An Evaluation of BOOSTER-Mag™ in Field Processing Tomato Production.

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Abstract
Calix Limited is developing BOOSTER-Mag™ for application as a low cost and benign foliar spray for agriculture. The product is a concentrated aqueous suspension of mineral derived bio-active magnesium hydroxide ($Mg(OH)_2$). Under the auspices of the Australian Processing Tomato Research Council (APTRC), Calix is working directly with Victorian processing tomato growers to quantify the effect of the product on marketable yield and fruit quality.

Over the 2015/2016 season, an initial split plot, multi-replicate field evaluation of BOOSTER-Mag™ treatment in field grown processing tomato was undertaken across three different farms in central Victoria.

Three BOOSTER-Mag™ treatments were applied at 1.5kg concentrate/ha over a 33 day period approximately coinciding with the grow-out midpoint. The treatments were in addition to the conventional pesticide treatments applied throughout the season according to IMP methodology and agronomist advice. Hand harvest data obtained one week prior to mechanical harvest demonstrated that additional treatment coincided with an increase in the average yield of red and unblemished fruit across all three farms (by 6%) relative to the conventionally farmed controls, an outcome somewhat concomitant with observed reductions in unripe, blossom end-rot and insect affected fruit. The reduction in the yield of insect damaged fruit is difficult to explain by macronutrient augmentation and suggests the additional treatment provided insect pest control.

Key Words
tomato, harvestable yield, bio-active magnesium hydroxide, insect pest control

Introduction

The use of pesticide is common in commercial scale field grown tomato production. Insect pest and disease pressure is such that preventative or systemic application of pesticide is an integral and expensive part of production. IPM strategies are adopted to minimise pesticide use to reduce associated costs and risks.

Calix has developed BOOSTER-Mag™ for application as a foliar spray in agriculture. The product is a concentrated aqueous suspension of micron scale magnesium hydroxide ($Mg(OH)_2$) particles and is readily diluted and applied using conventional agricultural chemical sprayers. The $Mg(OH)_2$ active is chemically similar to generic “milk of magnesia” and as such has very low human and aquatic toxicity and importantly, is non-phytotoxic. Calix manufactures in Australia using natural Magnesium Carbonate ($MgCO_3$) ore and advanced and proprietary mineral processing technology (catalytic flash calcination or CFC).

Magnesium is a critical macronutrient for plant viability. It is known or thought to play a key role in a number of essential plant functions and its importance to plant health and crop yield is well documented. The products primary function may be to augment a plant magnesium levels via foliar absorption.

However published research on nano-MgO reports a substantial inhibitory effect on plant pathogens and diseases, specifically; anti-mycotic activity (inhibition of fungal spore germination and mycelial growth) and anti-bacterial activity (suppression of bacterial proliferation).

Electron microscopy and synchrotron studies indicate BOOSTER-Mag™ active particles share key physical attributes with true nano-MgO; active particles are a highly porous assembly of nano-grains. In-vitro testing, undertaken in the course of an APVMA registration process, has shown the product active has anti-fungal and anti-bacterial properties similar to nano-MgO. Importantly, the micron scale of the particles alleviates general concerns about nano-scale materials.

In December 2015, Calix engaged with the Australian Processing Tomato Research Council (APTRC) to explore opportunities to evaluate BOOSTER-Mag™ in field tomato cropping in the Goulburn Valley in central Victoria. The region is one of Australia's most productive and intensively farmed areas and, at approximately 3,000 ha, accounts for nearly 90% of Australia's processing tomato production. Three growers agreed to participate in field evaluations and protocols, jointly developed by the APTRC and Calix, were implemented. This paper documents the activities undertaken, the outcomes and the planned next steps.

Methods

Trial Design

The trial protocol was developed to quantitatively establish the effect of three BOOSTER-Mag™ foliar applications made in addition to conventional pesticide treatments applied according to grower standard IPM methodology. The evaluation was conducted using a randomised split plot including 4 x trial, approximately half row or 300m length, strips (conventional treatment plus BOOSTER-Mag™ treatment) with the balance of the farm considered as the control (conventional treatment). True, completely untreated, control strips were not included. BOOSTER-Mag™ was applied at 1.5kg/ha, using standard boom-sprayers and spray nozzles, over a 33 day period approximately coinciding with the grow-out midpoint. Actual treatment dates; 1st week Jan. 16, 3rd week Jan. 16, 3rd week Feb. 16.

