Investigating the effects of different humic treatments/application rates on the growth of peppers, tomatoes, grass types, elderberry, Pacific ninebark, western red cedar (Thuja plicata), rooting of yellow cedar cuttings (Callitropsis nootkatensis) and counts of peppers and tomatoes in greenhouse trials.

Prepared for:
Agrotek Industries Inc. and BCCAI

Prepared by:

Ian Bercovitz
Sonny Min
Big Data Hub
Simon Fraser University

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Executive Summary

Agrotek Industries Inc. set up greenhouse trials to investigate the effects of four humic formulations with varying application rates on the counts and growth of cherry tomatoes, earl girl tomatoes, pepper plants, grass types, Pacific ninebark, elderberry, and western red cedar trees (Thuja plicata) and rooting of yellow cedar (Callitropsis nootkatensis) cuttings. The five treatments used in these trials include: Leonardite 1kg/100L soil, LDS 0.5kg/100L soil, LDS 1.0kg/100L soil, LDS 1.5kg/100L soil and a control group.

The main objective of the statistical analyses was to compare the responses (counts and heights for cherry tomatoes, earl girl tomatoes, pepper plants, grass types, Pacific Nine Bark, elderberry, red cedar trees and number of roots for yellow cedar cuttings between treatment levels at the end of each trial. For the rooting data three rooting methods were also used: H20, HA and IBA for each treatment level.

The analyses showed:

No differences in cumulative pepper counts between treatments at the end of the trial.

No differences in cumulative cherry tomato counts between treatments at the end of the trial. The results showed the cumulative cherry tomato counts for LDS 0.5kg (mean=38.5) and LDS 1.5kg (mean=35.5) were noticeably higher than the other treatment levels at the end of the trial.

There were differences in cumulative early girl tomato counts between the control (mean=2.75) versus Leonardite 1kg (mean=4.75) and control versus LDS 1.5kg (mean=4.75) at the end of the trial.

There were differences in pepper heights comparing LDS 1.5 kg (mean=47.4) vs. Leonardite 1kg (mean=56.2), LDS 1.5 kg (mean=47.4) vs. LDS 0.5 kg (mean=58.2) and LDS 1.5 kg (mean=47.4) vs. LDS 1kg (mean=57.1) at the end of the trial. It is worth noting for the LDS fertilizer type, a lower application rate of 0.5kg resulted in over 20% higher pepper plant heights compared to the 1.5kg application rate.

There were differences in mean cherry tomato heights between LDS 0.5kg (mean=153.0) and LDS 1.0kg (mean=218.0) at the end of the trial. Cherry tomato heights were 42% higher with the LDS 1.0kg level compared to LDS 0.5kg level.

There were differences in mean early girl tomato heights between Leonardite 1.0kg (mean=145.3) vs. LDS 0.5kg (mean=174.8) and Leonardite 1.0kg vs. LDS 1.5kg (mean=166.5) at the end of the trial. The early girl tomato heights for the LDS 0.5kg level were about 20% higher than the Leonardite 1.0kg level at the end of the trial.

No differences in Pacific ninebark heights at the end of the trial. There were only two levels of treatment for this trial. The control level (mean=86.5) resulted in 10% higher plants compared to the LDS 1.0kg level (mean=78.8).

No differences in red cedar heights between treatment levels at the end of the trial. The mean red cedar heights for all treatment levels are about 120 cm.

There were differences in mean grass heights between control (mean=26.0) vs LDS 0.5kg (mean=27.5) and control (mean=26.0) vs. LDS 1.5kg (mean=27.5) at the end of the trial. Due to a small sample of n=2 and standard deviation=0 for some treatment levels, these findings may not be reliable.

There were differences in mean tall grass heights between LDS 0.5kg (mean=54.50) vs. Leonardite 1kg (mean=41.5), LDS 0.5k (mean=54.50) vs. LDS 1.0k (mean=45.5), LDS 0.5k (mean=54.50) vs. LDS 1.5k (mean=47.5), LDS 0.5k (mean=54.50) vs. Control (mean=45.3) at the end of the trial. The mean tall grass heights for the LDS 0.5k treatment level were consistently higher (15-20%) than LDS 1.0k, LDS 1.5K and the control group for all days.

