The influence of Diatomaceous Earth (Si) on the growth and development of Date Palms and the potential role of Si, P and K in reducing slip skin disorders in Medjool Date Palms, grown under moderately saline irrigation water in the Riverland of South Australia.

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ABSTRACT

The South Australian Mallee region is characterised by alkaline soils. The site where the date palms are grown in this trial are from a moderately saline backwater of the Murray River where irrigation EC can be as high as 2600Ec Ds/m. Published research has indicated that silica is a very important nutrient in date palm production and that reduction in plant silica levels resulted in slower growth rates. The aim of this project was to investigate the role that increasing silica applications (Agripower Si) would have on the growth and development of young date palms and if previously published research could be replicated under Australian growing conditions. Applications of the product were applied to *Barhee* date palms at the rate of 2, 4 and 8kg per palm tree commencing in October 2012. Tissue test data in the first 2 years revealed less Si where the Agripower Si product had been applied irrespective of treatment application in comparison to the control. It is proposed that this decrease in plant tissue levels is a function of a growth dilution effect. What was noticeable was that where the product was applied mean frond and leaflet length were significantly increased in comparison to untreated control palms. Frond and leaflet analysis data indicated that leaflet Si levels were significantly less than entire frond analysis. This suggests that Si is distributed unevenly within the plant and when looking at leaf P and Mg levels would appear to be more mobile than either of these 2 nutrients. The significance of this data was that treated palms were visibly larger than untreated control palms within the first growing season that the product was applied and this has continued over the life of the trial. It also suggests that Si may be a highly mobile element within the date palm. Fruit analysis data comparing Medjool with slip skin and sound fruit showed variances in nutrient composition for Si, P and K from 0.27 to 0.43 mg/kg Si, 0.15-0.21 mg/kg P and 1.98-2.5mg/kg K. This is suggesting that Si may be playing an important role in not only alleviating slip skin disorders but enhancing mobilisation of P and K within the fruit skin itself increasing skin stability. Ongoing research along this line will continue in 2015 onwards.

Acknowledgements

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Introduction

Date palms have been grown in Australia since the late 1800's yet it is has only been in relatively recent times has the crop been looked as a potentially significant horticultural crop in Australia. As a result the technical understanding of production and suitable varieties relies heavily on the experience of those in the Northern Hemisphere and extension and application of this data into Australian growing conditions. As a result the agronomic knowledge of specific issues in managing Date Palms in Australia, and the variance of application of overseas data for Australian growing conditions are still very much based on learning to adapt overseas information. This has meant determining the significance of overseas data and screening its' application to Australian growing conditions.

Matichenkov and Bocharnikova (2006) noted that historically date palms grew in oases that were related to a geological depression and artesian waters. These regions were characterised by silicon rich waters due to the concentration of mobile silica in the geological depression zones. Their conclusion was that date palms require high amounts of silica and in further studies determined that plants irrigated with desalinated water were deficient in silica nutrition. Fruit analysis determined that the maximum total of Si could be found in the epidermal tissue of the clingstone (0.81-1.51% from dry mass) and lower amounts in the fruit stem, clingstone core and pulp. They also noted that as Si levels dropped so did fruit sugar content as did the growth of young palms. With increasing plantations of date palms grown on water significantly different from the composition of the oases where they were originally grown, Si could play a significant role in plant nutrition.

From being a plant found around oases throughout the Middle East today the date palm is commercially grown on reclaimed, desalinated, bore and river water across the globe. Therefore the chemical composition of the water is significantly different to that which the plant has evolved on and this variance could create issues in the growth and development of date palms in a number of environments.

Silica is such a large percentage of the mineral matter of the earth's crust by weight (27.7%) (Hausenbuiller,(1985). With such a high percentage of silica in the earth's crust, the role of silica in plant nutrition has been regarded more widely as a curiosity to researchers; at a field level applications of silica for crop nutritional purposes are largely ignored. However in recent years there has been a renewed interest in the potential role of Silica in plant nutrition.

Silica has been well documented as a plant nutrient and oats can contain 1% Si as dry material (Leeper 1967). This is significantly more than K in dry matter at 0.6%. Leeper notes in his book 'Introduction to Soil Science' which has been a foundation book of young soil scientists since it was first published in 1948 and edited over the next 30 years was that a soil with a good supply of primary silicates can remain chemically rich over many years of cropping. An interesting note in this book on page 170 states that 'The conclusion is rather that the primary minerals can guarantee the chemical fertility. The experiment is so striking that it is strange that this section of the knowledge of soils has been so neglected. The experiment also shows the powerful weathering properties of acid clay.' Is it possible that with Si being such an abundant element that it has been traditionally regarded as an element that does not gain a lot of attention in traditional plant nutritional management plans? The documented variance in Si levels between different plant species also makes conventional recommendations more difficult than with nutrients such N, P and K.

It is also interesting to note that aluminium toxicity in soils while being dependant on solubility at low soil pH but also on the nature of the clay soil that is being acidified. It has been noted that the sesquioxidic clays provide more aluminium than the siliceous clays and hence a higher degree of toxicity under acidifying conditions. The significance of this should not be lost in the potential of Si to alleviate Al toxicity under acidifying soil conditions. With increasing use of recycled water and acidification of drip zones issues around aluminium toxicity and potential management considerations may need to be considered. It is in these areas that the use of silica may be beneficial.

