Evaluation of the efficacy of Amino Boost Transit Max® in improving nutrient content and yield of almonds.

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1. INTRODUCTION

Amino Boost Transit Max (ABTM®) is a unique formulation of bio-stimulants and chelating agents, including17 organically derived amino acids (10%), kelp (6%), fulvic acid (4%) and biologically active organic molecules (2%, patented product). The unique combination of organic molecules contained in Amino Boost Transit Max® promotes both the uptake and transport of nutrients within plants and stimulates growth and physiological functions to improve stress tolerance.

2. OBJECTIVE

The specific objectives of this study are:

1. To study the impact of Amino Boost Transit Max® application through fertigation on the plant nutrient status; specifically leaf nutrients and nut nutrients.
2. To study the site-specific transport of different nutrients, as per the nutrient requirement of plants at each growth stage, via Amino Boost Transit Max® treatment.
3. To examine the effect of Amino Boost Transit Max® treatment on crop vigour.
4. To examine the impacts of Amino Boost Transit Max® on yield parameters: nut weight, hull weight, kernel weight, and the outturn and return on investment.

3. MATERIALS AND METHOD

3.1. Site Selection and Trial Design

This trial was conducted in an Almond orchard located in the Sunraysia region of Victoria (34°52′S 143°08′E). A block in the new development (5th leaf) was selected. Five rows were selected in the trial block, and ten trees in each row (50 trees altogether) were isolated by inserting isolation taps in the fertigation lines. These were treated as control trees. From the same rows from which control trees were selected, ten further trees in each row (50 trees altogether) were chosen to receive Amino Boost Transit Max® treatment as per the orchard's fertigation plan. Table 1 shows the application rate of ABTM® in the treated versus control Almond trees.

Table 1. Application rate of ABTM® in treated vs control Almond trees.

Treatment	Rate/ ha
Amino Boost Transit Max®	10L/ ha at bud burst and 15 L/ha at post-harvest
Control	0

4. OBSERVATIONS

4.1. Kernel and Leaf Nutrient Analysis

During the nut maturation stage, the following analysis was conducted at the Phosyn Analytical Laboratory in QLD:

1. Ten leaves per plant were collected from five plants per treatment, and washed leaves were then analysed for the elements: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn) Boron (B), Zinc (Zn), Iron (Fe), Molybdenum (Mo), Copper (Cu) and Sulphur (S).

2. Ten nuts per plant were collected from five plants per treatment. These nuts were analysed for elements N, P, K, Ca, Mg, Mn, B, Zn, Fe, Mo, Cu and S.

4.2. Kernel Weight, Hull Weight and Nut Weight

At harvest, trees were mechanically shaken, and nuts were swept into the midrow. Samples of sixty nuts were randomly collected from a sampling spot of 50 cm length windrow nut piles. Five separate replicate samples were collected for both the control and Amino Boost Transit Max® treated plants. Nut weight, hull weight and kernel weight were separately recorded.

4.3. Crop Vigour and Normalised Difference Vegetation Index Assessment

Four weeks after the post-harvest Amino Boost Transit Max® application, crop vigour was assessed by drone based aerial imaging and assessment of the NDVI (Normalised Difference Vegetation Index) of each tree in the control treated areas by Hort-Eye Pty Ltd, Melbourne VIC. Fifty trees each from the ABTM® treated area and the control area were taken as 50 replicates each for the assessment.

4.4. Soil Nutrient Analysis

Soil nutrient analysis of the trial site was done in the autumn. Ten core samples of soils were collected separately from the treated area and the control area, mixed and subsamples of 500 g were analysed for N, P, K, Ca, Mg, B, Zn, Fe, Mo, Cu and S at Phosyn Analytical Laboratory, QLD.

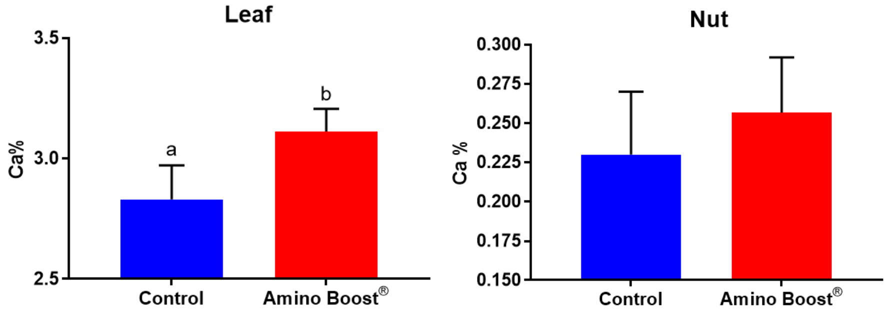
4.3. Statistical analysis

Prism 7 (Graph Pad Software) was used for the statistical analysis. *t*-test was performed to determine the significant difference between the control versus treated, P values <0.15 were considered to be significant.

