Assessing the Effectiveness of Amino Boost Transit Max (ABTM) on Commercial Potatoes (Solanum tuberosum, L) for Improved Nutrient Uptake and Increased Yield

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Abstract

Amino Boost Transit Max (ABTM) is a highly refined biological stimulant product containing organically derived amino acids, pure kelp, organically sourced and purified fulvic acid and Biologically Active Organic Molecules (BAOM). When applying this unique combination of organic molecules, uptake of soil nutrition is significantly enhanced and absorption and translocation of key macro and micro elements are transported around the plant system to where they are most heavily required. As a result, growth and plant physiological functions are is increased promoting higher yields and healthier crops. Amino Boost Transit Max was trialled using 2 commercial cultivars of potatoes (Atlantic and 1867) which are commonly used for the processing of crisps (chips). These cultivars were treated with Amino Boost Transit Max and monitored to assess the benefits associated with sprout emergence (glass house), tuber initiation, number of tubers per plant, % of marketable potatoes, dry matter content (tubers and shoots), plant height and leaf nutrient concentrations. It was found that there was an 11% increase in emergence after the initial application of ABTM, 14.1% increase in plant height after emergence, 30% more tuber initiation compared to control Atlantic potato plants, increased dry matter content of shoots and tubers in both varieties, increase in the weight of marketable tubers per plant in both varieties treated with ABTM and higher estimated yields in both varieties treated with ABTM.

Keywords: Amino Boost Transit Max, Atlantic, 1867, commercial potatoes, tuber growth, nutrient absorption, yields

1. Introduction

The effectiveness of biological molecules such as amino acids, kelp and fulvic acid have been studied extensively throughout the years assessing how these molecules assist in producing quality crops and increased yields. Dual Chelate Fertilizer Pty Ltd have developed a superior biologically stimulating liquid product known as Amino Boost transit Max (ABTM). ABTM is a premium quality plant bio stimulant which assists in increasing root uptake, root growth and translocation of nutrients and promotes the availability of sufficient nutrients throughout the complete growing season (Technical report, Amino Boost Transit Max, Dual Chelate Fertilizer., 2019). ABTM not only improves the nutrient status in plants but also increases plant tolerance to abiotic stresses such as heat and water stress whilst also strengthening plant growth and yield development.

ABTM contains 10% organically derived amino acids, 6% kelp, 4% purified fulvic acid which is organically sourced and 2% Biological Active Organic Molecules (BAOM).

The potato (*Solanum tuberosum, L.*) crop starts with vegetative growth followed by tuber induction and tuber enlargement. Nutrient uptake, Carbon assimilation and translocation take place throughout the entire cropping cycle. In addition, plant growth and development are strongly dependent on the sink-source interaction. Due to the shallow rooting system of potatoes, efficient use of nutrients is very low (Liu et al. 2015), therefore increasing root uptake of available macro and micro nutrients throughout the cropping cycle will assure good vegetative growth and optimum yield quality. Amino Boost Transit Max promotes the uptake of nutrients through the roots, especially under stress conditions such as drought. This is due to the low molecular weight of humic substances along with plant derived polyphenols (tannins) which can act as mitochondrial activation factors which can speed up the respiration rate of plants (Fact Sheet CPPA, FB Sciences).

This study focuses on how ABTM increases soil and plant nutrient uptake, improves yield quality and vegetative growth throughout the cropping season. Nutrient uptake and overall crop performance will be determined by collecting data on sprout emergence, analysing plant tissue and soil reports, tuber and shoot biomass and measuring fresh weight of tubers at harvest with reference to the marketable characteristics required to commercially sell potatoes for processing. Photos will also be taken to visually compare plant growth and health between treatments and cultivars.

2. Objectives

The specific objectives of this trial were to:

- Evaluate yields and tuber quality after applications of ABTM.
- Measure the relationship between ABTM applications and total biomass accumulation.
- Observe growth quality parameters such as sprout development, crop vegetative growth and root growth along with tuber initiation during applications of ABTM.

3. Materials and Methods

Site Selection and Trial Design

<u>Field Trial</u>

The field experiment was conducted on a 10-ha section of a potato field irrigated by a pivot on private property at Lake Powell, Victoria 3597 from August to December 2020. The soil is categorised as sandy to sandy loam which has low organic matter and the soil pH before planting was 8.2- 8.5. The field experiment was arranged as a factorial experiment based on the complete block design with two treatments (ABTM and Control). There were two different cultivars included in the ABTM treated block area which were Atlantic and 1867 cultivars which are commonly used for processing crisps (chips). The rest of the area counted as the untreated (control) block which contains the same cultivars.

There were three commercial ABTM applications, 1st was an in-furrow application at planting and the 2nd and 3rd applications were applied through foliar applications at emergence and row closure using a boom sprayer.

In addition, 10 plants were selected in the ABTM treated block in both cultivars and 10L/ha was applied as an in-furrow application at tuber bulking. All the other fertilizer applications were the same as the grower’s standard. Soil samples were collected to evaluate soil nutrition condition in both treated and untreated areas after harrowing the soil. See table 1 for precise application rates.

Table 1: Application rates and timings of ABTM applied to Atlantic and 1867 potato plants in field. * 10 plants treated only with application done through watering can.

