Evaluation of the Efficiency of Transit Silicate® to Improve Pest Resistance and Yield of Almonds

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Abstract

Silicon (Si), although a micro element, is one of agriculture's key plant nutrients due to its beneficial effects on plants with research specifically being conducted in the benefits of Silicon is managing and assisting in the tolerance of both biotic and abiotic stresses (Luyckx, Hausman, Lutts and Guerriero, 2017). Along with management in stress conditions, Si has also been proven to promote greater yields at a greater quality as a result of increased stress tolerance and increased beneficial plant physiology (Korndörfer and Lepsch, 2001). Two applications of Transit Silicate® were applied to selected trees and on average, these treated trees had higher lower canopy growth, higher whole nut weight, hull weight, kernel weight (significant) and out-turns (significant) compared to the control. It was also measured that on average, Transit Silicate® treated trees contained more nuts per tree compared to the control. Due to Transit Silicate® containing amino acids and Biologically Active Organic Molecules (BAOM), leaf and soil nutrition was also improved with a 10.4% increase in silicon concentrations in the leaves of almond treated with Transit Silicate®. It was also measured that there was significantly less Carpophilus beetle damage in Transit Silicate® treated trees and no Carob moth damage.

Keywords: Silicon, almonds, abiotic and biotic tolerance, yields, out-turns, Carob moth, Carpophilus beetle

1. Introduction

Silicon (Si) is the second most abundant element in the Earth's crust, however it is rare to see plants accumulate enough silicon for it to become beneficial in terms on biotic and abiotic pest tolerance (Song et al., 2021). This is why Si fertilisation in agricultural crops has raised much attention and is now being explored as a suitable addition for integrated pest management. Plant available Si is limited in most soils as the silicon/silicate is most commonly found naturally in the solid phase contained in crystalline structures where chemical weathering is needed in order to break down the solid phase into an absorbable or liquid phase which produces monosilicic and polysilicic acids (Tubana, Babu and Datnoff, 2016). These silicic acids are plant available and hence absorbable by plants roots. However, this chemical weathering process can be slow as the source of dissolved Si is produced through biochemical reactions by microbes in the soil. Therefore, it is important to apply supplemental sources of Si which are plant available through soil applied fertiliser.

Dual Chelate Fertilizer had developed a Silicon based fertigated fertiliser known as Transit Silicate®. Transit Silicate® contains 32% potassium silicate which is available for microbes to convert into silicic acid. This formulation also contains amino acids (42%) and Biologically Activate Organic Molecules (BAOM) (1.5%). These added amino acids and BAOM both assist in the translocation of the silicic acid through the plant to the cell walls where structure is increased resulting in a natural abiotic and biotic resistance. The amino acids also assist in the uptake of the silicon through the roots as the amino acids act as a chelating agent. This increases the effectiveness of Transit Silicate®. Apart from the silicon, Potassium (K) is also a key macro element which makes up Transit Silicate®. Potassium assists in plant growth by regulating the movement of water, nutrients and carbohydrates (Hasanuzzaman et al., 2018). These regulatory processes all play positive roles in assisting in increasing yields and overall tree growth. This study aims to evaluate the efficiency of soil applied Transit Silicate® at nut development stages and assess overall nut parameters such as whole weight, hull weight and kernel weight at harvest along with an average kernel damage from biotic and abiotic stresses.

2. Objectives

The specific objectives of this trial were to:

- Evaluate the effect of fertigation with Transit Silicate® on improving nutrient status of almonds.
- Evaluate the effect of fertigation with Transit Silicate® on the yield parameters of almonds: nut weight, hull weight and kernel weight.
- Evaluate the effect of Transit Silicate® on improving nut quality by looking at damage caused through Carpophilus beetle, Carob moth and aborted nuts.
- Measure the quantity of nuts per tree between Transit Silicate® and control trees.

3. Materials and Methods

This trial was conducted in an Almond orchard within the Sunraysia region of Victoria. The block selected in the orchard had severe pest pressure in the past making it a suitable area for this trial. The trial was conducted in 2 separate areas of the block with a total of 5 replicates of control and treated rows. Commercial fertigation of Transit Silicate® was applied across the block twice during plant development, once during the nut development stage and once during the nut maturing stage. Trees on the control rows had isolation taps on the drip line which prevented Transit Silicate® from reaching 10 trees in each control row. Ten trees from each of the control rows were isolated from the drip taps, and were considered the control trees. Ten trees from the adjacent rows were considered as the treatment trees. Figure 1 shows the application rates and dates of Transit Silicate®

Table 1: Treatment rates and application dates of Transit Silicate® applied to almond trees.

Treatment	Application Rate L/ha	Application Date
Control	0 L/ha	N/A
Transit Silicate®	30 L/ha	9/10/20
	30 L/ha	17/11/20

4. Observations

Soil Nutrient Analysis

Soil samples (30cm deep) were taken in mid-January 2021 just prior to the beginning of almond harvesting as requested by the orchards technical agronomist following correct soil sampling techniques. Soil samples were then sent to the Australian Precision Ag Laboratory (APAL) for a full soil nutrient profile analysis. See figure 1 for images of soil sample collection. The results were then analysed using GraphPad Prism software to determine any significant differences in soil nutrient concentration between the treatments.

Figure 1: Images of soil sampling for Complete Blend 10® trial. Soil samples were taken 30cm deep and sent to APAL for analysis.