Leeper further notes that the monocots absorb silicon in large amounts with up to half of the ash being Silica dioxide. Si has been documented in increasing resistance to pathogens such as blast in rice(Datnoff et al 1997) and powdery mildew in cucumber (Miyake and Takahashi 1982).Si has also been found to prevent lodging in rice and it is perhaps this role that has the greatest application in world wide applications.

Jones and Handreck (1967) note that importance that Si plays in alleviating Mn toxicity. This may play an important role where acidic soil conditions are required but Mn toxicity symptoms are an issue. Applications of Si may be useful in reducing plant available Mn and reducing toxicity risks. West (et al) 2007, note that while Si is not noted as an essential mineral element for plant growth it has many beneficial effects on plant performance. This stems from increased resistance to fungal diseases, improved mechanical stability of leaf and blades and improved water stress. They further note that there is great variation in uptake of Si in plant species and that it is not unrealistic to assume that responses to soil applied Si in one species do not mean that similar responses would be expected in other species.

Ahmed et al (2012) note that Si is able to help plants withstand the adverse effects of drought and improve plant water use efficiency. It is proposed that the mechanisms to improved salinity tolerance in plants as a result of Si were increased photosynthetic activity and ultra-structure of leaf organelles. In their work on drought tolerance of wheat they determined that while a single trait cannot make a plant resistant to water stress, the beneficial effects that Si would play for screening drought resistant genotypes. In a world facing heat waves and shortages of irrigation water this work may prove to be significant in our application of Si to agricultural crops

Silicon (Si) plays a significant role in imparting biotic and abiotic stress resistance (Ma et al, 1989) and enhancing growth and yield, especially in accumulator species (Street-Perrot and Barker, 2008). While there have been numerous studies, some specific examples include Si increasing resistance to pathogens such as blast in rice (Datnoff et al, 1997) and powdery mildew in cucumber (Miyake and Takahashi, 1982). Si has been found to prevent lodging in rice and it is perhaps this role that has the greatest current application in worldwide applications.

Si deficiency in soil is now recognized as being a limiting factor for crop production, particularly in soils that are deemed to be low or limiting in plant available Si and for known Si-accumulating plants (Ma and Takahashi, 2002).

The plant available Si of a soil is reliably measured through an extraction procedure using a calcium chloride solution. Calcium chloride extracts the easily soluble Si and has been shown to correlate well with yield increases (Berthelsen et al, 2001; Haysom and Chapman, 1975). Critical limits and ranges have been reported (Narayanaswamy and Prakash, 2009) for the $CaCl_2$ extractant method on soils. They determined that 43ppm was the critical soil level for this extraction method.

The aim of this trial is to investigate the potential use of Si in the mallee soils used for date palm production and if published research work on the role of Si in date palm growth can be extended into Australian growing environments.

Materials and Methods

Site

The date palm trial site is located at the property of Dave and Anita Reilly in the Gurra region of the Riverland in South Australia. The property is irrigated out of the Gurra Lake which is a backwater from the Murray River. Due to its location water is significantly more saline than irrigation water taken straight out of the river system. Irrigation water has been as high as 5000EC dS/m but with the breaking of the drought and increased flows in the river system, irrigation water salinity levels have dropped to between 1200-1800 EC dS/m in recent seasons.

The local climate is associated with hot dry summers and mild winters with rainfall averaging 245mm/pa. Due to the nature of storm events, rainfall is highly variable and over the past 10 years annual rainfall events have ranged from 83-435mm/pa.

The soil at this property is a calcareous sandy clay loam with clay subsoils at depth. Irrigation is undertaken with drip irrigation with drippers based around each palm. Dripper output is 25L/hr with 3 drippers per palm. The large output drippers enable soils to be filled to field capacity and manage high algal content associated with water in this area. The larger outputs also enable better manage for the high colloidal content of the irrigation water.

Treatments

Applications of the Agripower Si material were banded around the base of each *Barhee* date palm at rates of 2, 4 and 8kg per palm. As the site is used for commercial production full rows of each treatment were implemented for incorporation with minimal disruption into the overall farm management operation.

Agripower Si was applied on the 14/9/12 and again on the 4/9/13. Measurements of soil nutrient status, tissue tests and plant phenology were undertaken over the 3 growing seasons.