Application Number	Application Rate (L/ha)	Application Timing
1	20 L/ha	At planting in-furrow (fertigated)
2	10 L/ha	10 – 15 days after emergence (foliar)
3	10 L//ha	40 – 45 days after planting at tuber initiation (foliar)
4*	10 L/ha	In-furrow at tuber bulking (fertigated). 10 plants per cultivar.

Sampling

In field trial sampling was collected in randomized plots which included tissue sampling at 25-30% flowering, tuber initiation at growth stage III (35 days after emergence), plant height, above ground biomass (dry matter content) at growth stage IV (tuber bulking at 50 DAE) and Brix levels in petioles at tuber bulking. Yield weight and tuber diameter were measured at harvest to calculate the percentage of marketable quality tubers.

A buffer zone was created which ensured that the trial area was 5 meters away from the boundary line of the paddock. 10 alternative rows from both treated and untreated blocks were then selected and the first plant sampled was the 20th plant from the paddocks edge.

When collecting yield data at harvest, four replicates in both treated and untreated blocks were collected. Two meters per row was randomly selected and all tubers and shoots that are within 2 meters were harvested. In addition to this, the 4th in-furrow application of ABTM, which included 10 plants, were all dug up to assess the tuber weight and diameter. Figure 1 shows the sampling pattern used in the in-field data.

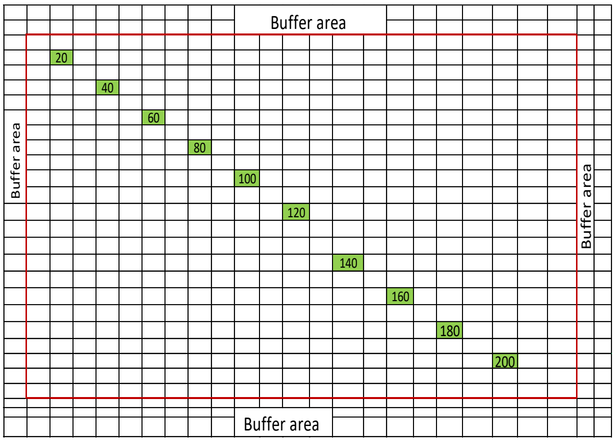

Figure 2: Sample collecting procedure in the field experiment.

Glass House Trial

The second part of this trial was a pot trial conducted in a glass house in Robinvale. There were six treated pots and six untreated pots. The 6 treated pots were separated into 3 pots containing the Atlantic cultivar and 3 pots containing the 1867 cultivar. The first ABTM application was done at planting and second and third applications at emergence and row closure. All other nutrients provided were in accordance with the grower's standard fertiliser program. Figure 2 below shows the trial layout in the glass house.

Untreated pot - C1	Treated Pot – T2	Untreated pot – C4	Treated Pot – T5
Treated Pot -T1	Untreated pot – C3	Treated Pot -T4	Untreated pot – C6
Untreated pot – C2	Treated Pot -T3	Untreated pot – C5	Treated Pot – T6

Figure 1: Trial layout in the glass house

Sampling

Samples were collected from each pot which included, sprout emergence, plant height at growth stage III, tuber initiation at growth stage III, leaf tissue sampling at 25-30% flowering and tuber and shoot biomass at tuber initiation. Yield parameters were not able to be measured as the tubers became rotten and some began to shrink due to the extreme high temperatures and high relative humidity (RH) experienced in the glass house. This could not be controlled and hence negatively impacted the tuber bulking stage.

4. Results

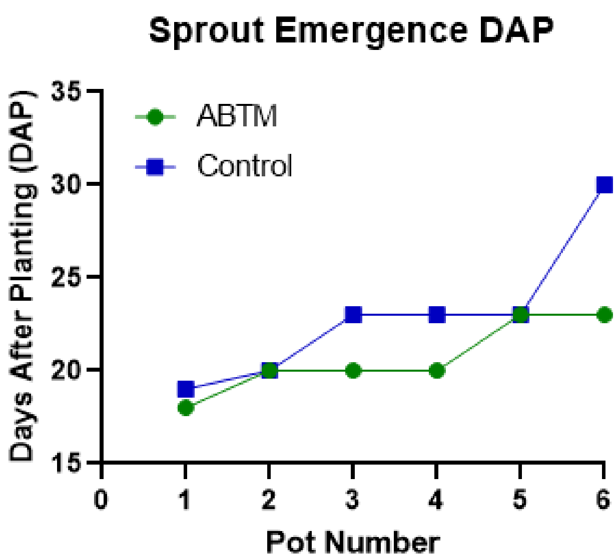

Figure 3: The number of days after planting it took for sprout emergence to occur in ABTM treated and untreated tubers in the glass house experiment.