5. RESULTS

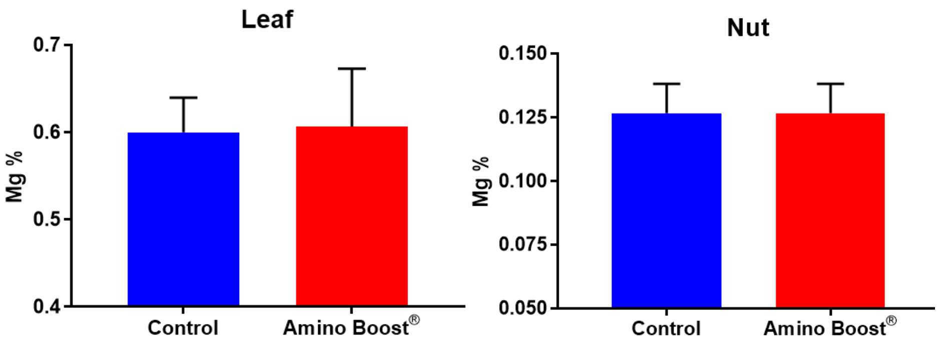
5.1. Nutrient levels in the leaves and nuts

Figure 1. Analysis of Calcium (Ca) in the leaves and nuts with reference to Control vs ABTM® treatment.



Significantly higher Leaf Ca levels were observed in the Amino Boost Transit Max® (ABTM®) treated plants as compared to the control plants (Figure 1). A 10% increase in the leaf Ca levels and a 11% increase in the nut Ca levels was observed in the ABTM® treated plants compared to control plants (Table 2).

Figure 2. Analysis of Magnesium (Mg) in the leaves and nuts with reference to Control vs ABTM®



There was no significant difference in the levels of Mg in either the leaves or the nuts between the control and the ABTM® treated plants (Figure 2).

Figure 3. Analysis of Manganese (Mn) in the leaves and nuts with reference to Control vs ABTM®

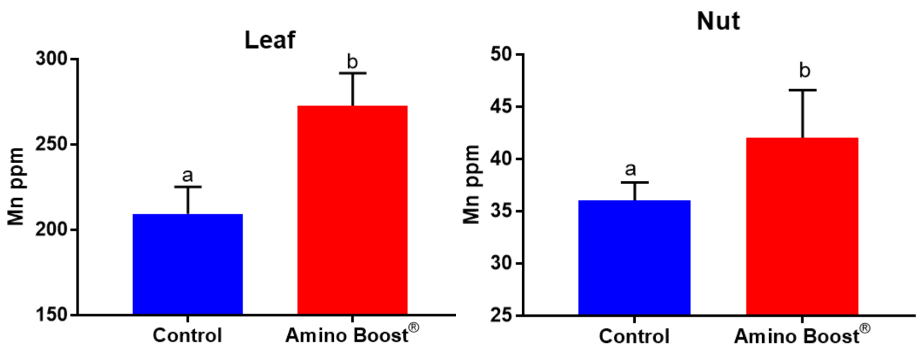
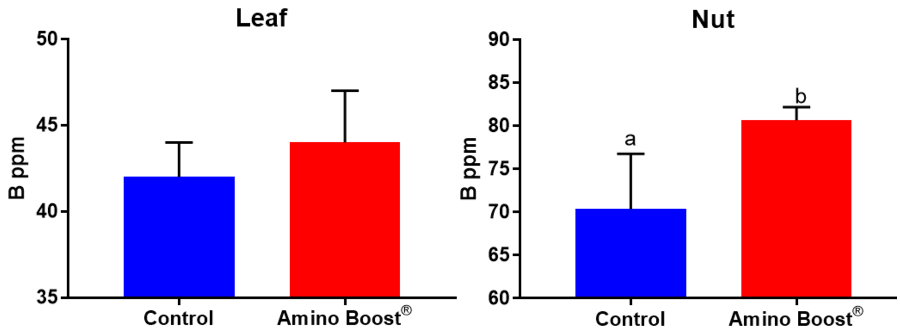