Product Analysis and Site Data

A complete analysis of the Agripower Si sample what was to be applied in the trial site and a pre-treatment soil test were undertaken to determine starting point soil fertility and also the chemical composition of the Si to be applied in this soil test

Table 1: Technical Information on Product: AgriPower Silica Raw Material: Diatomite

A typical analysis of this mineral is given below:

Typical Analysis	
Calcium	1.5%
Iron	5.9%
Magnesium	1.05%
Potassium	0.07%
Zinc	19ppm
CEC	52cmol/kg
Soluble Si	1,212ppm
pH	8.1

Table 2: Soil test results from trial site, prior to application of AgriPower Silica

Element	Result	Units
pH (1:5)	8.7	
Electrical Conductivity (1:5)	0.16	mS/cm
Organic Carbon	0.3	%
Nitrate – N	4	mg/kg
Phosphorous (BSES)	41	mg/kg
Phosphorous (Colwell)	18	mg/kg
Phosphorous (Olsen)	11	mg/kg
Potassium (exchangeable)	431	mg/kg
Calcium (exchangeable)	4858	mg/kg
Magnesium (exchangeable)	302	mg/kg
Cation exchange Capacity	28	cmol/kg
Sulphate – S	42	mg/kg
Chloride – Cl	31	mg/kg
Boron	0.58	mg/kg
Zinc (DTPA)	0.32	mg/kg
Copper (DTPA)	0.62	mg/kg
Iron (DTPA)	2.42	mg/kg
Manganese (DTPA)	0.68	mg/kg
K Cation	3.93	%
Ca Cation	86	%
Mg Cation	9	%
ESP	0.74	%
K:Mg	0.44	Ratio
Ca:Mg	9.6	Ratio
C:N	0.08	
Soluble Silica	52	Ppm

Comments on Soil Results

The alkaline nature of soil in this sample is typical of the region. The soil has high levels of underlying limestone of variable particle size. Soil phosphorus levels are low and potassium levels are high which is typical of most soils in this region. The hot dry conditions and low rainfall results in very low levels of organic carbon.

The soluble silica was measured using the calcium chloride extraction method and found to be 52ppm suggesting that this soil type would be responsive to applications of silica.

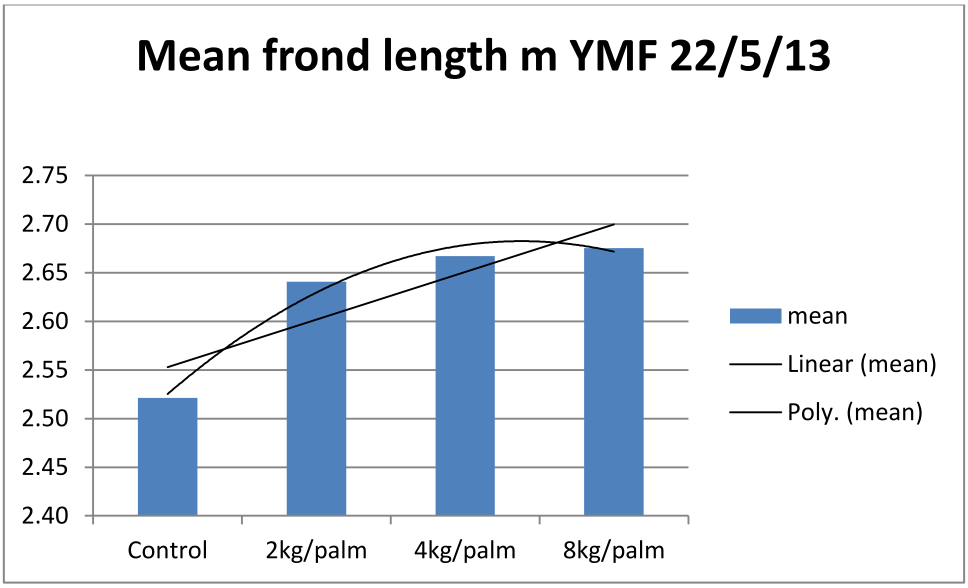
The property is devoted to the production of organic dates so the lower nutrient levels in comparison to more intensive systems in line with soil nutrient levels in this region. The regional clay loam based soils are traditionally high in potassium and trace element levels (low) are normal for this soil type.

Results and Discussion

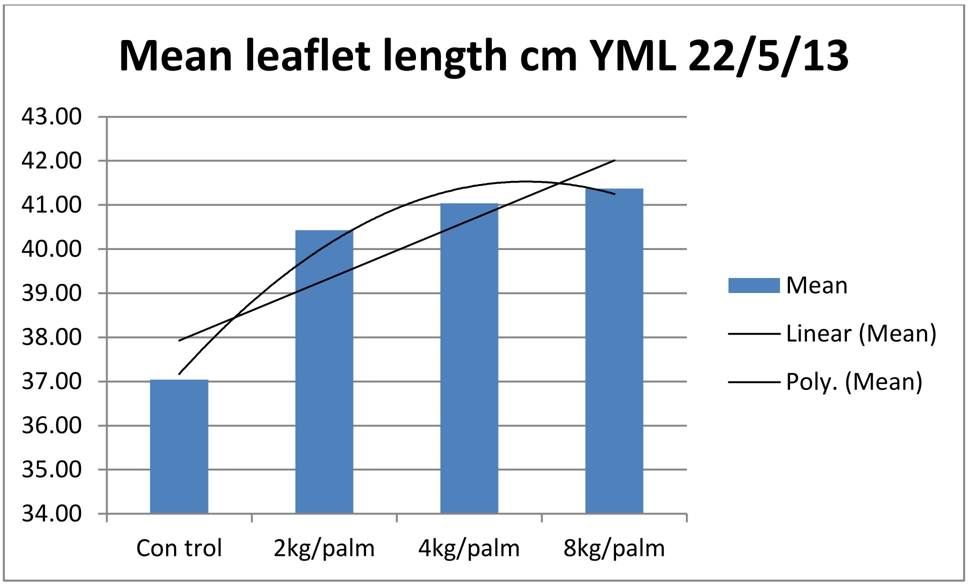
Plant Phenology Data

Fronds and leaflets were measured from the youngest mature frond to determine any potential variance between treatments. Measurements were taken twice over the growing season with individual data collated and compared between and within treatments for analysis of variance.