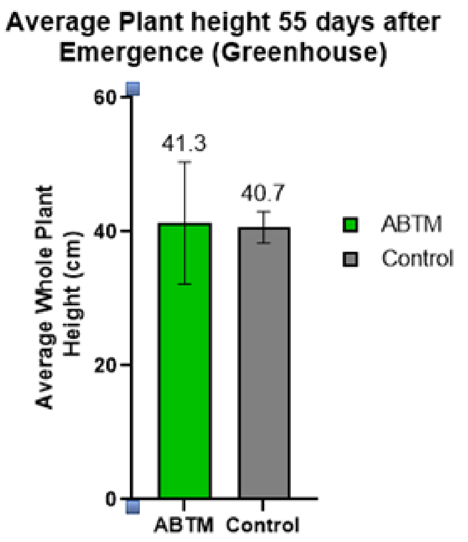

Figure 4: The average plant height of potato plants 55 days after emergence in the glass house.

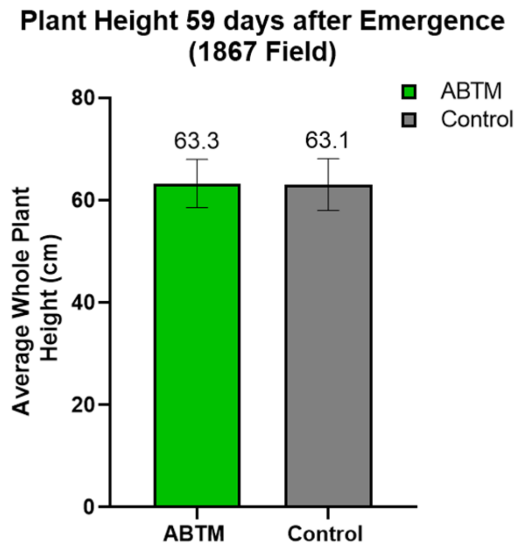

Figure 7: Average plant height of 1867 cultivar potatoes in field 59 days after emergence.

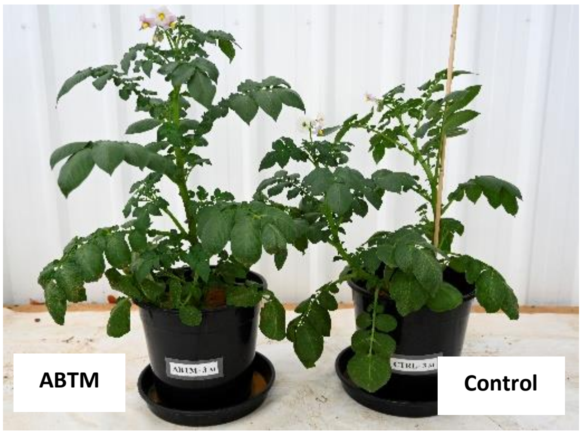

Figure 5: Comparative image of an Atlantic potato plant treated with ABTM and an untreated (control) Atlantic potato plant in the glass house experiment.

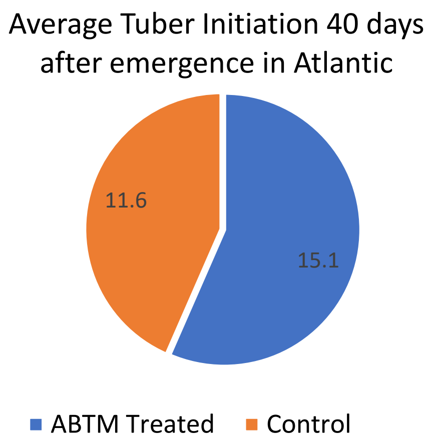

Figure 8: Average tuber initiation (number of tubers per plant) in Atlantic potatoes 40 days after emergence in field.

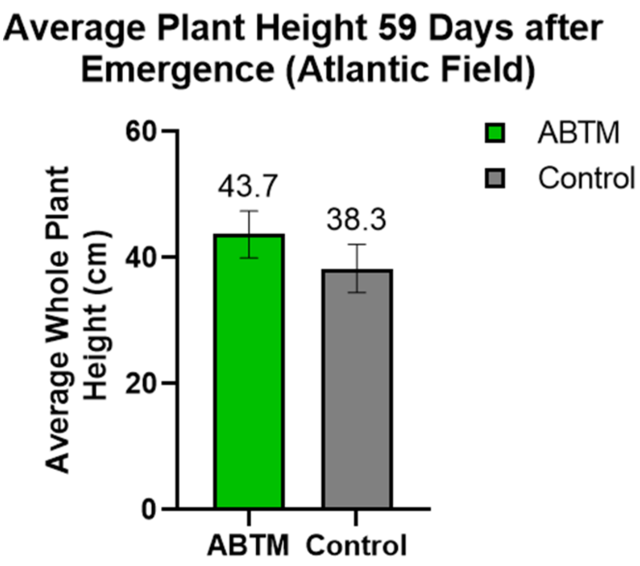

Figure 6: Average plant height of Atlantic cultivar potatoes in field 59 days after emergence. Significant difference ($P<0.05$).

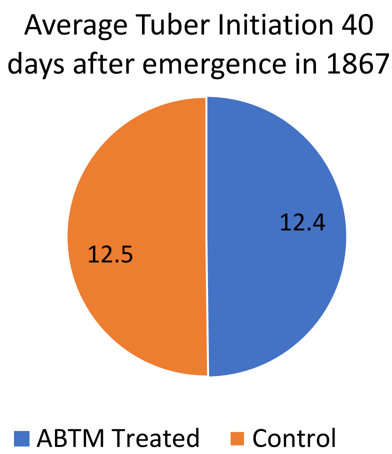

Figure 9: Average tuber initiation (number of tubers per plant) in 1867 potatoes 40 days after emergence in field.

