Effects of an organic seed treatment on the growth and yield of maize in the field

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Abstract

The objective of this field trial was to establish whether Launch™ organic seed treatment would improve plant population and growth and yield of maize. Launch™ was compared with two commercially available treatments and Untreated (organic alternative). The trial, carried out in spring 2018 and harvested in 2019, was grown in Marton. It aimed to expose the seed treatments to a range of plant stresses to determine any differences between treatments. VP483 Maize seed from the same line was treated and sown with Launch™ organic treatment, H&T Optimised® treatment, Poncho® + Rancona Dimension® and Untreated.The maize was sown into a fully cultivated paddock with eight replicates in a randomized complete block design. Plant numbers were counted and plant height was measured at 27 days after sowing (DAS) with the trial harvested for grain at 173 DAS. On 27 DAS H&T Optimised® treated plants were significantly taller and had more plants when compared with the other treatments and Untreated. Poncho® + Rancona Dimension® ranked second in plant height and number. Launch™ ranked third for plant height and plant number and was greater than untreated in both plant height and number. Untreated had the lowest plant height and number. The differences between the treatments in plant height and number were all significant ($P<0.05$). At 173 DAS the cobs were harvested and the grain yield measured. H&T Optimised®, had the highest yield of 14.99 t/ha followed by Poncho® + Rancona® 12.34 t/ha, Launch™ 10.77 t/ha, and Untreated 9.85 t/ha. The differences seen in maize grain yield between each treatment and Untreated were significant ($P<0.05$).

Additional keywords: H&T Optimised®, Launch™, Poncho®, Rancona Dimension®, plant growth, yield, *Zea mays* L**.**

Introduction

Maize (*Zea mays* L.) is one of the more important food crops worldwide and is widely grown in New Zealand. Maize is a versatile crop that has multiple end-uses for both grain and silage. It is primarily grown and used for stock feed as a supplement to fill feed deficits (Dairy NZ, 2020).

Under favourable climatic conditions crop yields are significantly higher than alternative spring and summer grown cereals, pasture grasses and forage brassicas (Brown *et al.*, 2007) grown in New Zealand. This makes maize a cost-effective crop that can yield consistently when grown in the right conditions and locations in New Zealand. There has been consistent improvement in plant traits, hybrid selection, cultivation techniques, maize planters, agronomic management and new technologies to help maximise yield (Booker, 2009). It is recognised that biotic and abiotic stresses prevent crop systems from achieving their yield potential (Yakhin *et al.*, 2017). In a field environment the conditions are uncontrolled unlike those of a laboratory, involving simultaneous exposure of plants to more than one abiotic and/or biotic stress conditions. Environmental stress conditions such as drought, heat, salinity, cold, or pathogen infection can have a devastating impact on plant growth and yield in the field (Suzuki *et al.,* 2014). The trial location can deliver a cool spring and turn hot and dry in the summer. Maize seed treatments are common practice in New Zealand. The addition of insecticides and fungicides, and more recently bio-stimulants, to combat disease, insects, pests, environmental stresses to improve early plant growth, establishment, plant health and yields in the field (Oliver *et al.*, 2018).

In New Zealand, there have been no seed treatment alternatives to bare or untreated seed for organic maize growers. In 2018 Launch™ seed treatment became the first BioGro® certified organic seed treatment available for organic growers. Launch™ applies organically sourced compounds derived from botanicals, plants, seaweeds and fungi onto seed. The addition of compounds to combat disease and stimulate seedling growth in plants has been used for hundreds of years in many different crops (Yakhin et al., 2017). Brining was used in the 17th century in the United Kingdom to control bunts (Sharma *et al.*, 2015) and the benefits of seaweeds as sources of organic matter and fertiliser nutrients has led to their use as soil conditioners for centuries (Kahn *et al.*, 2009). Increased root branching and root hair development of maize roots were reported when plants were grown in a bio-stimulant nutrient solution containing organic compounds (Lee & Bartlett, 1976).

The purpose of this field trial was to measure the effect Launch™ (BioGro® certified organic) seed treatment had on maize compared to H&T Optimised, Poncho + Rancona® (the industry standard treatment used in this trial) and untreated seed. The differences in plant number, plant height and grain yield were measured. This field trial follows on from the seed treatment benefits found in previous work carried out on the effects on germination and growth of maize in the field (Oliver *et al.*, 2016; Oliver *et al.*, 2018).