Graph 1: Mean frond length youngest mature frond (YMF) in metres 22/5/13

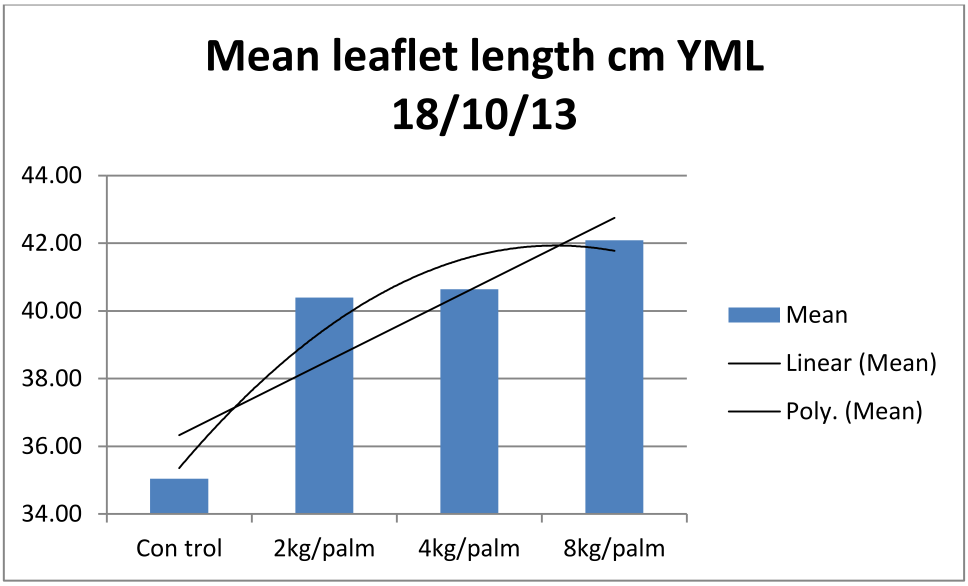


Mean frond length can be seen to be greater in the treated over the untreated palms within the same planted area in the trial block. By applying a polynomial trend line to the data the aim was to determine potential limiting rates to Si application as influencing frond length.



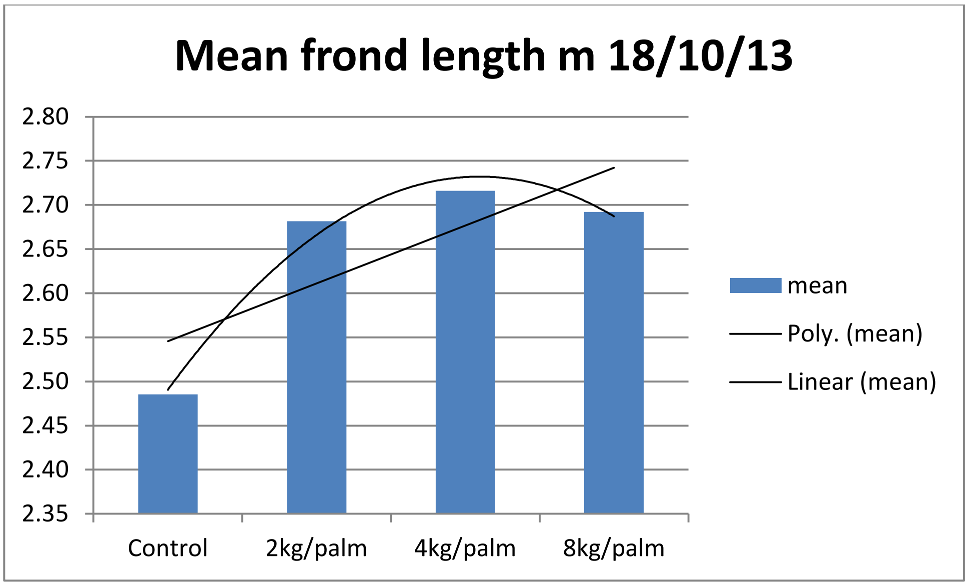
Graph 2: Mean leaflet length from the mid leaflet of the youngest mature leaflet (YML). 22/5/13

Leaflet length and frond length are in line with each other and would suggest that leaflet length correlated to frond length in a date palm.