Atlantic ABTM	Atlantic Control

Figure 10: Image of tubers of the Atlantic cultivar 59 days after planting (growth stage III) in field.

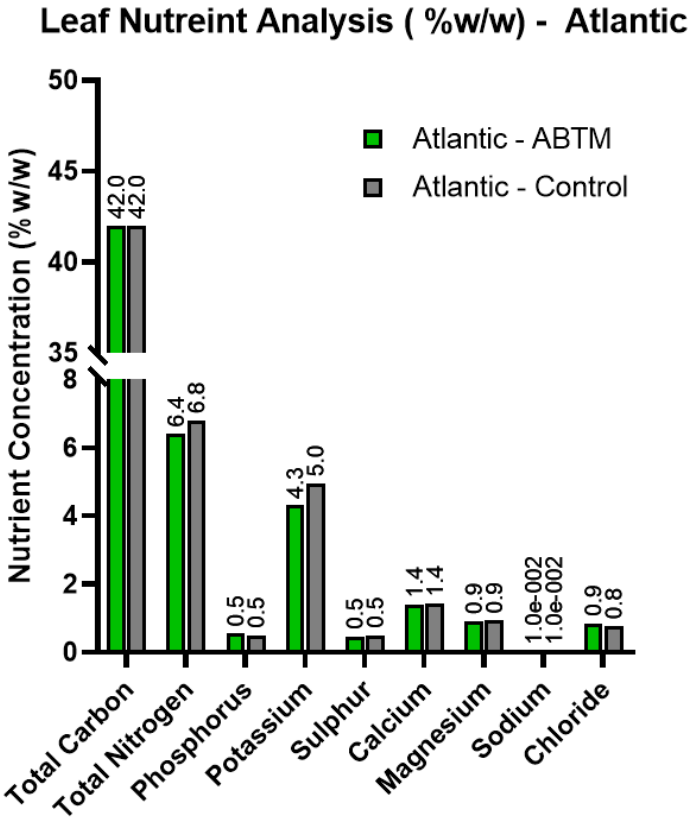

Figure 12: Leaf nutrient analysis of Atlantic potatoes 45 days after emergence (%w/w) in field.

1867 ABTM	1867 Control

Figure 11: Image of tubers of the 1867 cultivar 59 days after planting (growth stage III) in field.

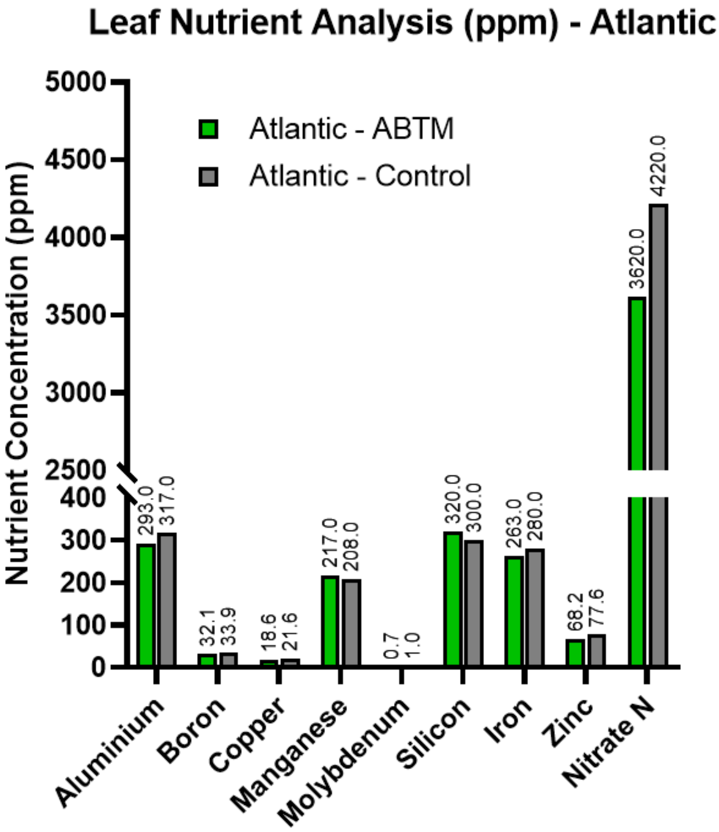

Figure 13: Leaf nutrient analysis of Atlantic potatoes 45 days after emergence (ppm) in field.