Agronomic Management

Due to disease and insect pressures apparent at times during the 2015/2016 season, a combination of contact and systemic fungicides and a variety of insecticides were applied across the entire paddock in each farm. Substantial variation, in terms of both the number of different products used and the frequency of their use, was apparent between the three farms. Only Farm 2 used a ripening agent.

Sampling and Analysis

Soil Analysis; prior to the initial BOOSTER-Mag™ treatment, a representative soil composite sample (collected to a depth of 30cm) from each farm were analysed according to Nu-Test® protocols by AgVITA Analytical.

Petiole Analysis; after the 2nd BOOSTER-Mag™ treatment, a representative composite sample of new foliar growth from control and trial plots in each farm were analysed according to Soil Response® protocols by AgVITA Analytical.

Hand Harvest; on the 16th March, 2016, approximately one week prior to mechanical harvest, four, 2m bed lengths within the control and 4 x trial strips were hand-harvested. The following yield parameters were quantified according weight of; ripe (or likely to be fully ripe at harvest) and unblemished fruit; green (unlikely to ripen by harvest) and unblemished fruit; insect and grub damaged fruit and; blossom end-rot (BER) affected fruit.

Fruit Quality; Representative composite samples of ripe fruit from each farm were tested using refractometry (Kagome laboratory, Shepparton) to determine comparative fruit sugar (°Brix) levels.

Results

Yield and Yield Quality - Hand Harvest

The results obtained from the hand harvesting undertaken at each farm were evaluated using a standard t-Test; two-sample assuming unequal variance at a confidence level of 95%. Table 1 shows the average individual farm hand harvest results, the three farm average and the outcome of statistical analysis.
Variability in the averaged results of each parameter is apparent between the three farms. This is believed to reflect a number of factors including; soil chemistry; proximity to other farming activity, and individual farming practices and techniques including; fertilisation regimes; choice of seed grown versus transplant; pesticide treatment regimes.
Variability is also apparent between yield data obtained from within individual farm replicates and yield data averaged across the three farms. The results in Table 1 are not intended to provide a comparison of outcomes between individual farms. However the data may enable a comparison between the control and trial yield

within a farm. Yield data averaged across the three farms is included as it was considered to provide an instructive and conservative indication of trends.

Table 1. Average individual farm and three farm average data obtained from hand harvest.

Control	Red (kg)	Green (kg)	Insect (kg)	BER (kg)	Total Yield (kg)	Brix (°Bx)
Farm 1.	40.74	3.18	0.06	0.34	44.31	5.00
Farm 2.	38.84	1.15	1.46	0.46	41.91	5.18
Farm 3.	47.65	6.73	0.88	3.55	58.80	5.05
AVERAGE (3 sites)	**42.41**	**3.68**	**1.20**	**1.45**	**48.34**	**5.08**
Standard Deviation	**4.64**	**2.82**	**0.70**	**1.82**	**9.14**	**0.09**
Trial (B-Mag)	**Red (kg)**	**Green (kg)**	**Insect (kg)**	**BER (kg)**	**Total Yield (kg)**	**Brix (°Bx)**
Farm 1.	42.61	2.31	0.03	0.59	45.54	5.20
Farm 2.	40.78	1.19	1.01	0.31	41.69	5.10
Farm 3.	51.78	6.60	0.15	0.73	59.25	4.60
AVERAGE (3 sites)	**45.05**	**3.37**	**0.40**	**0.54**	**48.83**	**4.97**
Standard Deviation	**5.89**	**2.86**	**0.54**	**0.21**	**9.23**	**0.32**
Statistical Significance	**NSD**	**NSD**	**NSD**	**NSD**	**NSD**	**NSD**
P(T<=t) two-tail	**0.57**	**0.50**	**0.47**	**0.48**	**0.76**	**0.92**
% Change c.f. Cont.	**6%**	**-9%**	**-67%**	**-63%**	**1%**	**-2%**

Table 1 indicates that no statistically significant differences between measured parameters are apparent at the 95% confidence level.