Leaf Nutrient Analysis

Leaf samples were taken in mid-January 2021 just prior to the beginning of almond harvesting as requested by the orchards technical agronomist following correct leaf sampling techniques. 10 leaves from each tree per row were collected and the samples were then express posted to SWEP Analytical Laboratories for a full leaf nutrient analysis. See figure 2 for images of leaf collection. The results were then analysed using GraphPad Prism software to determine any significant differences in leaf nutrient concentrations between the treatments.

Figure 2: Images of leaf sampling. Leaves were taken from non-fruiting spurs at the 3rd leaf. Samples were sent to SWEP Analytical Laboratories for analysis.

Whole Nut weight, hull weight and hull nuts from nuts collected before harvest

Before commercial harvest, 10 nuts per tree (100 nuts per row) were collected from the trial blocks to get whole nut weight, hull weight and kernel weights. This was done to compare the out-turns calculated from nuts collected on the tree and also nuts collected at harvest from the ground. This data was also collected to compare weight between each component of the nut.

Nut collection at harvest for field weight (kg of nuts/tree)

Once the trees had been shaken and the nuts were on the ground, all the nuts from 16 trees (8 trees from the control treatment and 8 trees from the Transit Silicate® treatment) were raked into rows, sifted using a slatted shovel and then weighed. This provided data on the quantity (kg) of nuts per tree. Trees which have similar canopy densities were chosen to weight nuts from. Figure 3 shows the methods used to gather the field weight data. A small sample of approximately 500 grams of nuts were also collected from each tree to make final out-turn calculations.

Figure 3: Images of nuts collected from shaken trees. Nuts were sifted to remove leaves, sticks and dirt then weighed to provide kg of nuts/tree

Out-turn calculations

Out-turns are calculated to determine the percentage of kernel in a whole almond nut. The higher the percentage, the heavier the kernels are. Out-turns are crucial to determine profits made on almond orchards. In this trial, out-turns were calculated from almond nuts collected prior to harvest and also during harvest. Out-turns are calculated using the following equation:

Out-Turn% = (Kernel Weight/Whole Nut Weight) x 100

Pest Damage Analysis

150 nuts were randomly selected from the control and Transit Silicate® nuts collected at harvest. These nuts where then carefully cracked and the kernels were analysed closely to determine if there were any damages caused by pests such as Carpophilus beetle and Carob moth. Nuts which had kernel gumming or kernel abortion were also recorded.

Statistical analysis

Statistical analyses (t-test and multiple t-tests) were done using GraphPad Prism 9. Significant difference ($P<0.15$) between treatments was determined by comparing the replicate means. Error bars were also used on graphs.

5. Results

Figure 4: A photo taken of almond trees treated with Transit Silicate®.

Figure 5: A photo taken of a control row before harvest which is adjacent to the Transit Silicate® treated row.

Figure 6: Almond tree treated with Transit Silicate® before harvest.

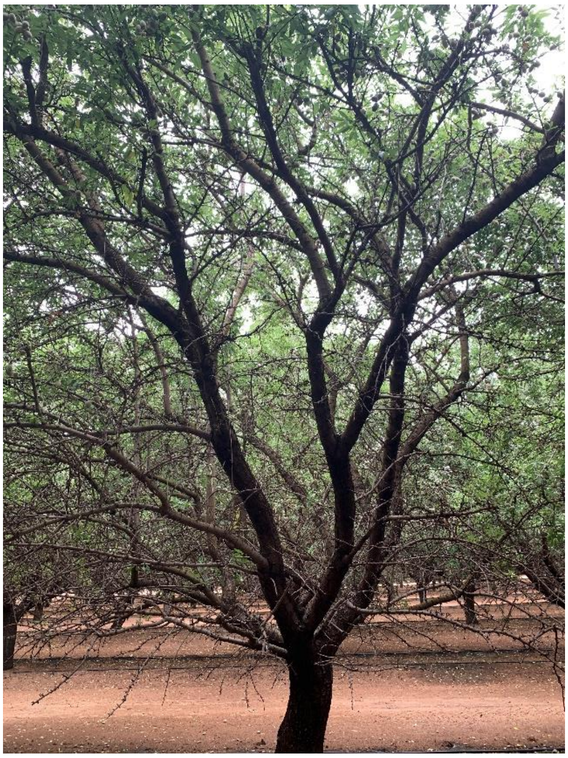

Figure 7: Control almond tree in the Transit Silicate® trial before harvest.

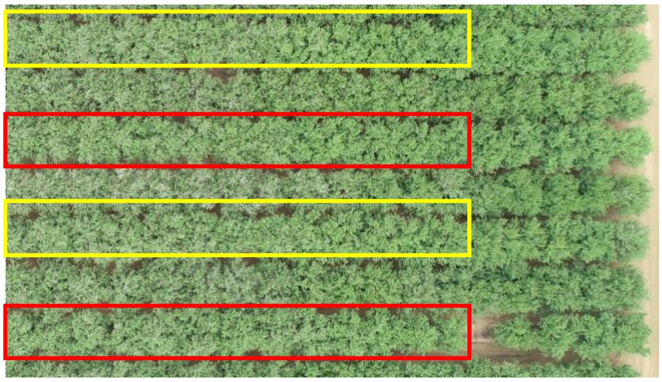

Figure 8: Drone image of the block treated with Transit Silicate®. Rows with red rectangles were treated with Transit Silicate® and rows with yellow rectangles are control rows.