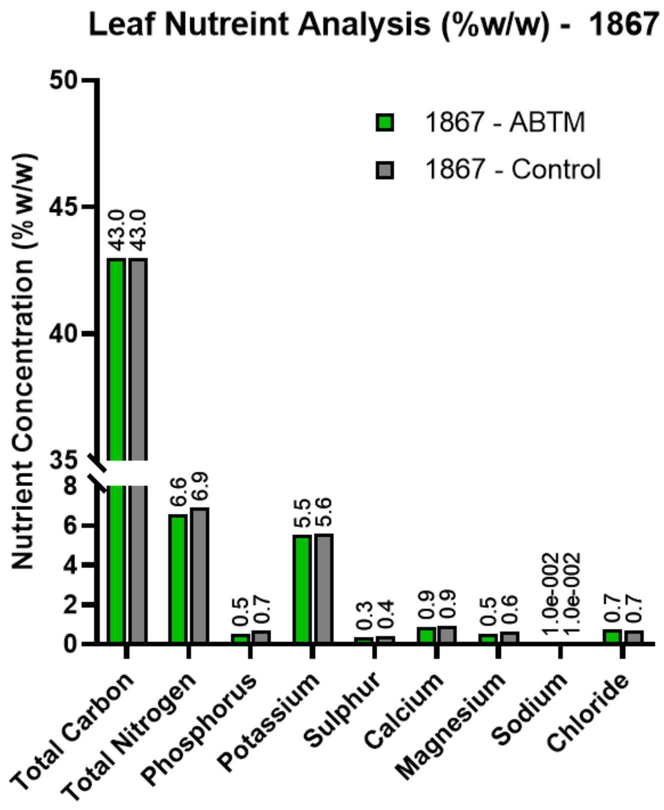

Figure 14: Leaf nutrient analysis of 1867 potatoes 45 days after emergence (%w/w) in field.

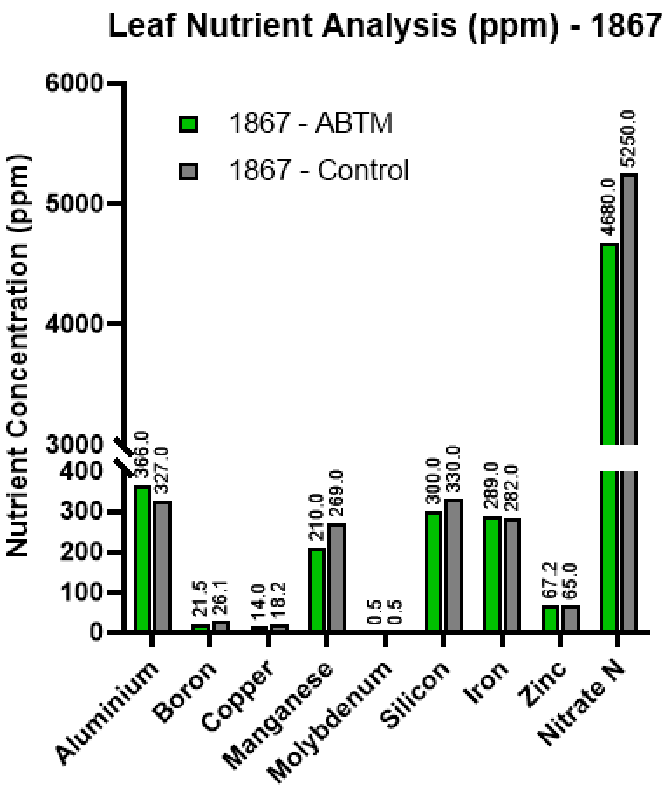

Figure 15: Leaf nutrient analysis of 1867 potatoes 45 days after emergence (ppm) in field.

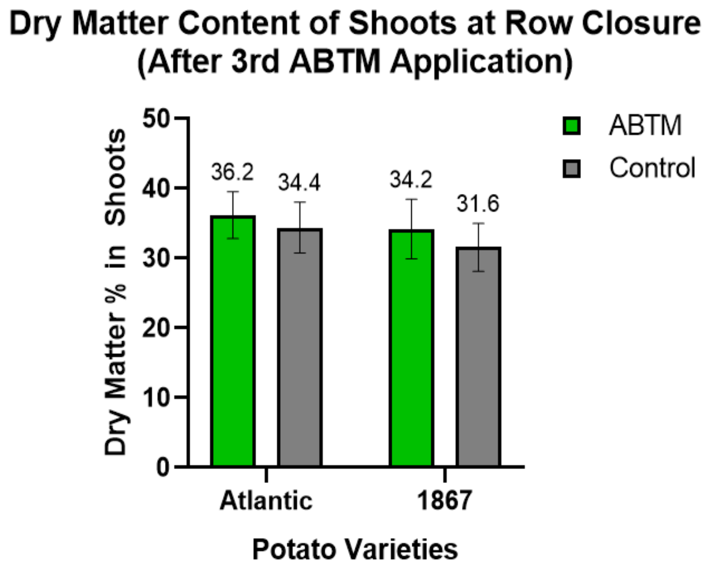

Figure 16: Dry matter content of shoot in ABTM and control Atlantic and 1867 potatoes (field). Samples taken 50 days after emergence.