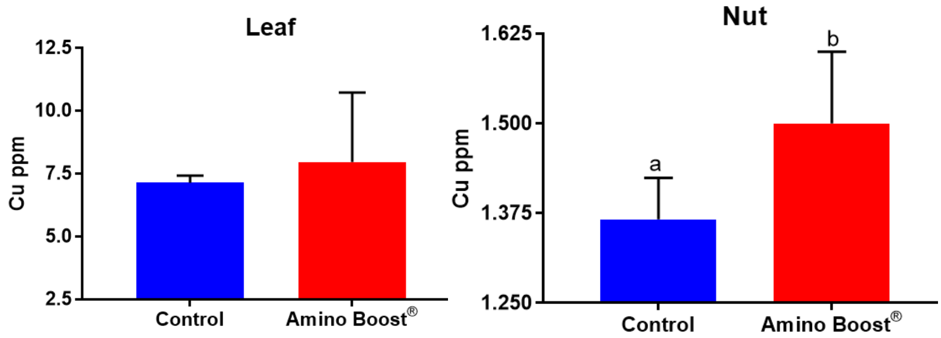
Figure 3 shows significantly higher levels of Mn in the leaves and nuts of the ABTM® treated plants compared to the control plants. A 30% increase in the leaf Mn levels and a 16% increase in the nut Mn levels was observed in the ABTM® treated plants compared to control plants (Table 2).

Figure 4. <u>Analysis of Boron (B) in the leaves and nuts with reference to Control vs ABTM® treatment.</u>



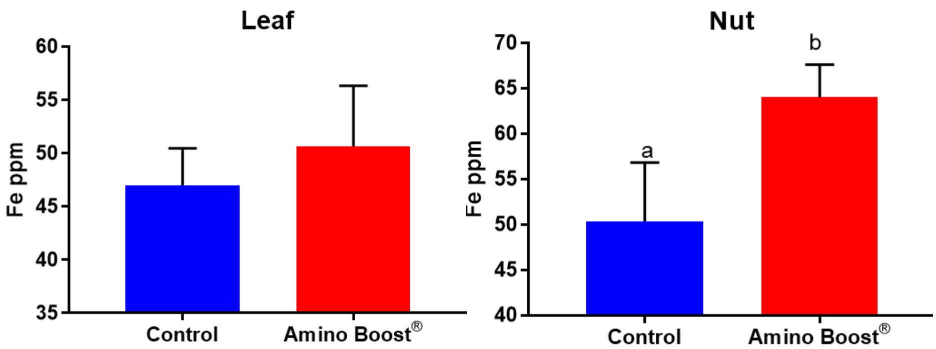
Significantly higher nut B levels were observed in the ABTM® treated plants compared to the control plants (Figure 4). A 14.7% increase in the nut B levels and a 4.8% increase in the leaf B levels was observed in the ABTM® treated plants as compared to control plants.

Figure 5. <u>Analysis of Copper (Cu) in the leaves and nuts with reference to Control vs ABTM® treatment.</u>



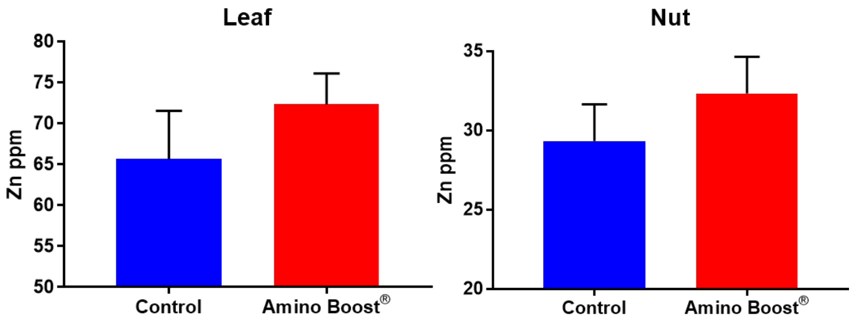
Significantly higher nut Cu levels were observed in the ABTM® treated plants compared to the control plants (Figure 5). An 11.7% increase in the leaf Cu levels and a 9.7% increase in the nut Cu levels was observed in the ABTM® treated plants compared to control plants.