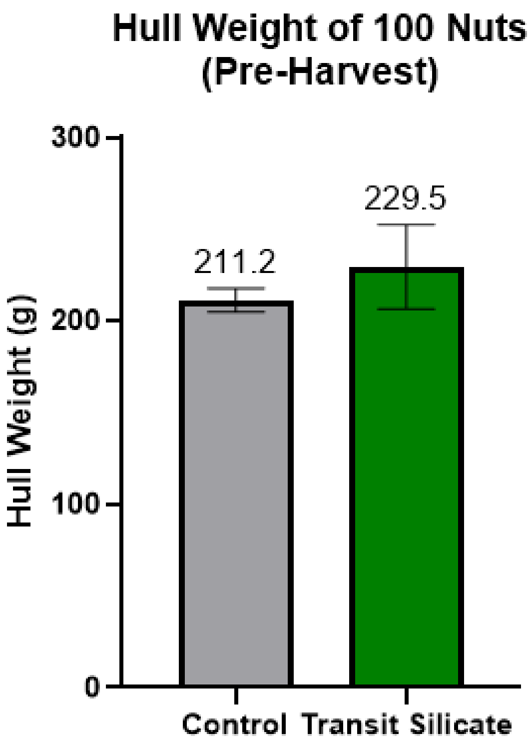

Figure 10: The average hull weight of 100 nuts collected from almond trees in the Transit Silicate® trial. Nuts were picked randomly from the trees.

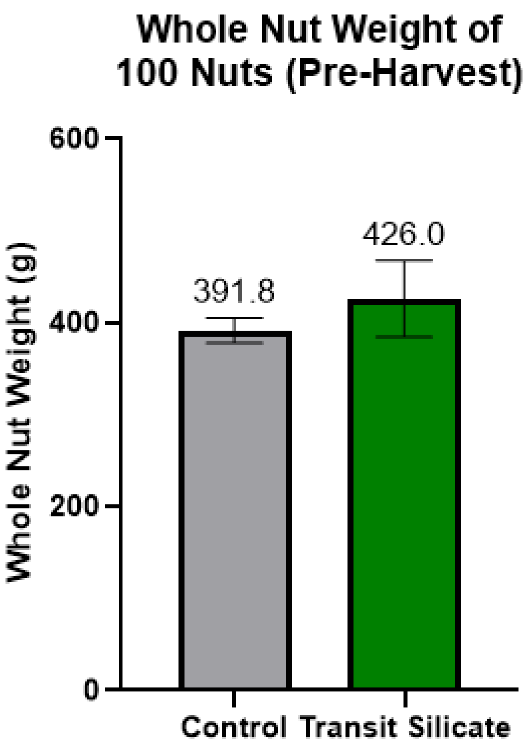

Figure 9: The average whole nut weight of 100 nuts collected from almond trees in the Transit Silicate® trial. Nuts were picked randomly from trees.

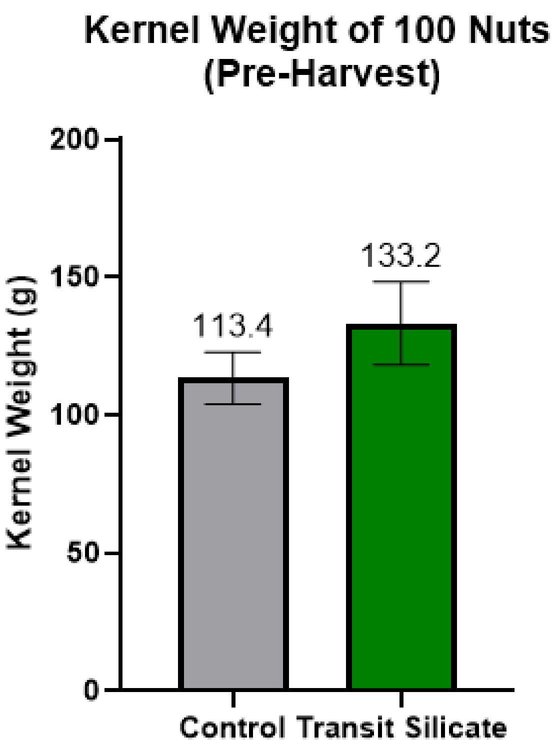

Figure 11: The average kernel weight of 100 nuts collected from almond trees in the Transit Silicate® trial. Nuts were picked randomly from trees. Significant difference (P<0.15).

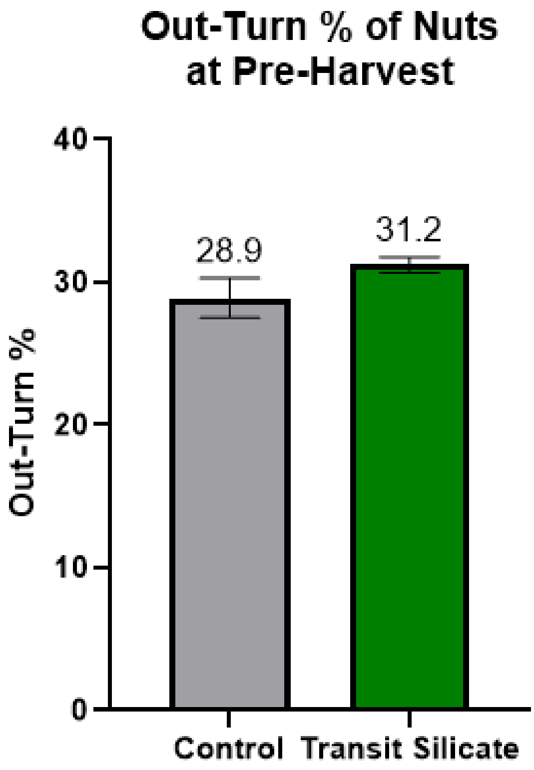

Figure 12: Out-turn % of nuts collected on the trees before harvest. **Significant Difference (P<0.15).**