Materials and Methods

Experimental details

The field trial was sown at 352 Jeffersons Line, Marton (40° 0’ S, 175° 25’ E), on 27 October 2018. The trial was sown using a two-row maize trial planter. The trial design (Table 1) comprised of 4 x 5.3 m long rows per treatment plot, with 76 cm between rows, replicated 8 times in a randomized complete block design. Each row had 43 maize seeds from the same VP483 line per row (a sowing rate of 107,000 seeds per ha).

The soil type was Kiwitea Loam. The paddock had grown maize grain in the two previous seasons. Soil tests taken in the previous year showed no nutrient deficiencies. Pre-emergent weed control was boom sprayed, using 3 L/ha of 840 g/L Acetochlor and 3 L/ha of 500 g/L Atrazine following sowing. At planting 250 kg/ha of Nitrophoska 12-10-10 banded fertiliser was applied. There was no fertiliser side dressing.

The seed treatments were applied using a Cimbria CC150 Centricoater.

Weather

The trial was not irrigated. Rainfall events at the trial location for the 2018/2019 maize growing season are shown in Table 2. Included is the rainfall information from the trial location for the growing seasons for the previous 4 years and a combined 4-year average for comparison.

FAR's Maize in Action reported the region experienced lower cumulative Growing Degree Days (GDD) than the 10-year average (Holmes *et al.*, 2019). While the region received around the 10-year average for cumulative radiation (Holmes *et al.*, 2019), hot, dry conditions were experienced that led to drought stress. Some crops had poor cob tip fill and low row counts, indicative of conditions during pollination (Holmes *et al.*, 2019).

Table 1: Seed treatment descriptions applied to seed sown on 27 October 2018.

Seed treatments	Insecticide	Fungicide	Growth Promotant	Polymer
H&T Optimised®	Poncho® Votivo (508 g/L clothianidin + 2.0x109 cfu/mL Bacillus firmus I-1582)	Rancona Dimension® (ipconazole 25 g/L + metalaxyl 20 g/L)	H&T proprietary blend of biostimulants	L552
Poncho® + R	Poncho® Votivo (508 g/L clothianidin + 2.0x109 cfu/mL Bacillus firmus I-1582)	Rancona Dimension® (ipconazole 25 g/L + metalaxyl 20 g/L)		L522
Launch™ (the process BioGro® certified)		Biofungicide	A combination botanicals, plants and seaweeds extracts	Organic polymer
Untreated				

Table 2: Rainfall (mm) records taken at the trial location for the four maize growing seasons.

Growing season	October	November	December	January	February	March	Total
2014/2015	150.5	129	60	0	109	64.5	513
2015/2016	127	40	52.5	67.5	35.5	86.5	409
2016/2017	94	100	60	94	123.5	100	571.5
2017/2018	118.5	51	33	119	65	66.5	453
4 year average	123	80	51	70	83	79	487
2018/2019	50.5	109.5	136	26	34	35	391

Plant measurements

The first measurement was taken at 27 days after sowing (DAS) - plant number and height of each maize plant was recorded. Plant height was measured in centimetres using a steel tape measure. The measurement was taken by measuring from the soil surface to the full extension of the tallest leaf tip by stretching the plant tip out. Every plant was measured and counted in each of the rows and each of the replicates. Plant height was measured to identify differences in foliar growth between treatments, while plant number was counted to identify any differences in establishment. Results showed the effects seed treatment had on the growth and establishment of plants.

The trial was grown through to 173 DAS when it was harvested for grain. Each plot was hand-picked and processed separately. The husk and cob were removed from the maize plant and processed using a Haban corn husker sheller maize thresher to separate the grain, husk and cob. The remaining grain was collected in buckets and weighed. At this time a 200 g sample of grain from each plot was taken for grain moisture levels to be calculated (using a grain analysis computer 2000, Dickey-John Corporation, Auburn, Illinois). The grain yields were calculated at 14% moisture for each plot for the different treatments.

Statistical analysis

Statistics were run to determine any significant differences between the three treatments and untreated control in plant height, plant number and final grain yield. The results were analysed using Minitab 18. A one-way ANOVA was completed on plant height and plant number at 27 DAS and grain yield at 173 DAS. A Fishers protected LSD test was also performed on the data to establish any differences between treatments.

Results

Average plant height measured at 27 DAS showed significant differences between all of the treatments ($P<0.05$) (Table 3). H&T Optimised® had the greatest average plant height (20.00) cm) followed by Poncho® + R (19.50 cm), Launch™ (12.50 cm) and the untreated control (12.00 cm) (Table 3) The two synthetic treatments (H&T Optimised® and Poncho® +R) had a taller average plant height than the two organic treatments Launch™ and untreated.