Figure 6. <u>Analysis of Iron (Fe) in the leaves and nuts with reference to Control vs ABTM® treatment.</u>



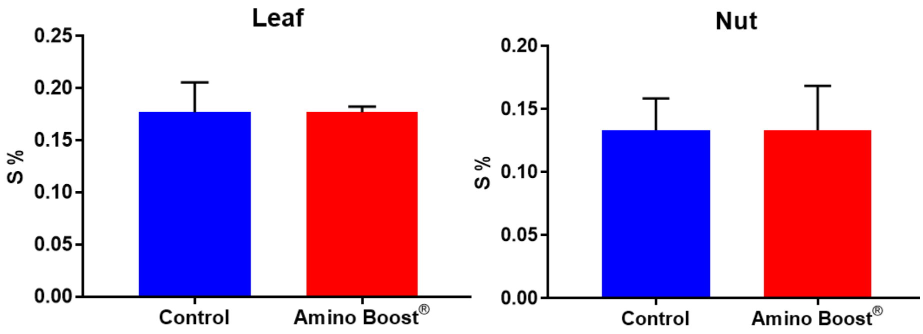
Significantly higher nut Fe levels were observed in the ABTM® treated plants compared to the control plants (Figure 6). A 27% increase in the nut Fe levels and a 7.8% increase in the leaf Fe levels was observed in the ABTM® treated plants compared to control plants.

Figure 7. Analysis of Zinc (Zn) in the leaves and nuts with reference to Control vs ABTM® treatment.



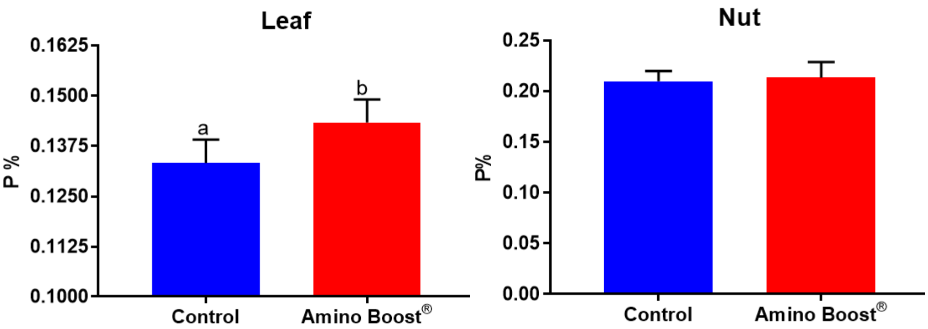
Even though not statistically significant, the average values of leaf Zn levels and nut Zn levels were higher in the ABTM® treated plants compared to the control plants (Figure 7). A 10% increase was observed both in the leaf Zn levels and in the nut Zn levels by the ABTM® treatment (Table 2).

Figure 8. Analysis of Sulphur (S) in the leaves and nuts with reference to Control vs ABTM® treatment.



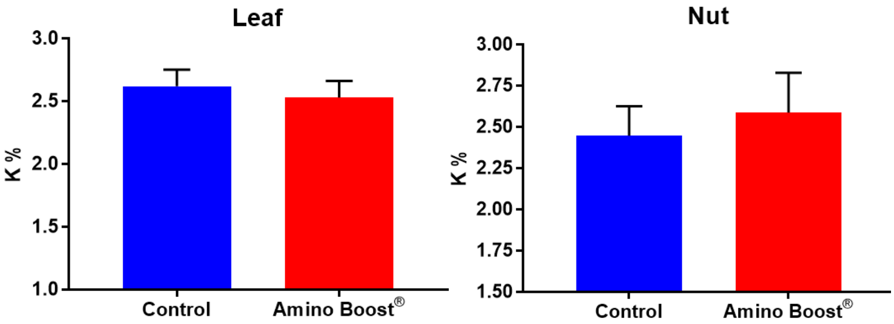
There was no significant difference in the levels of S in either the leaves or the nuts of the control and the ABTM® treated plants (Figure 8).