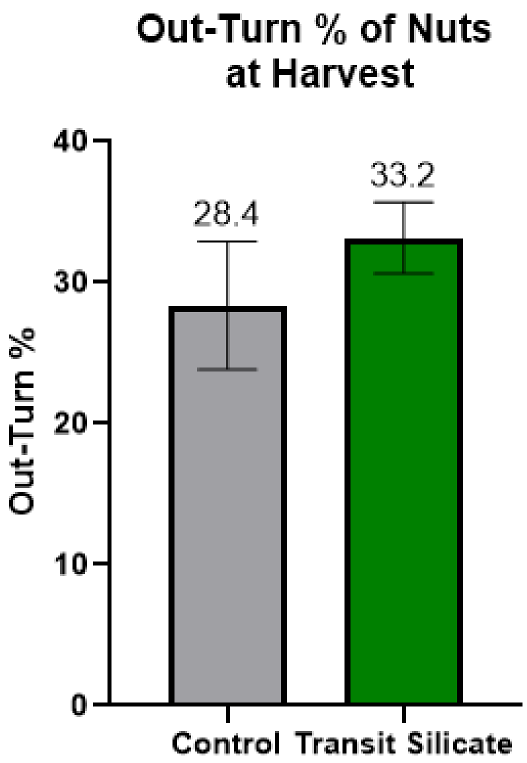

Figure 13: Out-turn % of almonds at harvest. **(Significant Difference (P<0.15).**

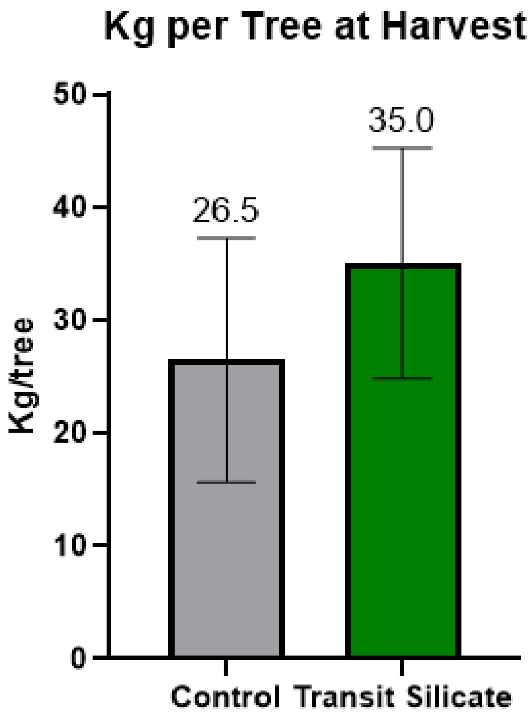

Figure 14: The average quantity (kg) of nuts per tree between Transit Silicate® and control trees. **Significant difference (P<0.15).**