There were significant differences in plant number at 27 DAS between all the treatments ($P<0.05$) (Table 3). The H&T Optimised® average plant population was 41.00 plants per row. This was greater than Poncho® + R, Launch™ and Untreated ($P<0.05$) (Table 3). The establishment percentage for H&T Optimised® was 96% which was the highest. Poncho® + R average plant population was 39.50 plants per row giving establishment percentage of 92%. This showed 1.5 plants less per row on average than H&T Optimised® but greater than both Launch™ and untreated control ($P<0.05$) (Table 3).

Launch™ treated seed had an average plant number of 32.00 which was significantly lower than the two synthetic seed treatments H&T Optimised and Poncho®+ R but significantly greater than untreated($P<0.05$) (Table 3). Untreated had the lowest average plant number of 29.00.

Table 3: Mean plant height and plant population per row at 27 DAS for three different seed treatments and untreated. Means that do not share a letter are significantly different ($P<0.05$) using a Fishers protected LSD test.

Treatment	Plant Height (t DM/ha)	Plant Number (counted)	Establishment (%)
H&T Optimised®	20.00 ^{A}	41.00 ^{A}	96
Poncho® + R	19.50 ^{B}	39.50 ^{B}	92
Launch™	12.50 ^{C}	32.00 ^{C}	74
Untreated	12.00 ^{D}	29.00 ^{D}	67
Grand Mean	16.00	15.50	
Standard Deviation	1.00	3.00	
P	0.0	0.0	

H&T Optimised® treatment had the highest grain yield (adjusted to a common base of 14% moisture content of 14.99 t/ha (Table 4) which was 2.65 t/ha greater than Poncho® + R which had the next highest yield (12.37 t/ha), followed by Launch™ (10.77 t/ha) and the untreated control (9.85 t/ha). The differences in yield were all significant from each other and followed the same pattern seen at 27 DAS with the differences in plant height and plant number.

Discussion and Conclusions

This trial was designed to expose the treated seeds to a greater range and number of stresses common in the field to compare any differences between Launch™ treated seeds with untreated and two commercially available maize seed treatments (H&T Optimised®, and Poncho® + R).

The Rangitikei trial site experienced overall a lower average rainfall (391 mm) over the maize growing season (October to March) than the 4-year average recorded at the site (487 mm) (Table 2). However, the 2018 November and December period was wetter than average with 114 mm more rain than the four year average at the site (Table 2). The wet spring early and summer was followed by 147 mm less rainfall in the January, February March period than the 4-year average. This low rainfall period was compounded with New Zealand's third hottest summer on record (Fedaeff, 2019).
This period of heat stress and moisture stress coincided with the critical six-week period for maize. This was prior to tasselling and early grain fill where maize needs 60% of its moisture requirement for cob development (Genetic Technologies Ltd, 2016).

Table 4: Adjusted to 14% harvested mean maize grain weight per hectare at 173 DAS, for three different seed treatments and the untreated control. Means that do not share a letter are significantly different (P<0.05) using a Fishers protected LSD test.

Treatment	Grain Yield (t DM/ha)
H&T Optimised®	14.99
Poncho® + R	12.34
Launch™	10.77
Untreated	9.85
Grand Mean	11.99
Standard Deviation	0.84
P	0.0

Multiple years of maize grain cropping with no break crops increases the risk of disease severity where stubble and soil provides a host for pathogens (e.g. Fusarium, Rhizoctonia, Pythium) to survive. Wet, cool soils promote the development of seedling diseases with seedling susceptibility to infection increased the longer the seed sits in the ground. (Robertson, no.date).

The wet weather post planting at the trial site and repeated maize cropping are likely to have increased the risk of disease.

Maize plants come under environmental challenge throughout their growing life with performance influenced by various factors: (insect pests, fungi and climatic conditions). Seed treatments can help decrease the impact of these factors by providing protection and can increase subsequent yields (Cook & Gore, 2018).

Combinations of different seed treatments can be used together to address multiple pre and post emergent insect issues and disease and help stand uniformity across a wide variety of soil types, cultural practises and environmental conditions (Shrama *et al.*, 2015).

The difference in plant height between Launch ™ and untreated (Table 3) showed the Launch™ plants to have longer and larger leaves and in some cases more leaves than the untreated plants. The combination of organic compounds and seaweed products in Launch™ likely contributed to this difference by stimulating growth activity. The use of seaweed formulations in biostimulants in crops is well established, while also positively affecting the physical, chemical and biological properties of the soil that influence plant growth (Kahn *et al.*, 2009).

Plants that can develop larger roots and shoots are able to better handle exposure to stresses in the field (Suzuki *et al.*, 2014). The combination of these effects is likely to have contributed to the increase in plant height and the increased yield at harvest after the plants had come under drought pressure.

