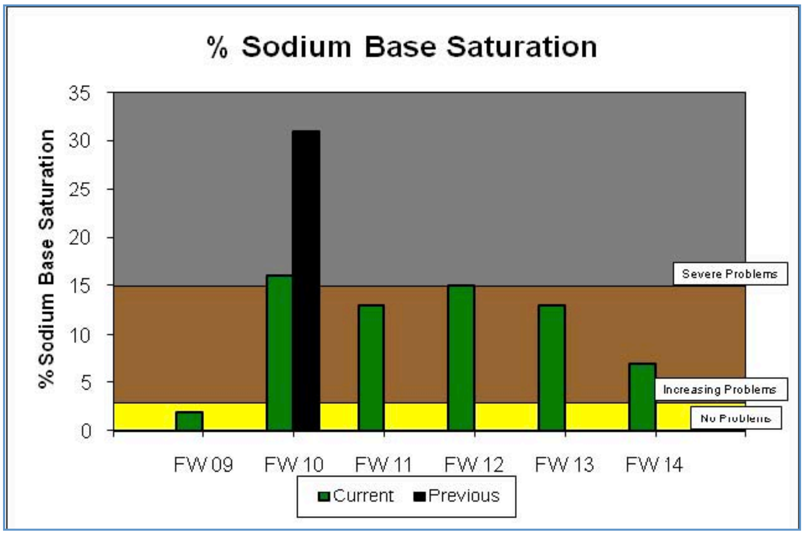


Figure 30.0: Sodium % of base saturation on clay soil from Ballarat Victoria golf course after application of CalSap @ 40 L/Ha. Source: Australian Golf Course Superintendants Technical Services 2008.

Romsey Racecourse

Romsey Racecourse in Victoria has high sodium clay soils on the racetrack. CalSap was applied once in early April and again in early May 2008 through sprinkler irrigation. The effect was a decrease in sodium as a base saturation by 5 %.

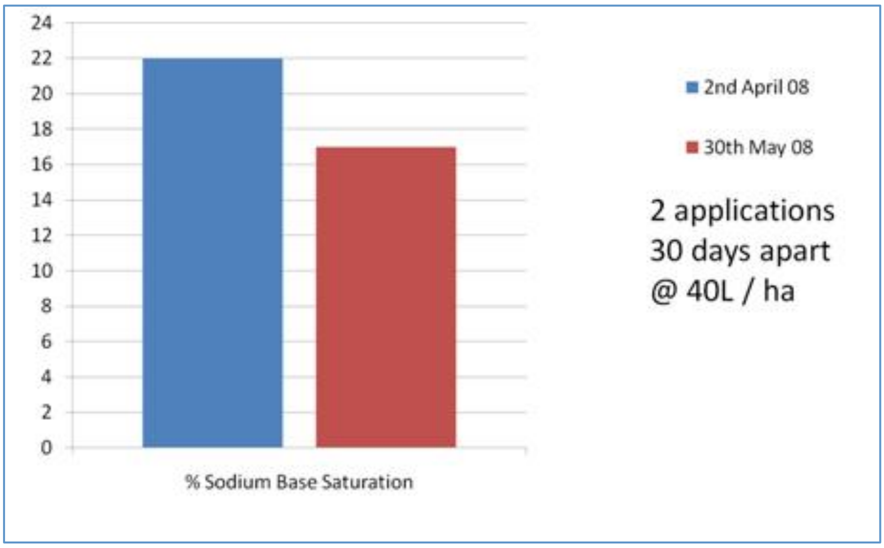


Figure 31.0: Change in sodium base saturation % in 2 months from application of CalSap at 40 L/Ha in Early April and early May 2008. Source: Independent Turf Services 2008.

CalSap is currently used in many industries to overcome several production-limiting problems, particularly broadacre agriculture. Research into the additional benefits that CalSap is providing plants and soil has currently provided many positive results, demonstrating the versatility of CalSap. Further research is continuing in Australia and internationally to prove that CalSap can provide benefits into almost any soil.

If you would like further information on CalSap, then call Optima Agriculture on 1800 246 546, or go to the website, www.optimaagriculture.com.au.

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