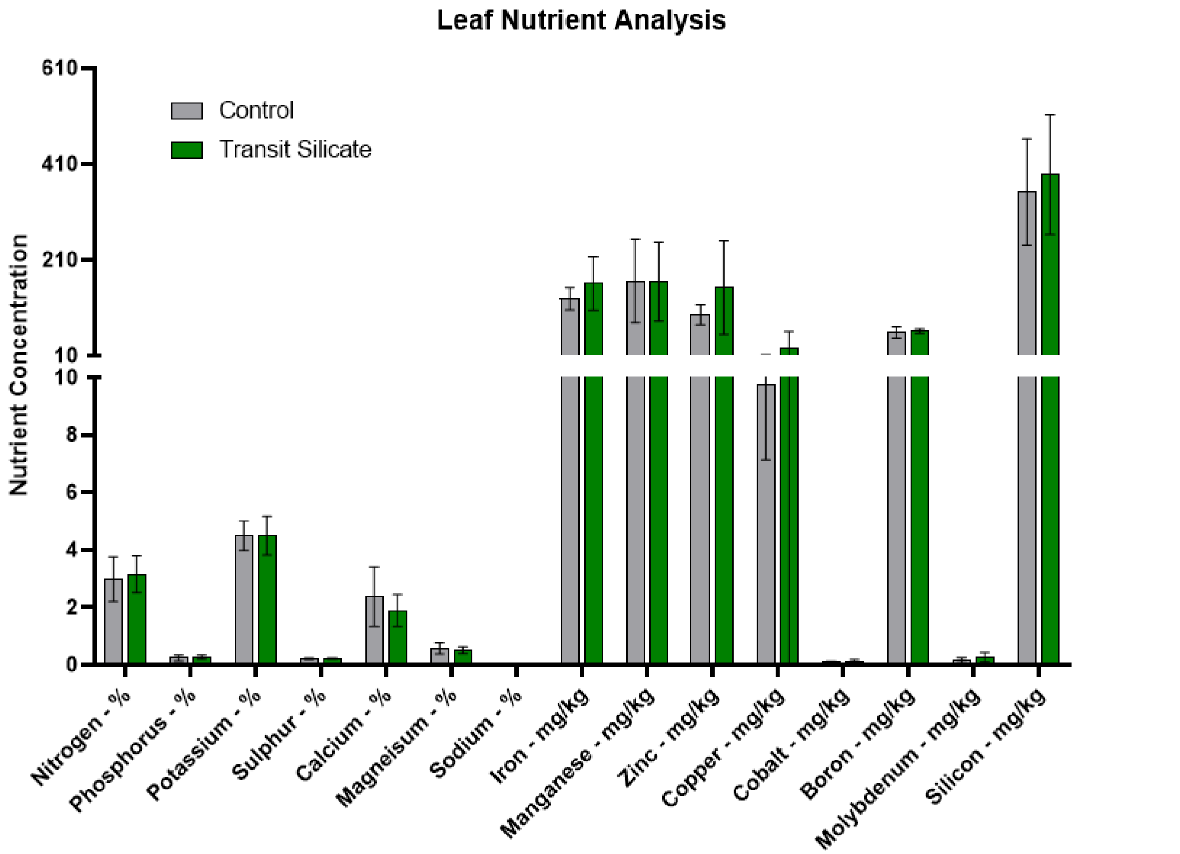

Figure 15: Leaf nutrient analysis of control almond trees and Transit Silicate® treated trees. Leaf samples were taken in mid-January 2021 in accordance with correct leaf sampling times. Samples were analysed by SWEP Analytical Labradorites.

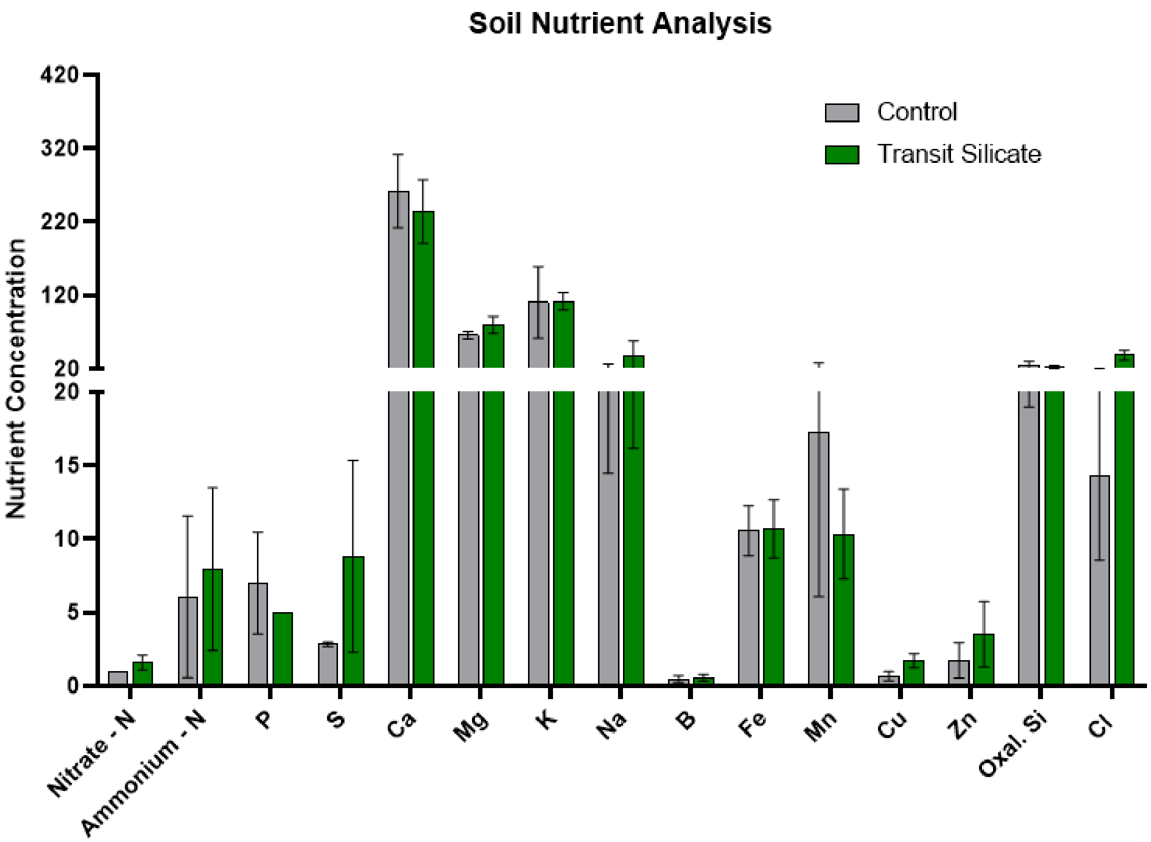

Figure 16: Soil nutrient analysis from control almond trees and Transit Silicate® treated almond trees. Samples were analysed by APAL.

Table 2: 150 Transit Silicate® nuts and 150 control nuts were randomly selected to analyse for defects including Carpophilus Beetle, kernel gumming, aborted kernels and Carob moth.