Graph 3: Mean Leaflet Length 18/10/13

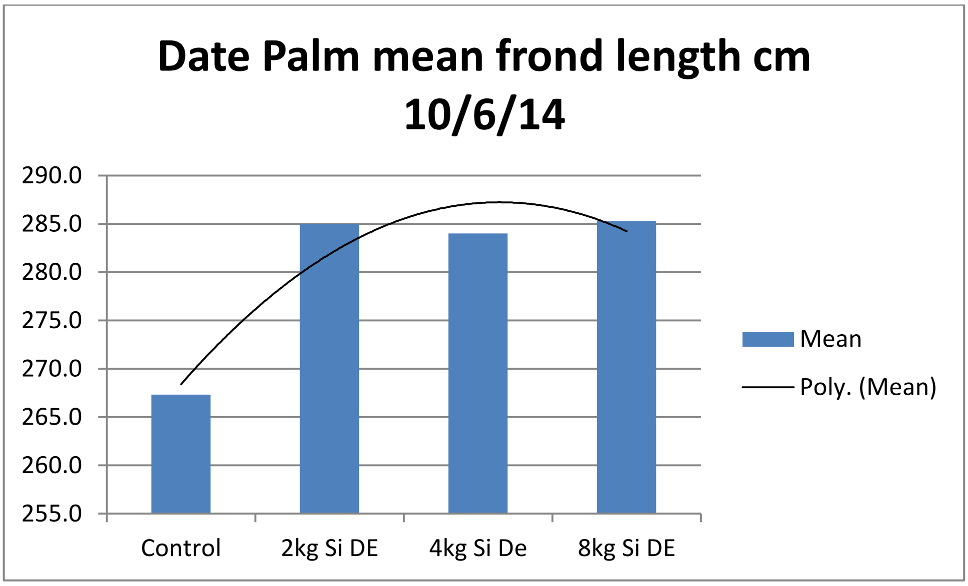
Data from the 18/5/13 is in line with sample data from the 22/5/13. There has been minimal change to leaflet length from the mid part of the frond since the original sampling.



Graph 4: Mean frond length 18/10/13

Data from the 2 sampling dates indicate that growth response to applications of the Agricpower Si product occur early in the development phase of the frond and leaflets and that this response is held over time in the plant. This would suggest that the impact of the vegetative response is made earlier in the growth phase and that relatively small applications of Agripower Si have resulted in quite significant increases in vegetative growth.

Graph 5: Mean frond length Bahee, youngest mature frond, 10/6/14



Graphs 4 and 5 which has been consistently seen over the life of the trial, is the increase length of frond where Agripower Si has been applied. If applying a polynomial trend line to this graph a consistent decline in at 8kg can be seen to occur suggesting that the maximum response to applied Si (as Agripower Si) is around the 2-4kg per palm under the Riverland growing environment.

Tissue Test Results

Tissue analysis was conducted on the 14/11/12, 20/9/13 and the 17/6/14 to determine if there were any significant differences in plant nutrient levels between treated and untreated palms, and also movement in Si levels over time. Leaflets were taken from each treated palm to form a composite tissue sample for analysis.

Table 3: Dried tissues analysis 14/11/12

Nutrient	Control	2kg Palm	4kg Palm	8 Kg/Palm
B ppm	16	15	15	14
Ca %	0.27	0.27	0.21	0.21
Cu ppm	118	108	89.5	61.8
Fe ppm	55	63	50	50
K %	2.02	2.02	2.06	1.91
Mg %	0.21	0.22	0.21	0.2
Mn ppm	25	26	23	23
Mo ppm	0.01	0.01	0.01	0.01
N %	1.62	1.49	1.4	1.46
NO3-N ppm	7	9	4	9
Na %	0.05	0.05	0.05	0.05
P %	0.14	0.14	0.16	0.14
S %	0.15	0.16	0.14	0.14
Si mg/kg	1387	689	698	692
Zn ppm	15	15	15	14

Sample Date 20/9/13

Nutrient	Control	2kg Palm	4kg Palm	8 Kg/Palm
B ppm	42	37	46	43
Ca %	1.01	0.95	1.08	0.99
Cu ppm	13.4	13.7	17.6	14.9
Fe ppm	70	70	88	69
K %	0.57	0.73	0.59	0.63
Mg %	0.39	0.37	0.4	0.37
Mn ppm	40	43	46	51
Mo ppm	0.39	0.40	0.36	0.38
N %	1.72	1.73	1.75	1.77
NO3-N ppm	20	21	18	18
Na %	0.05	0.05	0.05	0.05
P %	0.15	0.16	0.15	0.15
S %	0.25	0.16	0.24	0.27
Si mg/kg	3374	3015	3045	2642
Zn ppm	18	17	15	15