Figure 9. Analysis of Phosphorus (P) in the leaves and nuts with reference to Control vs ABTM®



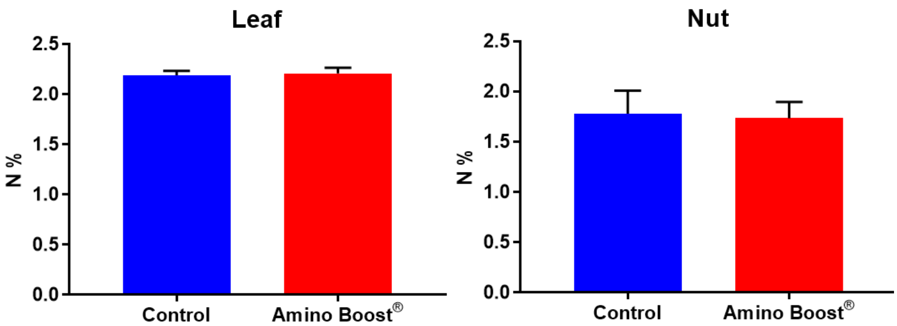
Leaf P levels were significantly higher in the ABTM® treated plants compared to the control plants, while there was no difference in the nut P levels (Figure 9). ABTM® treatment resulted in a 7.7% increase in the leaf P levels (Table 2).

Figure 10. Analysis of Potassium (K) in the leaves and nuts with reference to Control vs ABTM®



There was no significant difference in the levels of K in either the leaves or the nuts of the control and the ABTM® treated plants (Figure 10).

Figure 11. Analysis of Nitrogen (N) in the leaves and nuts with reference to Control vs ABTM® treatment.



There was no significant difference in the levels of N in either the leaves or the nuts of the control and the ABTM® treated plants (Figure 11).

* ***Figure 1 to Figure 11.*** *Each bar represents mean± SE (n=5 replicates). A t-test was performed to determine the significant difference between the control Vs treated; different superscripts show significant difference (P<0.15). The t-test was performed with Prism 7 (Graph Pad Software).*

Table 2. Analysis of different nutrient levels in the Almond leaves and nuts with reference to Control versus Amino Boost Transit Max treatments.

Parameters	Treatments		Average % increase	*P* value	Statistical Significance
	Control	Amino Boost Transit Max®			
Leaf Ca %	2.83 ± 0.082	3.113 ± 0.054	**10%**	0.0443	Yes
Nut Ca %	0.23 ± 0.023	0.2567 ± 0.02	**11%**	0.4345	-
Leaf Mg %	0.6 ± 0.023	0.6067 ± 0.038	-	0.8890	-
Nut Mg %	0.127 ± 0.007	0.1267 ± 0.007	-	>0.9999	-
Leaf P %	0.133 ± 0.003	0.1433 ± 0.003	7.7%	0.1012	Yes
Nut P %	0.21 ± 0.007	0.2133 ± 0.009	-	0.7676	-
Leaf Mn ppm	209.3 ± 9.062	272.7 ± 10.97	30.3%	0.0112	Yes
Nut Mn ppm	36 ± 1	42 ± 2.646	16.7%	0.1012	Yes
Leaf B ppm	42 ± 1.155	44 ± 1.732	4.8%	0.3911	-
Nut B ppm	70.33 ± 3.712	80.67 ± 0.882	14.7%	0.0536	Yes
Leaf Cu ppm	7.133 ± 0.167	7.967 ± 1.588	11.7%	0.6293	-
Nut Cu ppm	1.367 ± 0.033	1.5 ± 0.058	9.7%	0.1161	Yes
Leaf Zn ppm	65.67 ± 3.383	72.33 ± 2.186	10.1%	0.1732	-
Nut Zn ppm	29.33 ± 1.333	32.33 ± 1.333	10.2%	0.1868	-
Leaf Fe ppm	47 ± 2	50.67 ± 3.283	7.8%	0.3942	-
Nut Fe ppm	50.33 ± 3.756	64 ± 2.082	27.2%	0.0335	Yes
Leaf S %	0.177 ± 0.017	0.177 ± 0.003	-	>0.9999	-
Nut S %	0.133 ± 0.015	0.133 ± 0.02	-	>0.9999	-
Leaf K %	2.62 ± 0.076	2.53 ± 0.076	-3.4%	0.4473	-
Nut K %	2.447 ± 0.104	2.587 ± 0.1396	4.4%	0.4658	-
Leaf N %	2.19 ± 0.025	2.21 ± 0.032	-	0.6499	-
Nut N %	1.78 ± 0.132	1.733 ± 0.094	-	0.7879	-

The values given are mean ± standard deviation, n=5. P values <0.15 were considered to be significant.

5.2. Yield Parameters

Figure 12. Analysis of yield parameters with reference to Control vs ABTM® treatment.