	Carpophilus Beetle	Kernel gumming	Aborted Kernels	Carob Moth
Transit Silicate®				
Control				

6. Discussion

Image Comparison

Figure 4 to 8 show images taken between Transit Silicate® treated trees and control trees. When comparing images of rows shown in figure 4 and 5, Transit Silicate® treated trees (figure 4) had slightly more foliage in the lower portion of the canopy in comparison to the control trees (figure 5). However, all of the Nonpareil trees in this block had low amounts of vegetative growth on the lower portions of the tree canopy. This is most likely due to the trees being too large and not enough light is penetrating through the canopy into the lower portions of the tree. Due to lower canopy vegetation seen on the transit Silicate® trees, there was also less nuts on the lower portions of both treated and control trees the tree. However, it should be noted that when collecting nuts and leaves for analysis, there was slightly more leaf and nut growth on the lower portions of treated trees compared to the control. This slight increase in vegetative growth and nut development observed in the Transit Silicate® treated trees can be explained through the addition of Amino Acids and Biologically Active Organic Molecules (BAOM) which make up 7% and 1.5% of the formulation of Transit Silicate respectively. Amino Acids and BAOM assist in the uptake, transportation and translocation of nutrients in the soil and in the plants through biologically chelating elements (Souri, 2016). These elements are able to be more readily absorbed and utilised by the plant for a number of different processes which are key to improving yields and weights of almonds. Potassium also plays a key role in the boosting growth and encourages nut-fill for the best performing yields (Amanullah, Iqbal, Irfanullah and Hidayat, 2016).

Transit Silicate® treated trees also had higher amounts of nitrogen, iron and zinc which are all important for leaf development (figure 15).

Pre-Harvest Analysis of Nuts

Figures 9 to 12 show multiple different analyses done on almonds collected from the trees before harvest. Whole nut weight, hull weight, kernel weight and out-turn % (pre-harvest) measurements and calculations were made to see if there were any differences in weight from nuts collected on the tree prior to harvest and nuts collected at harvest. These nuts were collected off the tree shortly before harvest to minimise any moisture differences.

100 nuts from each row were collected and measured and it was found that almond trees treated with Transit Silicate® produced nuts which were 8.7% heavier than the control nuts (figure 9). Due to the 8.7% increase in whole nut weight, this trend was also followed through when analysing the hull kernel and out-turn% of nuts prior to harvest. Figure 10 shows the hull weight differences between Transit Silicate® treated trees and the control trees and it was calculated that there was an 8.7% increase in hull weight. Figure 11 shows the kernel weight differences between the treated and control trees and it was calculated that trees treated with Transit Silicate® had a 17.5% increase in kernel weight compared to the control. This 17.5% increase in kernel weight was statistically significant and provides a high degree of confidence that an application of Transit Silicate® produced heavier almond kernels. Due to the kernels weighing significantly more than the control, this meant that the out-turn % prior to harvest were also significantly higher than the control trees. Figure 12 shows the out-turn percentages between the treated and control trees. Out-turn % are determined by dividing the kernel weight by the whole nut weight and multiplying by 100. It was calculated that trees treated with transit silicate had a nut out-turn % which was 8% higher than the control at 31.2%. Having a higher out-turn% is extremely important as it relates directly back to return on investments.

The higher whole nut weight, hull weight and kernel weight seen in trees treated with Transit Silicate® can be explained through the chelating properties of amino acids and BAOM. Transit Silicate® not only provides plants with available silicon to assist in stress management, but also provides 2 key organic chelating agents (amino acids and BAOM) which have shown exceptional performance in chelating nutrients already in the soil and improving plant uptake and translocation to parts of the plant which require specific nutrition at a specific time. Nutrients which were already at the root zone at the time of Transit Silicate® application would have been naturally chelated by the amino acids and BAOM improving the fertiliser use efficiency of the farm managers fertiliser regime (Souri, 2016). Figures 15 and 16 show the leaf and soil nutrient concentrations respectively shorty before harvest and it can be seen that almond trees and soil treated with application of Transit Silicate® have higher concentrations of a number of elements such as nitrogen, sulphur, iron, zinc, copper, boron and silicon. With higher concentrations of nutrients available in the plant, the more growth the plant can achieve which boosts yields and nut development.

Harvest Analysis of Nuts

Figures 13 and 14 both show the data collected from the almond trees at harvest time. Once the trees had been shaken, all the nuts around 18 trees were swept using a hand rake and each trees total kg of nuts was weighed. Each tree had a small sample collected at harvest and out-turn % calculations were then done.

Figure 13 shows the out-turn percentages of the treated and control trees at harvest and it was calculated that control trees had an out-turn percentage of 28.4% and treated trees had an out-turn percentage of 33.2% which is a percentage increase of 16.9%. This increase in out-turn is statistically significant and suggests that trees treated with Transit

Silicate® produced kernels which made up a higher ratio of the whole nut weight compared to control trees.

Figure 14 shows the differences between the quantity of nuts per tree between the control and Transit Silicate® treated trees. Transit Silicate® trees on average had 32.3% more nuts per tree compared to the control trees at approximal 35 kg per tree (treated) compared to 26.5 kg per tree (control). This difference was also statistically significant.

Again, this increase in the quantity of nuts per tree in the Transit Silicate® tree can be explained though the increased nutritional benefits which Transit Silicate® provides in terms of its organic chelating capabilities, but also treated trees would have experiences less stress from the environment and also pests which can damage the tree. This is due to the abiotic and biotic stress resistance which silicon provides. Silicon applications increase antioxidant defences which prevents cell death (Kim, Khan, Waqas and Lee, 2017). Silicon has also been researched as a key element in stomatal development which controls photosynthesis and regulation within the plant easing the effects of drought or heat stress (Deshmukh, Ma and Bélanger, 2017). This can also improve the quantity of nuts per tree.