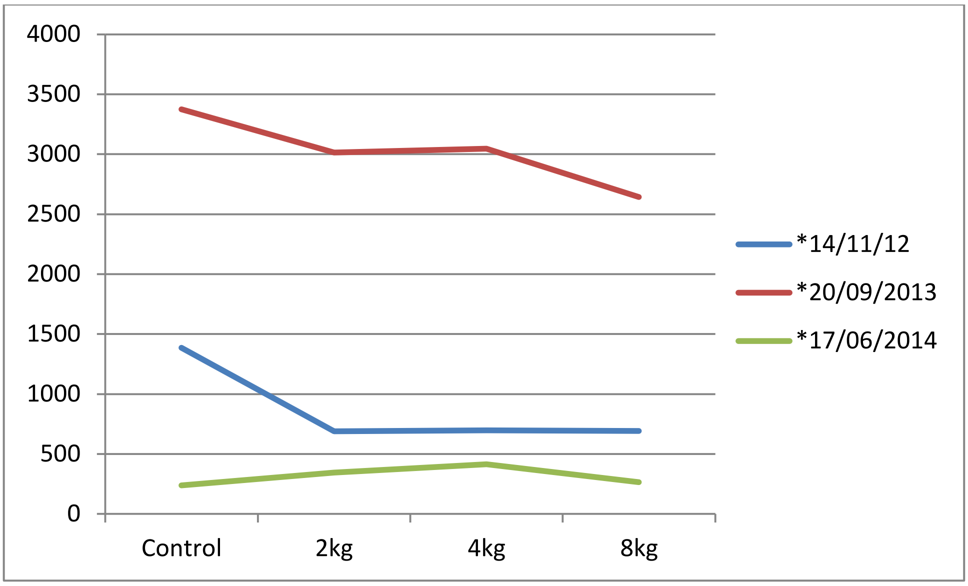
Table 4: Tissue testing data from the leaflet of the youngest mature leaflet on the youngest mature frond

Plant Tissue Analysis			Bahee	
17/06/2014	CONTROL	2 kg	4 kg	8 kg
Total N	1.4	1.5	1.5	1.3
NO3-N	33	40	15	29
P%	0.17	0.17	0.16	0.16
K%	2.31	2.28	2.27	2.31
Ca%	0.21	0.28	0.27	0.23
Mg%	0.18	0.21	0.2	0.18
S%	0.26	0.29	0.28	0.24
B ppm	18	16	16	17
Cu ppm	237	282	251	218
Fe ppm	25	31	29	27
Mn ppm	45	59	50	41
Zn ppm	49	52	46	39
Na %	0.05	0.05	0.05	0.05
Cl %	0.65	0.8	0.79	0.63
Si mg/kg	238	346	413	265

Si can be seen to increase with increasing applications yet drops away in terms of plant levels at the highest application rate. Trend line analysis presented at the Date Conference suggested that the most effective rates were in the 4kg per palm range. Phosphate levels appear to not vary between the leaflet and the frond.

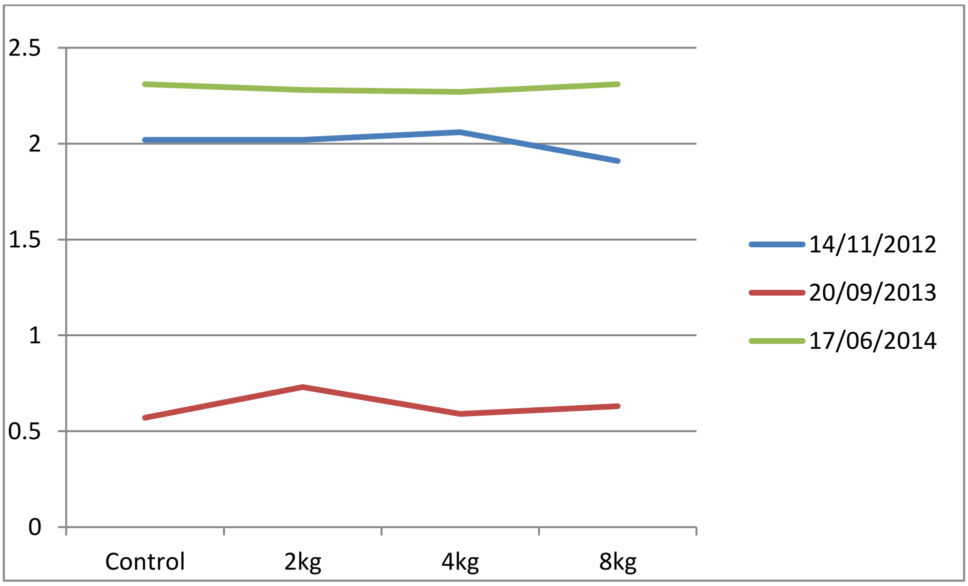
The graphs below highlight large variances in plant tissue Si levels from year to year and within the different sampling periods. This raises the question on not only the distribution of Si in the plant tissue but also mobility from the leaves over time. Phosphorus levels show very little variance over time in comparison suggesting that this nutrient is relatively stable within the plant tissue in the youngest mature leaflet over time. It is not unusual to see variance with mobile elements and the fluctuations over the seasons and a variable sampling point in time would suggest to Si having a high level of mobility. The other possibility that needs to be considered is that June 2014 saw the first significant flower initiation and such a massive decline in Si levels in the YML may be a result of the flower bud being a sink for Si. However this is a hypothesis and would need an analysis of the fruiting body to determine nutrient changes over time.