The combination of a wet period post planting and repeat maize cropping is likely to have increased early disease pressure that impacted on the number maize plants established (Table3).

The differences in plant number between Launch™ and untreated may have been due to the biofungicide component in Launch™. Launch™ treatment increased plant height by 0.5 cm with an extra 3 plants per row compared with the Untreated control. The increases in plant height and plant number (Table 3) of Launch™ compared with untreated translated into a significant increase in harvested yield (Table 4). In this particular year the Launch™ yield advantage over untreated was a 9.4% increase in grain yield (922 kg/ha) (Table 4). Organic maize grain has a current market price of $750/t (M. Dorward, *pers. comm.*, 2020) representing an extra $691.50/ha to the grower. At the time of writing, the cost of Launch™ was $157.80/ha (sowing rate of 107,000/ha). Subtracting the seed treatment cost from the increased grain return leaves the grower with an additional $533.70/ha.

Comparing the two synthetic seed treatments (H&T Optimised® and Poncho® + R) showed the H&T Optimised® treated plants had a greater plant population, average plant height and total yield. These seed treatments use the same insecticide and fungicide combination. The only difference being the addition of a proprietary blend of bio-stimulants in the H&T Optimised® treatment.

The maize faced unfavourable gemination conditions pathogen pressure, followed by heat and moisture stress. Bio-stimulants offer a novel approach for the regulation and modification of physiological processes in plants to stimulate growth, mitigate stress-induced limitations and to increase yield (Yakhin *et al.,* 2017). The blend of biostimulants, helps the plants better cope with the stresses by promoting a healthy root system and healthier surrounding soil leading to enhanced nutrient and water uptake and biological functions (Weaver & Bruner, 1927). Oliver *et al.* (2018) reported a 14.3% increase in root mass using the same H&T Optimised® biostimulant formulation (root mass was not measured in this trial).

The increase in grain yield of H&T Optimised® (2.65 t/ha) over Poncho® + R measured in this trial is a 23% increase. With grain at a current market price of $405/t this represents an extra $1073.25/ha to the grower. H&T Optimised® costs $10.70/ha more than Poncho® + R which provides the grower with an additional $1062.55/ha. The additional benefit of H&T Optimised® is likely to have come from improved plant health and ability to cope with the stresses during the trial.

H&T Optimised® and Poncho® + R had greater plant height, plant number (Table 3) and yield (Table 4) when compared with both the organic Launch™ treatment and the untreated control. The initial differences in plant number between Launch™ and untreated compared with H&T Optimised® suggests likely exposure to early disease and/or insect or pest pressure during establishment. The wet establishment and successive maize cropping probably increased the likelihood of disease exposure during the trial. These differences in plant number shows the levels of protection achieved when using a synthetic fungicide (Rancona Dimension®), a biofungicide (Launch™), and no fungicide (untreated). Protection from soil and seed-borne diseases and insect pressure is critical in plant establishment. Establishment of a plant population where plants are evenly spaced and uniform reduces competition for nutrients, light, water and improves growth to maximise yield (Houck, 2009).

Establishment (%) measurements in this trial showed H&T Optimised® (96%) and Poncho® + R (92%) achieved significantly higher rates than either Launch™ (74%) or the Untreated control (67%) (Table 4).

Overall, the three seed treatments used in this trial affected plant number and establishment rate demonstrating a positive effect. The more plants that germinate and survive may lead to a greater yield (Stone *et al.*, 2000) which was also demonstrated in this trial.

The Rangitikei region experienced a challenging maize growing season in 2018/2019. The hot dry conditions meant maize was under stress and this resulted in lower grain and silage yields than usual (D. Thomas, *pers. comm.,* 2019). The historical average grain yield of the trial paddock from 2014-17 was 14.9 t/ha (R. Harding, *pers. comm.*, 2019). The H&T Optimised® final grain yield (14.99 t/ha) was the only treatment above the historic paddock average. Poncho® + R, Launch™ and untreated were all lower.

H&T Optimised®, that used a synthetic insecticide + fungicide and bio-stimulants, had increased plant height and plant number than any other treatment. These initial differences transferred into a greater grain yield at harvest with larger cobs and more kernel rounds.

In this trial Launch™ increased plant height, plant population and grain yield over the untreated control. Launch™ appears to be a viable alternative and represents another option for organic maize growers wishing to increase their maize performance and is BioGro® certified.

Future work and trials could include measuring: 1) the differences between other commercially available seed treatments and 2) the differences between treatments in minimum-till or direct drilled maize.

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