Leaf and Soil Nutrient Analysis

Figures 15 and 16 show graphs of leaf and soil concentrations respectively. In the leaf nutrient analysis shown in figure 15, it was found that trees treated with Transit Silicate® had higher levels of nitrogen, phosphorus, sulphur, iron, manganese, zinc, copper, cobalt, boron, molybdenum and most importantly, silicon compared to the control trees.

In the soil nutrient analysis shown in figure 16, it was found that soil that was treated with Transit Silicate® had higher concentrations of ammonium nitrogen, nitrate nitrogen, sulphur, magnesium (significantly higher), potassium, boron, iron, copper (significantly higher), and zinc compared to the control soil.

These higher levels of nutrients in the leaf tissue and soil are a result of the extra nutrients which were naturally chelated in the soil by amino acids and BAOM. These organic molecules improve the absorption and transportation of nutrients within the plant. This increase in nutrition observed in the trees treated with Transit Silicate® correlates directly to the yield and out-turn increases. Transit Silicate® treated trees also had a 10.4% increase in the silicon concentration in the leaf tissue which improves photosynthesis, increases antioxidant defences, hormone signalling, nutrient transportation and improves cell wall integrity (Hasanuzzaman et al., 2018). These added benefits which silicon provides plants also directly relates to improved yields.

Pest Damage Assessment

Transit Silicate contains 33% potassium silicate in its formulation. Silicon (Si) plays a role in maintaining plant health when exposed to biotic and abiotic stresses (Luyckx, Hausman, Lutts and Guerriero, 2017). To assess the severity of kernel damage from pests and other kernel defects, 150 nuts were randomly collected from samples which were collected at harvest from treated and control trees. These nuts where then carefully cracked by hand and analysed for the presence of Carpophilus Beetle, Carob Moth, kernel gumming and aborted kernels.

Table 2 shows the results from this analysis and it clearly shows that Transit Silicate treated nuts had significantly less Carpophilus Beetle damage compared to the control. From the results displayed, Transit Silicate® treated nuts had 8.7% Carpophilus beetle damage, 0.7% kernel gumming, 2.7% aborted kernels and 0% carob moth damage in a random sample of 150 nuts. Whereas control nuts had 16% Carpophilus beetle damage, 1% kernel gumming, 1.3% aborted kernels and 1.3% Carob moth damage in a random sample of 150 nuts.

When analysing the nuts, it was noted that the severity of pest damage per kernel was also lower in comparison to the control kernels. This was determined by comparing the chew tunnels, entrance holes and frass (almond meal and excreta) on the kernels. Control kernels had more frass compared to the treated kernels and less kernel meat was eaten. Kernel gumming damage was also reduced.

Out of the 3 defects analysed (kernel abortion, kernel gumming and pest damage), the almond trees treated with Transit Silicate® resulted in less defects overall in comparison to the control nuts. This can be explained by the beneficial role silicon plays in plant health. In abiotic stress (salinity, drought, thermal and heavy metal stresses), reactive oxygen species (ROS) are produced as a reaction to the stress. These ROS can heavily impact normal cell function and cause the death of cells. Through supplementation of Si, increased antioxidant defences are increased which prevents cell death. This is done through upregulation of silicon transporters and expression of proteins linked to photosynthesis, ribosomes, oxido-reduction, hormone signalling, metal ion binding, and defence responses. Silicon has also been found to play key factors in stomatal development which has related roles in photosynthesis and transpiration regulation which also assists in easing abiotic stresses such as drought or heat stress (Deshmukh, Ma and Bélanger, 2017).

When analysing the benefits silicon has on abiotic stresses such as pests and diseases, silicon has been found to accumulate in cell walls which can prevent damage by pests and diseases. Silicon has also been found to affect the host-pathogen interaction which prevents further damage to plants by stopping effectors and signalling molecules produced by the pest (Wang et al., 2017).

Conclusion

In conclusion this trial was conducted to evaluate how two 30L/ha applications of Transit Silicate® at nut development effects plant nutrition, yields and kernel pest damage. Many parameters were considered and measured when coming to this conclusion including visual tree analyses, nut analyses before and after harvesting, analysing out-turns between treated and control trees and measuring pest damage. The results gathered from this trial demonstrated that through applications of Transit Silicate® at key kernel and nut development stages can increase the weight of kernels as well as increasing the out-turn whilst also reducing biotic and abiotic stress defects.

When studying the figures presented, it can be found that almond trees treated with Transit Silicate® had the following results:

- More vegetative growth in the lower potions of the canopy along with more nut available for picking on the lower portions of the Transit Silicate® treated trees.
- At pre-harvest, trees treated with Transit Silicate® had higher whole nut weights, hull weights, kernel weights and out-turn % (pre-harvest) compared to the control which have percentage increases of 8.7%, 8.7%, 17.5% (significant) and 8% (significant) respectively.
- At harvest, trees treated with Transit Silicate® produced higher out-turns compared to control trees with a percentage increase of 16.9% which was significantly higher than the control (28.4% vs 33.2%).
- On average, trees treated with Transit Silicate® had 32.3% more nuts per tree compared to the control trees.
- Leaves collected prior to harvest showed higher levels of nitrogen, phosphorus, sulphur, iron, manganese, zinc, copper, cobalt, boron, molybdenum and most importantly, silicon compared to the control trees.
- Treated soil collected prior to harvest showed higher concentrations of ammonium nitrogen, nitrate nitrogen, sulphur, magnesium (significant), potassium, boron, iron, copper (significant), and zinc compared to the control soil.
- Less biotic and abiotic stress defects. Noticeably a lower number of Carpophilus beetle damage in trees treated with Transit Silicate® in comparison to the control trees.
- Lower severity of pest damage and defects caused in trees treated with transit silicate®.