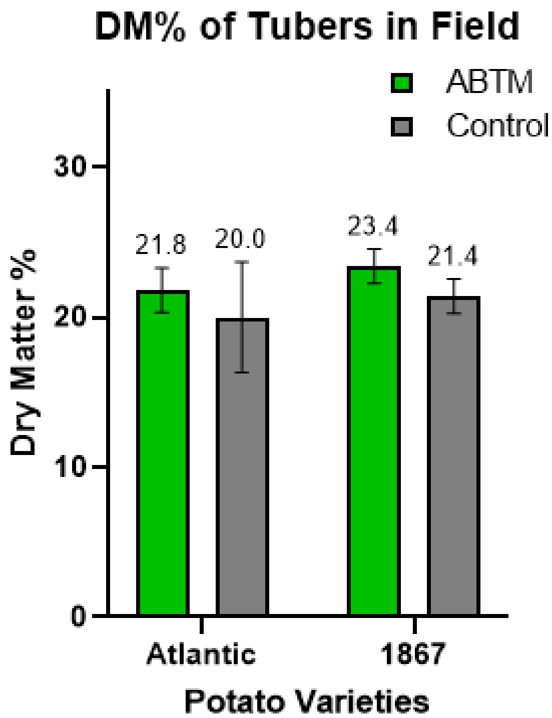

Figure 17: Dry matter content of tubers in ABTM and control Atlantic and 1867 potatoes. Samples taken 50 days after emergence. 1867 significantly different (P<0.05).

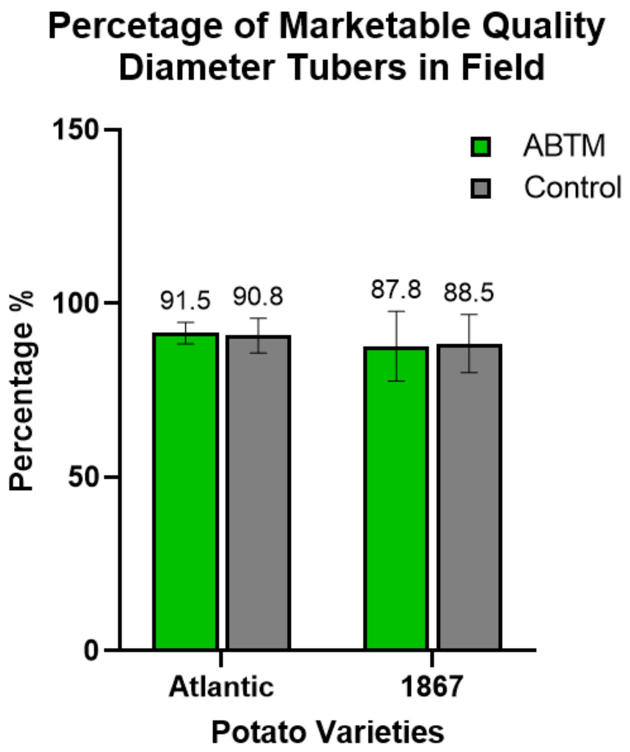

Figure 18: Percentage of marketable quality diameter tubers (diameter range >40mm and <90mm).

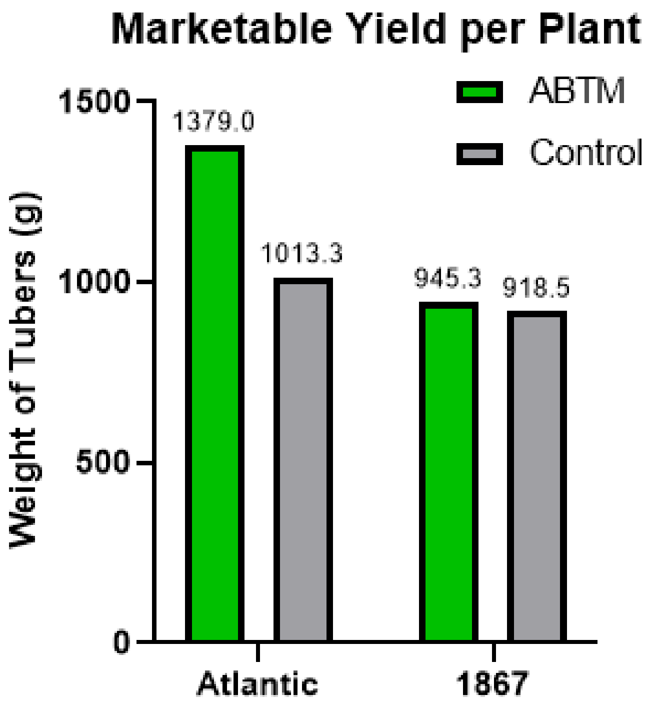

Figure 20: The marketable quality tuber weight per plant.

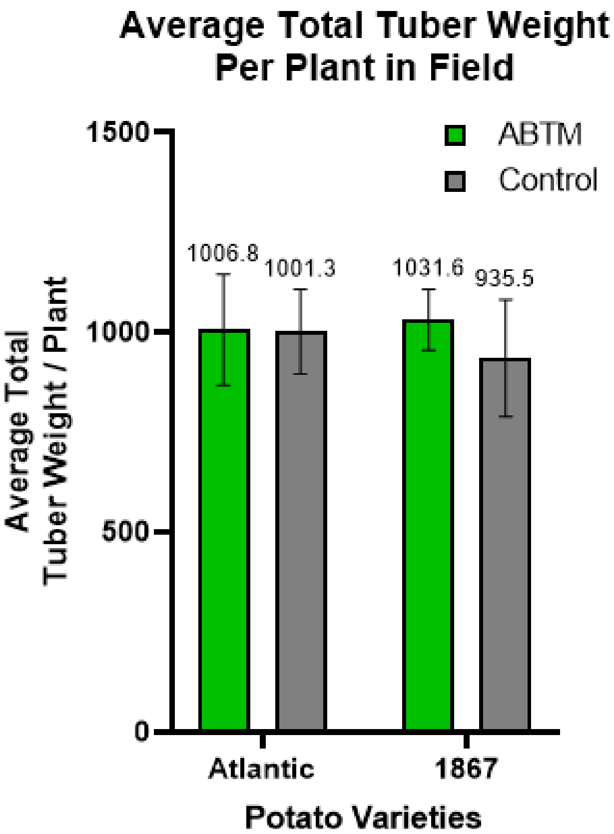

Figure 19: Average total tuber weight per plant in field.