Graph 6: Si levels in plant tissue of the YML over time, Si ppm



The above graph visually highlights variance in Si over the sampling period. Allowing for seasonal variance and the fact that an increase in vegetative growth was observed soon after an application the original hypothesis was that the decline in Si levels was a function of a dilution effect through greater leaf area and the low levels in 2014 a result of the onset of flower initiation. With whole frond analysis of the same part of the plant showing much higher Si levels it is not unreasonable to suggest that the rib of the frond containing higher Si levels than the leaflet. Without additional sampling of the trunk it is unknown as to how much Si is deposited within the main body of the palm.

Graph 7: K levels % in plant tissue of the YML over time



What is interesting when looking at YML potassium levels are not tracking in line with Si levels over the same time frame and sampling period. While the Agripower Si product does not contain Si and would be expected to have no influence on plant K levels the data suggests that Si and K levels within date palms do not show similar trend characteristics.

The analysis of the raw material and the nature of the application in the trial (2 years of banded applications) would suggest movement of the material into the root zone of the palm for uptake and translocation within the plant. The increase in Si, Ca and Fe in the frond would suggest that this product has sufficient solubility over time to influence plant tissue analysis data for these nutrients. It is interesting that Mg levels do not vary between either the treated or untreated plant parts suggesting that either the form of Mg held in the Agripower Si is not readily available or that date palms are efficient accumulators of this nutrient.

Frond Analysis Dried Tissue

The variance in leaflet data over the sampling periods resulted in the decision to assess elements held within entire fronds and leaflets. The aim of this was to see if there could be variable points of Si accumulation within the main frame of the frond.

Entire palm fronds were taken on the 2/6/14 and allowed to naturally dry down prior to analysis.

Table 5: Dry weight frond analysis 9kg Agripower Si per palm

Grower	AgriPower Pty Ltd	Region	World
Block Reference	9kg Agripower Si	Payment Status	To be billed
Report No.	HTS1846057-18072014	Date of Report	18/07/2014

Field Information

Crop	Date palm	Soil Texture	Default	Irrigation Type	
Variety		Soil Structure		Treatment Area	0
Crop Stage	Default	Soil Colour		Yield Goal	0.00

Method	Element	LOD	Result	Units	Optimal Range	Comment
DD-32	Total Nitrogen (Dry Tissue)		1.8	%		
BB-27	Nitrate N (Dry Tissue)		6	ppm		
DE-30	Phosphate (Drytissue)		0.14	%		
DE-11	Potassium (Drytissue)		1.15	%		
DE-11	Calcium (Drytissue)		0.49	%		
DE-11	Magnesium (Drytissue)		0.18	%		
DE-30	Sulfate (Drytissue)		0.27	%		
DE-30	Boron (Drytissue)		29	ppm		
DE-11	Copper (Drytissue)		5.0	ppm		
DE-11	Iron (Drytissue)		89	ppm		
DE-11	Manganese (Drytissue)		65.0	ppm		
DE-11	Zinc (Drytissue)		15.00	ppm		
DE-11	Sodium (Drytissue)		-0.050	%		
BB-27	Chloride (Drytissue)		0.71	%		
	Silicon (Dry Tissue)		2,216.00	mg/kg		

Notes: Sample Type: Date Palm Frond

Table 6: Dry weigh frond analysis Control

Field Information					
Crop	Date palm	Soil Texture	Sandy Loam	Irrigation Type	None
Variety		Soil Structure		Treatment Area	0
Crop Stage	Default	Soil Colour		Yield Goal	0.00

Method	Element	LOD	Result	Units	Optimal Range	Comment
DD-32	Total Nitrogen (Dry Tissue)		2.0	%		
BB-27	Nitrate N (Dry Tissue)		-1	ppm		
DE-30	Phosphate (Drytissue)		0.17	%		
DE-11	Potassium (Drytissue)		1.72	%		
DE-11	Calcium (Drytissue)		0.32	%		
DE-11	Magnesium (Drytissue)		0.17	%		
DE-30	Sulfate (Drytissue)		0.30	%		
DE-30	Boron (Drytissue)		22	ppm		
DE-11	Copper (Drytissue)		5.0	ppm		
DE-11	Iron (Drytissue)		68	ppm		
DE-11	Manganese (Drytissue)		30.0	ppm		
DE-11	Zinc (Drytissue)		14.00	ppm		
DE-11	Sodium (Drytissue)		-0.050	%		
BB-27	Chloride (Drytissue)		0.65	%		
	Silicon (Dry Tissue)		1,550.00	mg/kg		

Notes: Sample Type: Date Palm Frond

As expected as Si applications are increased this has led to an increase in Si levels in the entire frond. Ca levels are also increased as the Agripower product is 1.5% Ca (refer to analysis data in table 4). When looking at table 3 and looking for comparative trends iron levels are similar between all treatments yet when looking at the entire frond there is quite a large difference between the treated and control fronds. The drop in K levels in the frond as a result of increasing Si levels is not seen in leaflet analysis and supports published research indicating that Si can replace K in plant cell wall structures albeit at a very preliminary stage. Further cell wall analysis research would be required to substantiate this statement but initial data collection is encouraging.

Impact of Silica levels on fruit skin disorders

The significance of this data was that treated palms were visibly larger than untreated control palms within the first growing season that the product was applied and this has continued over the life of the trial. It also suggests that Si may be a highly mobile element within the date palm.