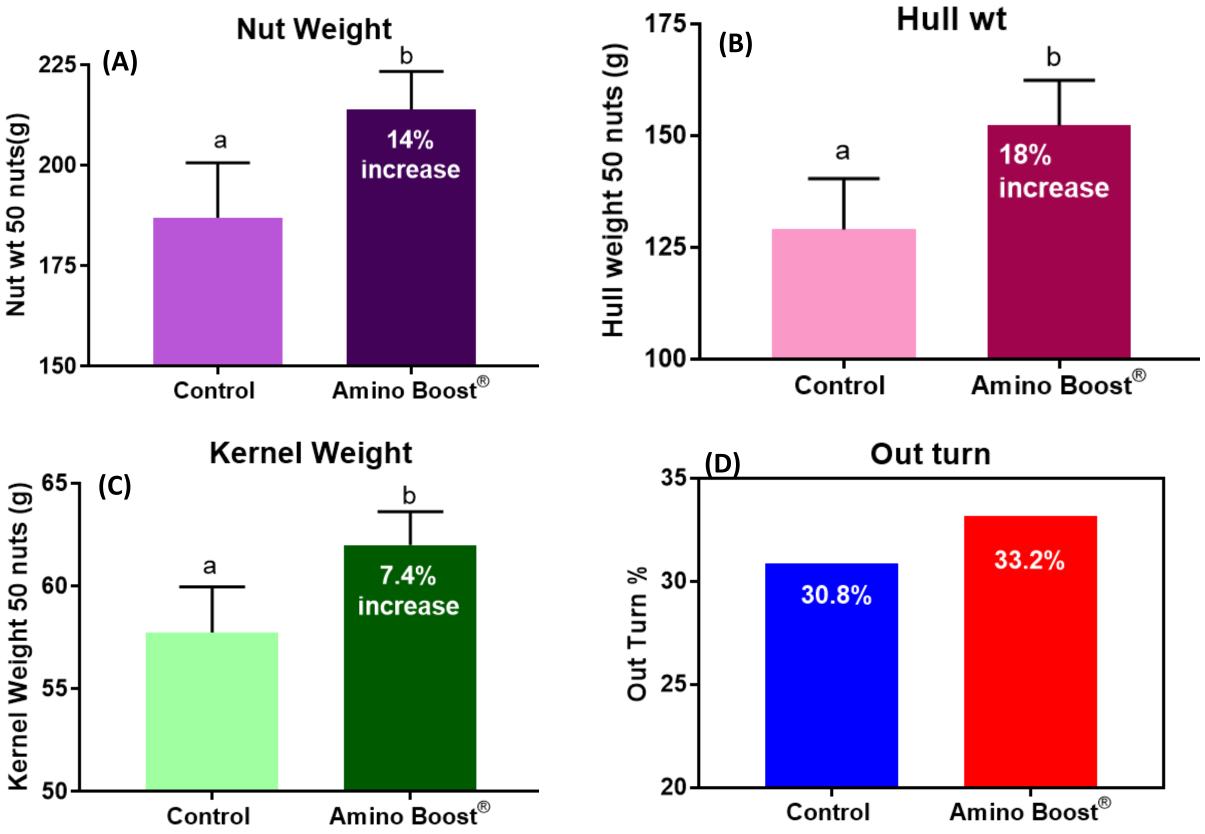


Figure 12 shows that ABTM® treatment significantly increased the Nut weight (A), Hull weight (B) and Kernel weight (C) compared to the control. Nut weight, hull weight and kernel weight were increased by 14%, 18% and 7.4% respectively by the ABTM® treatment (Table 3). Out turn (D) was calculated as the percentage of kernel weight to nut weight. Out turn was increased by 3% by the ABTM® treatment compared to the control.

*** Figure 12.** Each bar represents mean± SE (n=4 replicates). A *t*-test was performed to determine the significant difference between the control Vs treated, different superscripts show significant difference (*P*<0.05). The *t*-test was performed with Prism 7 (Graph Pad Software).

Table 3. Analysis of yield parameters with reference to Control versus Amino Boost Transit Max treatments.

Parameters	Treatments		Average % increase	*P* value	Statistical Significance
	Control	Amino Boost Transit Max®			
Nut Weight	187 ± 6.9	214 ± 4.743	14%	0.0178	Yes
Hull weight	129 ± 5.7	152.3 ± 5.089	18%	0.0227	Yes
Kernel weight	57.75 ± 1.1	62 ± 0.8165	7.4%	0.0215	Yes

The values given are mean ± standard deviation, n=4. P values <0.05 were considered to be significant.