Nevertheless, some numerical trends common to all three farms are apparent; the average yield of ripe and unblemished fruit within each farm was in all cases higher in trial areas and; the average yield of insect damaged fruit within each farm was in all cases lower in trial areas. To a lesser degree, the average yield of unripe and unblemished fruit within farms not treated with ripening agent was lower in the trial area.

In contrast, no consistent differences or trends were apparent with respect to; blossom end rot affected fruit; total fruit yield or fruit quality (expressed as Brix) which might be attributable to the additional treatment.

Soil Analysis.

Quantitative and qualitative results for selected parameters extracted from soil test reports are provided in Table 2.

Table 2. Soil Chemistry – Selected Parameters.

Analyte	Farm 1.	Comment	Farm 2.	Comment	Farm 3.	Comment
pH (H_2O)	6.58	Moderate	6.35	Moderate	7.42	High
K (meq/100g)	1.35	High	0.94	High	1.07	High
Ca (meq/100g)	15.87	High	10.14	High	17.53	V.High
Mg (meq/100g)	12.56	V.High	13.19	V.High	13.96	V.High
Na meq/100g	1.2	Moderate	2.09	Moderate	1.74	Moderate
Olsen P (ppm)	78.0	High	29.4	High	67.6	V.High
CECe (meq/100g)	30.99	High	26.37	High	34.29	High
Ca (% CEC)	51.20	Moderate	38.5	Moderate	51.10	Moderate
Mg(% CEC)	40.54	V.High	50.02	V.High	40.69	V.High
K (% CEC)	4.35	Low	3.58	Low	3.11	Low

Variability in soil chemistry was apparent between the three farms. An observation uniform to all farms is that magnesium was not deficient and further, the % contribution of magnesium to soil cation exchange capacity (CEC) may be considered very high.

Petiole Analysis

Quantitative and qualitative results for selected parameters extracted from nutrient uptake test reports are provided in Table 3.

Table 3. Nutrient Uptake - Selected Parameters.

Analyte (ppm)	Farm 1.			Farm 2.			Farm 3.		
	Cont.	**Trial**	**Comment**	**Cont.**	**Trial**	**Comment**	**Cont.**	**Trial**	**Comment.**
NH_4	11.1	9.1	Low	9.9	10.2	Low	11.9	14.1	Low
P	170	142	Sat.	181	197	Sat.	117	128	Sat.
K	4,608	4,408	Sat.	4,242	4,365	Sat.	4,401	3,805	Low
Ca	589	636	Sat.	586	502	Sat.	340	412	Sat.
Mg	749	720	Sat.	824	759	Sat.	925	824	Sat.
B	0.3	0.3	V.Low	0.4	0.4	Low	0.4	0.4	Low

Variability in the results is apparent between the three farms. No uniform nutrient uptake trends are apparent between the control and trial area. It is suggested that the yield is unlikely to have been influenced by the application of the magnesium hydroxide active, particularly given the low active application rates (one treatment would have theoretically supplied 425g Mg / ha).

Conclusion

The following general observations regarding the effect of BOOSTER-Mag™ application on field grown processing tomato have been made:

- A numerical increase in the yield of ripe and unblemished fruit was observed across all farms, irrespective of whether a ripening agent had been used.
- The increased yield of ripe and unblemished fruit is somewhat concomitant with observed reductions in unripe, insect damaged and BER affected fruit.
- The additional treatment did not result in any measurable change in the total fruit yield or fruit quality.
- The soil and plant nutrient uptake results indicate magnesium availability and plant uptake was high and satisfactory respectively in both the control and trial areas suggesting adequate available magnesium.
- The increase in ripe and unblemished yield and the reduction in insect damaged yield are not readily attributable to plant nutrient augmentation. It is therefore suggested that the increased yield of ripe and unblemished crop apparent is more likely to be the result of BOOSTER-Mag™ bio-activity with respect to pest control, and although not able be to quantified, plant pathogen and disease control.

Expanded scale (4 and 6ha) evaluations to further quantify BOOSTER-Mag™ pest and disease control efficacy and the effect of this on productivity (yield, conventional pesticide usage) over the 2016 / 2017 season have now been completed. The results are instructive and Calix will seek to publish these at a later date.

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