The significance of these observations led to the hypothesis that Silica could also be distributed unevenly within the fruiting body and this may have an influence on skin quality. Traditionally many of the skin related disorders in fruit finish have focused on the role of calcium in strengthening the cells of the outer wall of the plant as well as internal strengthening of the plant cell walls. Calcium related issues are associated with blossom end rot in tomatoes and capsicums, bitter pit, water core in apples and albedo breakdown in citrus. However there is a large body of work that indicates that other factors play a role in reducing the incidence of cell wall breakdown and issues on skin separation than calcium alone. In table grapes for example the alternating layers of hemicellulose in the outer layers of the parenchyma are high and low in potassium. When this is disrupted skin separation can occur resulting in lowered shipping quality of the product. Apples are known to require phosphorus for skin finish, and fruit size and skin quality is associated with citrus production. The work by Matichenkov and Bocharnikova highlights the significance of Si and it was in light of this work and field observations in the field trials that led to the setting up of trials to look at the potential role of Si as well as other nutrients could play in reducing the incidence of slip skin in date palms, in this case with the Medjool variety.

Fruit samples were taken from Medjool palms and dehydrated prior to analysis. Raw data was then back calculated to wet weights as would be expected in fruit destined to market. This also reduces errors that arise due to variable wet and dry weights between samples. Separate samples of fruit showing slip skin disorders and sound fruit were separately analysed to determine if any significant differences in nutrient composition could be seen.

Minor differences in the percentage of solids in fruit could be seen between slip skin and sound fruit. Slip skin fruit had 65.0% solids and sound fruit 62.5% solids. This was not surprising considering the increased surface area in slip skin fruit for desiccation to occur. As fruit desiccation increases it is proposed in these studies that skin separation increases. Where slip skin could be reduced the percentage of solids within the fruit would also decrease.

Tissue test data in the first 2 years revealed less Si where the Agripower Si product had been applied irrespective of treatment application in comparison to the control. Frond and leaflet analysis data indicated that leaflet Si levels were significantly less than entire frond analysis. This suggests that Si is distributed unevenly within the plant and when looking at leaf P and Mg levels would appear to be more mobile than either of these 2 nutrients. The significance of this data was that treated palms were visibly larger than untreated control palms within the first growing season that the product was applied and this has continued over the life of the trial. It also suggests that Si may be a highly mobile element within the date palm.

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Minor differences in the percentage of solids in fruit could be seen between slip skin and sound fruit. Slip skin fruit had 65.0% solids and sound fruit 62.5% solids. This was not surprising considering the increased surface area in slip skin fruit for desiccation to occur. As fruit desiccation increases it is proposed in these studies that skin separation increases. Where slip skin could be reduced the percentage of solids within the fruit would also decrease. The role of Si in cell strengthening may play a significant role in stabilising fruit from maintaining the integrity of fruit composition and reducing the incidence of slip skin as a result of increased outer skin layer stability in the fruit.

Table 7: Nutrient composition of Medjool dates in g/kg/wet weight

Nutrient	Slip Skin Fruit	Sound Fruit
Silica	0.27	0.43
Phosphorus	0.15	0.21
Potassium	1.98	2.50

Analysis of all other nutrients revealed insignificant differences in fruit analysis between sound fruit and that with slip skin when back calculated as wet weight. The only significant difference between the samples was with Si, P and K levels in fruit. This suggests that slip skin related fruit disorders may be more related to a combination of nutrients in this case Si, P and K than a point source nutrient such as Ca.

Research in the coming years will focus on confirming these field studies and then determining a predictive model for slip skin related disorders based on wet dry weight analysis of fruit over the growing season.

Discussion and Conclusion

The solubility of Si from the banded applications of Agripower Si over time would suggest that solubility of the product under natural rainfall and drip output is sufficient to enable uptake into the plant. It appears from the data that Si (as well as other nutrients) are distributed unevenly through the frond and leaflet with indications that Si is a major component of the main stem of the frond. Unfortunately as the entire frond and leaflets were not independently analysed the exact composition of frond stem and leaflets are not included in this study. .

From observation of the data, Date Palms can be seen to have a high leaflet content of Si to the extent that this nutrient could be regarded as one of the major plant nutrients for this species. These are in line with the observations made by Matichenkov and Bocharnikova (2006).

Slip skin is a major consideration limiting premium pack outs of date fruit in many areas around the world, not only in Australia. The significance of this work is that there appears to be a link between slip skin and lower levels of silica, phosphorus and potassium within the fruit. Further studies are planned to look at sub sections of date fruit in the next growing season to identify point sources of differences between slip skin and sound fruit. If this can be identified then a best management plan to reduce the incidence of this disorder can be implemented.

A field level study into plant nutrition effects is not an exact science since it is difficult to achieve perfect replicas of the same plant for the study in a field situation. Small variations in soil type and hydraulic distribution of water within the root zone can have significant physical effects on plant growth as well as genetic variance between plants of the same variety. However in spite of this natural variance applications of Silica have resulted in visually significant and measurable changes in plant growth and development. This is in line with published data showing the significance of silica on the growth and development of date palms in other parts of the world.

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