5.3. Crop Vigour and NDVI

Crop Vigour and NDVI comparison of the Control and ABTM® treated plants.

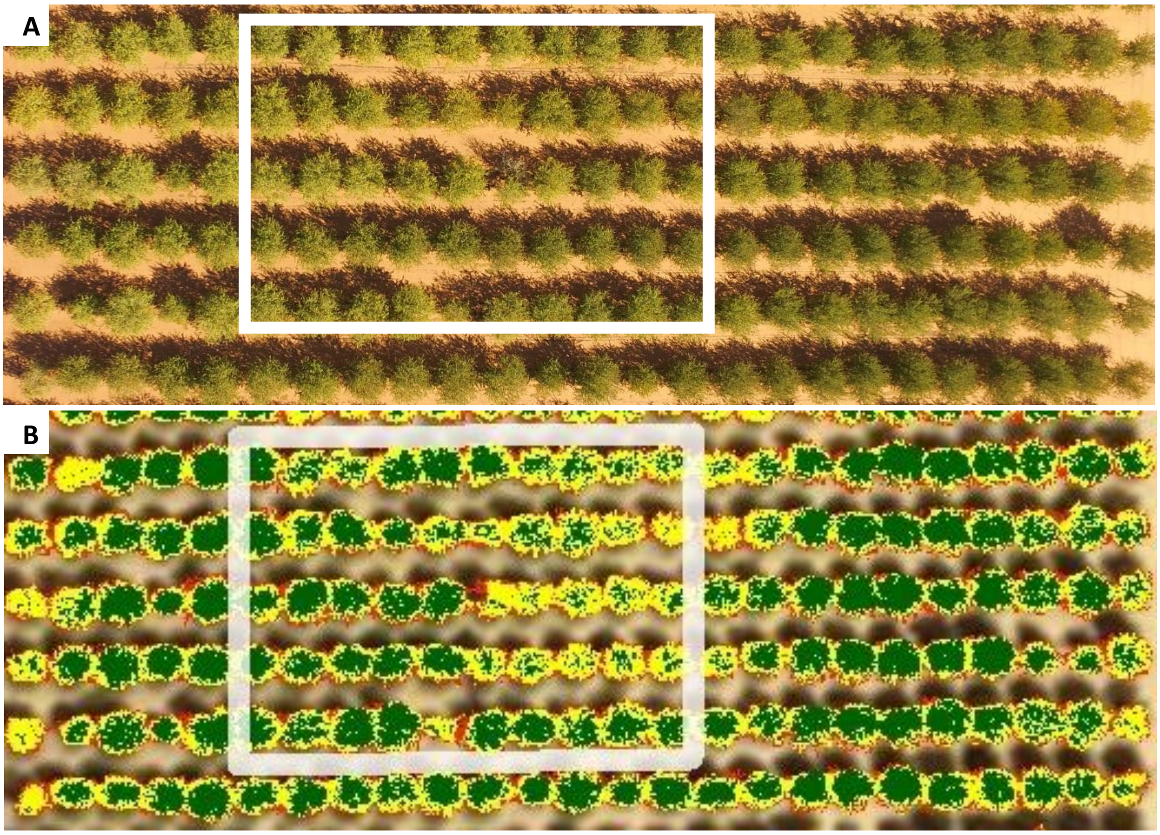
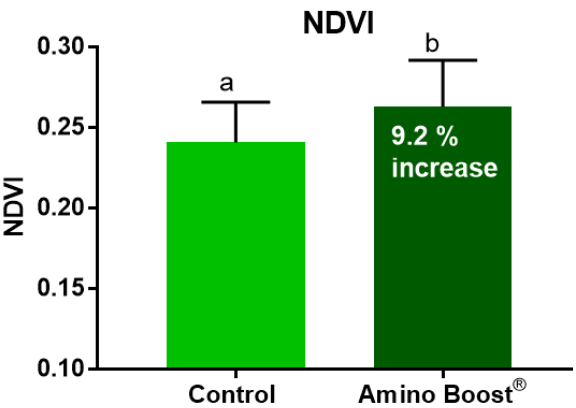


Figure 13. A – the aerial image of the trial site; plants outside the white square were treated with ABTM® and the plants inside the square were control plants. B- a tree-by-tree Normalised Difference Vegetation Index (NDVI) of the trial site showing control trees and ABTM® treated trees.