Table 2: Yield estimates of Atlantic and 1867 cultivars in field after final applications. 10 plants per treatment used to make estimates.

		Estimated Yield
Atlantic	ABTM	72.5 t/ha
	Control	60 t/ha
1867	ABTM	56.7 t/ha
	Control	55.1 t/ha

5. Discussion

5.1 Emergance

It is known that the nutrients already in potato tubers are the main source of energy which is used during plant germination. There are several factors that affect potato emergence and establishment, including seed quality, disease infestation, herbicide damage, size of seed pieces and weather conditions (S.V. Murashev, S.D. Kiru, V.G. Verzhuk, A.V. Pavlov, 2020). Therefore, different methods have been used for breaking dormancy in potato tubers such as physical, chemical and biochemical methods based on phytohormones. (Deligios, P.A., Rapposelli, E.M. & Mameli, G, 2019).

It was calculated that 66% of the ABTM treated tubers' shoots emerged within 20 days in the glass house trial (Figure 3), while 33% only emerged within 20 days after planting in the control pots. This means that ABTM treated plants on average emerged 11% faster compared to the control plants.

This quicker emergence rate is most likely due to the phytohormones in ABTM such as cytokinin (contained in kelp) and also the amino acids which increases the breaking dormancy in seed potatoes. Increasing the rate of early gemination results in a shorter the life cycle and hence early harvest can be obtained, especially in drought conditions.

5.2 Plant Height after Emergence

<u>In glass house</u>

Figure 4 shows the average plant height 55 days after emergence of potatoes in the glass house trial. Potatoes treated with ABTM had a 1.5% increase in plant height compared to the untreated potatoes. Figure 5 also shows an image taken which compares an ABTM treated Atlantic potato plant compared to the control which shows a significant difference in plant height.

Increases in plant height can be explained through the provided amino acids which contain Tryptophan, the amino acids used to synthesise the plant growth hormone Auxin. Auxin promotes stem elongation and guides shoot tips towards light sources which is a movement known as phototropism (Balzan, Johal and Carraro, 2014). Auxin also plays a role in maintaining apical dominance which explains the 1.5% increase in plant height compared to the control.

<u>In Field</u>

Figures 6 and 7 show the Atlantic and 1867 average plant heights respectively. Both varieties show higher average plant heights when treated with ABTM in comparison to the control. However, the Atlantic variety showed the biggest percentage increase in plant height of 14.1% compared to the control seen in figure 6. This difference was also statistically significant ($P<0.05$). Again, this significant difference in plant height compared to the control is most likely related to the increase in Auxin production by providing the precursor amino acids for Auxin synthesis.

5.3 Tuber Initiation

Figure 8 and 9 show the average tuber initiation rate 40 days after emergence between Atlantic and 1867 varieties in the field. The Atlantic variety had a significant increase in the amount of tuber initiation in potato plants treated with ABTM. It was calculated that on average, ABTM treated Atlantic potato plants had more tuber initiation which was 30% higher than the control plants (figure 8). The main nutrition related to increases in tuber initiation are phosphorus, potassium and calcium. ABTM contains amino acids, biologically active organic molecules and fulvic acid. These components are all able to naturally chelate nutrients within the soil and ultimately improve the uptake as plants recognise these chelators as natural, and allow them to pass through plant membranes much easier than synthetic chelating agents.

This significant increase in tuber numbers per plant in Atlantic potatoes treated with ABTM is also visually observed in figure 10 which shows an image of tuber production at growth stage III. When comparing the treated and control Atlantic potato tuber growth, it can be seen that the ABTM treated potatoes had more tubers than the control which relates directly back to figure 8 highlighting the tuber initiation 40 days after planting.

When comparing tuber initiation between the treated and control 1867 potato plants in figure 9, there is very little difference observed, and when comparing these results to the visual analysis in figure 11, there also seems to be little difference in tuber initiation. This might be due to the 1867 variety being an early medium maturing variety however the Atlantic variety is classified as an early maturing variety (Prager, Lewis, Michels and Nansen, 2014). These differences may have caused the 1867 treated and control potatoes to not have as much tuber bulking before measurements were taken.

5.4 Leaf Nutrient Concertation, shoot growth and tuber growth

Figure 12 and 13 show the leaf nutrient concentration in the Atlantic potato variety and figures 14 and 15 show the leaf nutrient concentration in the 1867 potato variety. In both varieties, there is very little difference between the treated and control leaves collected. This could be due to nutrient dilution experienced in both Atlantic and 1867 varieties due to more growth in the shoots (figure 6 & 7), increased dry atter content of shoots (figure 16), increases in the dry matter % (DM%) of tubers in the field (figure 17) and also increased average total tuber weight per plant (figure 20).