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Appendix 1. Statistical Analysis of Results

Table 1: Analysis of yield parameters with reference to control and treated (Transit Silicate®) almond trees. Values are given mean ± standard deviation. P value <0.15 was considered to be statistically significant

Parameter	Treatment		*P*- Value	Significance	% Change
	Control	Treated (Transit Silicate®)			
Whole Nut Weight (g) (100 nuts) Pre-Harvest **Figure 9**	391.8 ± 13.56	426.0 ± 41.52	0.247	No	8.7
Hull Weight (g) (100 Nuts) Pre-Harvest **Figure 10**	211.2 ± 6.44	229.5± 22.91	0.254	No	8.7
Kernel Weight (g) (100 Nuts) Pre-Harvest **Figure 11**	113.4 ± 9.44	133.2 ± 15.10	0.127	Yes	17.5
Out-turn % of Nuts Pre-Harvest **Figure 12**	28.91 ± 1.39	31.23 ± 0.54	0.0546	Yes	8.0
Out-turn % of Nuts Harvest **Figure 13**	28.39± 4.54	33.18± 2.52	0.0730	Yes	16.9
Kg of Nuts per Tree (kg) Harvest **Figure 14**	26.46 ± 10.83	35.01± 10.24	0.127	Yes	32.3

Table 2: Analysis of different nutrient levels in the leaves with reference to Control and Treated (Transit Silicate®). P value <0.15 was considered to be statistically significant.

Nutrient	**Treatment (Mean)**		***P* Value**	**Significance**	**% Change (Control to Treated)**
	Control	**Treated (Transit Silicate®)**			
"Nitrogen - %"	2.976	3.156	0.698572	No	6.05
"Phosphorus - %"	0.2370	0.2656	0.650571	No	12.07
"Potassium - %"	4.490	4.490	>0.999999	No	0.00
"Sulphur - %"	0.2086	0.2104	0.907670	No	0.86
"Calcium - %"	2.362	1.892	0.399357	No	-19.90
"Magnesium - %"	0.5746	0.5036	0.492390	No	-12.36
"Sodium - %"	0.009582	0.01030	0.412204	No	7.53
"Iron - mg/kg"	129.0	161.0	0.269407	No	24.81
"Manganese - mg/kg"	166.0	164.8	0.982639	No	-0.72
"Zinc - mg/kg"	95.78	152.5	0.239713	No	59.22
"Copper - mg/kg"	9.762	26.93	0.285059	No	175.82
"Cobalt - mg/kg"	0.08940	0.1228	0.313750	No	37.38
"Boron - mg/kg"	58.98	61.44	0.674884	No	4.17
"Molybdenum - mg/kg"	0.1610	0.2621	0.279498	No	62.80
"Silicon - mg/kg"	352.0	388.6	0.637582	No	10.40

Table 3: Analysis of different soil nutrient levels and properties in the Transit Silicate® trial. P value <0.15 was considered to be statistically significant.

Nutrient	Treatment (Mean)		*P* Value	Significance	% Change (Control to Treated)
	Control	Treated (Transit Silicate®)			
pH 1:5 Water	6.897	6.770	0.619154	No	-1.84
pH CaCl2	5.787	5.673	0.715528	No	-1.96
Organic C (%)	0.3067	0.3100	0.939645	No	1.09
Nitrate – N (mg/kg)	1.000	1.600	0.106208	Yes	60.00
Ammonium – N (mg/kg)	6.067	7.967	0.695446	No	31.32
Colwell P (mg/kg)	7.000	5.000	0.373901	No	-28.57
Sulphur (mg/kg)	2.833	8.833	0.186575	No	211.76
Calcium (mg/kg)	262.0	234.0	0.504129	No	-10.69
Magnesium (mg/kg)	66.00	80.00	0.128588	Yes	21.21
Potassium (mg/kg)	110.3	112.0	0.957031	No	1.51
Sodium (mg/kg)	20.67	37.00	0.262992	No	79.03
Boron (mg/kg)	0.4767	0.5567	0.676885	No	16.78
Iron (mg/kg)	10.57	10.70	0.933945	No	1.26
Manganese (mg/kg)	17.23	10.33	0.359238	No	-40.04
Copper (mg/kg)	0.6700	1.733	0.031300	Yes	158.71
Zinc (mg/kg)	1.747	3.533	0.286220	No	102.29
Ca:Mg ratio	24.67	22.33	0.541034	No	-9.46
K:Mg Ratio	2.400	1.767	0.022948	Yes	-26.39
ECEC (cmol/kg)	0.5167	0.4500	0.657005	No	-12.90
Chloride (mg/kg)	2.220	2.270	0.839677	No	2.25
Salinity EC 1:5 (dS/m)	14.33	38.67	0.008369	Yes	169.77
(Ece dS/m)	0.04033	0.06600	0.082303	Yes	63.64
Clay %	0.9300	1.533	0.078765	Yes	64.87
Sand (+20 micron) %	2.467	2.000	0.516490	No	-18.92
Silt (2-20 micron) %	94.67	95.67	0.467605	No	1.06