Figure 14. Analysis of Normalised Difference Vegetation Index (NDVI) with reference to Control vs ABTM® treatment.



Each bar represents mean± SE (n=50 replicates). A *t*-test was performed to determine the significant difference between the control Vs treated, different superscripts show significant difference (P<0.05). The *t*-test was performed with Prism 7 (Graph Pad Software).

The ABTM® treated trees showed significantly higher NDVI compared to the control trees (P value < 0.0001). However, it should be noted that this trial was not replicated in different sites and the natural variability in tree vigour due to other factors such as variability in soil conditions, topography, soil water status may also have contributed to this result.

5.4. Soil Analysis

Table 4. Soil analysis from the ABTM® treated area and the Control Areas. Guidelines for adequate levels of each parameter is also given in the table.

Soil Analysis	ABTM® Treated Area	Control Area	Guideline
CEC (meq/100g)	1.96	2.98	12.0-40.0
pH [1:5 CaCl2]	6.2	6.5	5.2-7.9
Organic Matter (%)	0.7	0.9	3.0-8.0
NO3-N (ppm)	-1	-1	15.0-70.0
NH4-N (ppm)	-1	-1	
Phosphorus [Olsen] (ppm)	4	6	30-100
Potassium (meq/100g)	0.17	0.18	0.5-1.5
Magnesium (meq/100g)	0.59	0.64	1.00-4.50
Calcium (meq/100g)	1.14	2.09	6.0-15.0
Sulphur (ppm)	5	7	8.0-20.0
Manganese (ppm)	5.7	7.2	5.0-60.0
Boron (ppm)	0.1	0.3	1.0-5.0
Copper (ppm)	2.1	5.9	2.5-20.0
Iron (ppm)	10	13	5-120
Zinc (ppm)	2.4	5.9	5.0-15.0
K base saturation (%)	8.9	5.9	2.0-5.0
Mg base saturation (%)	29.8	21.6	5.0-15.0
Ca base saturation (%)	58.1	70.1	50.0-75.0
Na base saturation (%)	1.5	1.8	1.0-2.0
Ca:Mg Ratio	1.95	3.25	2.5-3.0

(red)	Very Low
(orange)	Low
(green)	Adequate
(blue)	High

Soil in the trial area is very light sandy loam with very low Cation Exchange Capacity (CEC), which means limited nutrient storage ability. All of the tested nutrients (except Mn, Cu, Fe, Zn) were low to very low in the control area. Interestingly, all of the tested minerals were lower in the ABTM® treated area compared to the control area, while mineral levels in the plant tissues were higher from the ABTM® treated area compared to the control area. This suggests that ABTM® facilitates mobilisation of nutrients from the soil and transports them into the plant tissues.

6. RETURN ON INVESTMENT

A 7.4% increase in the kernel weight was observed in the ABTM® treated plants (Figure 12). Return on investment for ABTM® was calculated by the following way:

Average kernel yield = 3.5 t/ha

Kernel weight increase by ABTM® treatment =7.4%

Total kernel yield by ABTM® treatment = 3.759 t/ha

Increase in the kernel yield per ha =259 Kg/ha

Increased revenue per ha; 259 x $8 = $2072/ha

Cost of product (25 L/ha), $3.4/L = $85/ha

$$\text{ROI} = \frac{(\text{Gain from the investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

ROI = ($2072 - $85)/$85

ROI = 23.4 (in percentage 2340%)

Assumptions: Average kernel yield per ha is 3.5 t, and the selling price of 1 kg almond kernel is AUS$ 8.00.

7. CONCLUSION

This trial showed that Amino boost facilitates nutrient mobilisation in the soil and transport into plant tissues. All tested nutrients in plant tissues were higher in the ABTM® treated plants when compared to the control plants. The ABTM® treatment significantly increased yield parameters: nut weight by 14 %; hull weight by 18%; and kernel weight by 7.4%. The out turn was found to increase by 3% with the ABTM® treatment. The NDVI analysis showed a 9.2% increase via the ABTM® treatment. In conclusion, ABTM® was found to be effective in improving plant nutrient status, crop vigour and the yield parameters of almonds. Return on investment was calculated a 2340%.