Atlantic plants treated with ABTM had a significant increase in plant height by 14.1% (figure 6), a 5.2% percentage increase in the dry matter content of shoots at row closure (figure 16), a 9% increase in the DM% of tubers (figure 17) and a 0.55% increase in average total tuber weight per plant (figure 20). All these increases in growth in both shoot biomass and also tuber growth means that nutrients in the plants are diluted to accommodate for all the extra growth compared to the control plants. This explains why there is very little and almost less nutrition in the leaves of Atlantic plants treated with ABTM. Due to ABTM containing multiple natural chelating agents (amino acids, fulvic acids and BAOM) these nutrients can become more mobile within plants and can be easily transported to areas of more nutrient demand such as in the tubers where there is rapid growth during tuber bulking and maturing.

1867 plants treated with ABTM had an increase in plant height by 0.32% (figure 7), an 8.2% percentage increase in the dry matter content of shoots at row closure (figure 16), a significant increase in the DM% of tubers by 9.3% (figure 17) and a 10.3% increase in average total tuber weight per plant (figure 20). Again, these increases in plant and tuber growth caused diluted nutrition within the leaves of the treated plants due to higher nutrition demand to match the increased growth.

5.5 Marketability of Tubers

Tubers need to be within an acceptable diameter in order to be sold to market for chipping. The acceptable diameter of tubers needs to be more than 40mm but less that 90mm.

Figure 18 shows the percentage of marketable quality tubers in the field. Atlantic potatoes have an increase of 0.77% in the percentage of marketable tubers compared to the control, however the 1867 variety has a percentage decrease of 0.79% in the percentage of marketable tubers compared to the control. This suggests that the 1867 variety either had slightly more tubers outside the acceptable diameter range.

These marketable tubers where then weighed and the average weight of marketable tubers per plant were recorded. Atlantic potatoes had a significant increase in the weight of marketable tubers by 36.1% per plant. Interestingly, the weight of marketable tubers per plant for the 1867 variety also showed a percentage increase of 2.9% compared to the control, even though there was a lower percentage of marketable quality tubers in the ABTM treated plants. This suggests that although there was less tubers within the acceptable diameters, they were still heavier than the control potatoes for the 1867 variety.

From these results, an estimated yield/ha can be calculated which is shown in table 2. It can be estimated that when ABTM is applied to Atlantic potatoes plants, there is a 20.8% increase in yields compared to the control. It can also be estimated that when ABTM is applied to 1867 potato plants, there is a 2.9% increase in yields compared to the control plants.

This increase in yields in potato plants treated with ABTM can be explained by studying the phytohormone effect on tuber growth. Auxin and Cytokinin both have positive roles in tuber growth. It has been researched that Auxin stimulates tuber growth and cytokinin enhances the sink capacity of growing tubers (Aksenova et al., 2012). ABTM contains the amino acid tryptophan which is the precursor for the essential plant hormone Auxin. In potatoes, there is a strong positive correlation observed between the rate of tuber growth and the amount of Auxin in the tubers.

ABTM also contains kelp which has been highly purified and is proved to contain high concentrations of the plant growth hormone Cytokinin. In potato tuber growth, it has been researched that Cytokinin enhances the sink capacity in tubers (Aksenova et al., 2012). In potato tubers, the sink is the point where sugar is accumulated and stored. Since cytokinin increases the sink capacity in the tubers, there is more sugar and carbohydrate accumulation which increases the size and weight of the tubers. This explains why the dry matter in tubers treated with ABTM weight more and yields are also higher.

6. Conclusion

In conclusion this trial was conducted to test how ABTM applications during potato growth can improve the emergence of the seed potatoes, plant height after emergence, tuber initiation, leaf nutrient concentrations, shoot growth, tuber growth, marketability of tubers and yields between 2 different potato varieties – Atlantic and 1867. This trial was conducted in a commercial setting and also in a glass house to closely observe changes after ABTM applications. After analysing the results, it was found that applications of ABTM had the following positive effects on potato plant growth:

- Emergence occurred 11% faster in potato seeds treated with ABTM at planting.
- 14.1% increase in plant height after emergence in potato plants grown in the field.
- 30% increase in tuber initiation resulting in more tubers per plant and increased yields.
- Increased dry matter % in both tuber and shoots in both varieties.
- Atlantic variety produced a higher % of marketable tubers compared to the control
- Both varieties had increases in the weight of marketable tubers per plant.
- Increase in estimated yields for both varieties.

However, applications of ABTM the following negative effects on potato plant growth:

- The 4th in furrow application may have promoted the growth of more smaller tubers. However, during this stage of tuber bulking all energy and carbohydrates need to be diverted to the growth of the existing tubers.

In future trials, ABTM will only be applied at planting and tuber initiation to minimise the production of smaller tubers at the tuber bulking stage. Changes in the ratio of ABTM application will also be revised and assessed to ensure maximised yield quality.

7. References

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