No differences in elderberry heights at the end of the trial. There were only three levels of treatment for this trial. The LDS 1.0kg level (mean=97.8) resulted in 12% higher elderberry plants compared to the Leonardite 1.0kg level (mean=88.5) and about 20% higher elderberry plants compared to the control (mean=82.8). The elderberry plants with the LDS 1.0kg treatment level were 12-20% higher than the Leonardite 1kg and control treatment levels for all days.

The results showed the highest number of yellow cedar roots using rooting method H20 and treatment LDS 0.5k (mean=13.7). For the H20 rooting method, treatment LDS 0.5k produced 60%, 120%, 50 % and 100% more roots than treatments Leonardite 1kg (mean=8.6), LDS 1.0k (mean=6.2), LDS 1.5k (mean=9) and the control group (mean=6.9) respectively.

A formal statistical analysis could not be performed for cherry tomato weights, early girl tomato weights due to no replicates in the data sets. Sets of visual plots were created to display the findings in the appendix.

Power analyses were run to determine the minimal sample size needed (for each treatment level) to detect statistically significant differences between treatments at the end of the trial. An 80% power cutoff was used. The results in table 23 show the minimum sample sizes/treatment level varies between 3 and 128.

Introduction

Agrotek Industries inc. has developed humic based fertilizers, organic fertilizers, and plant propagation products to enhance plant growth. Various trials were conducted to study the effects of five treatment levels on the growth and yields for cherry tomatoes, earl girl tomatoes, pepper plants, grass types, Pacific ninebark, elderberry, and red cedar trees. Three rooting methods (H20, HA, and IBA) were also used for each treatment level for the yellow cedar rooting trials.

The trials varied the use of 5 treatments for each of the plant types in separate trials.
The treatment levels used in the statistical analyses include:

1- Leonardite 1kg/100L soil
2- LDS 0.5kg/100L soil
3- LDS 1.0kg/100L soil
4- LDS 1.5kg/100L soil
5- Control

The main objectives of the analyses were:

1) To determine if there are differences in the cumulative counts of cherry tomatoes, earl girl tomatoes and peppers between these 5 levels of treatment at the end of the trial.

2) To determine if there are differences in the heights of peppers, tomatoes, grass types, elderberry, red cedar trees and Pacific ninebark between these 5 levels of treatment at the end of the trial.

3) To determine if there are differences in the mean number of yellow cedar roots between levels of treatment and rooting method at the end of the trial

Methodology

A linear mixed effects model was used to test for differences in mean responses between treatment levels over time. The response variables include:

1- Cumulative counts of cherry tomatoes, early girl tomatoes and peppers.

2- Heights of grass types, Pacific ninebark, elderberry, red cedar trees, early girl tomato, cherry tomato, and pepper plants.

3- Counts of the number of yellow cedar roots

Treatments were considered as a fixed effect with levels (Leonardite 1kg/100L soil, LDS 0.5kg/100L soil, LDS 1.0kg/100L soil, LDS 1.5kg/100L soil and the control). Time was considered as a fixed effect with sampling occurring at different times and frequencies for each plant type. Plants were considered as a random effect to account for the repeated measurements on the same plants over time. Post hoc tests were used to locate differences in mean responses between pairs of treatment levels for each day with the focus on the response differences at the end of the trial.

For the yellow cedar rooting data a two way analysis of variance model was used to test for differences in the mean number of roots between levels of treatment and rooting method. Treatment and rooting method and the two way interaction between treatment and rooting method were considered to be fixed effect factors in the model.

The model assumptions regarding the residuals of the model were verified. The residuals from the model were approximately normally distributed centered about zero with constant variance. A natural logarithmic transformation was used in cases where the model assumptions were not satisfied.

All of the analyses were carried out using SAS® statistical software version 9.4.

Results

Pepper counts

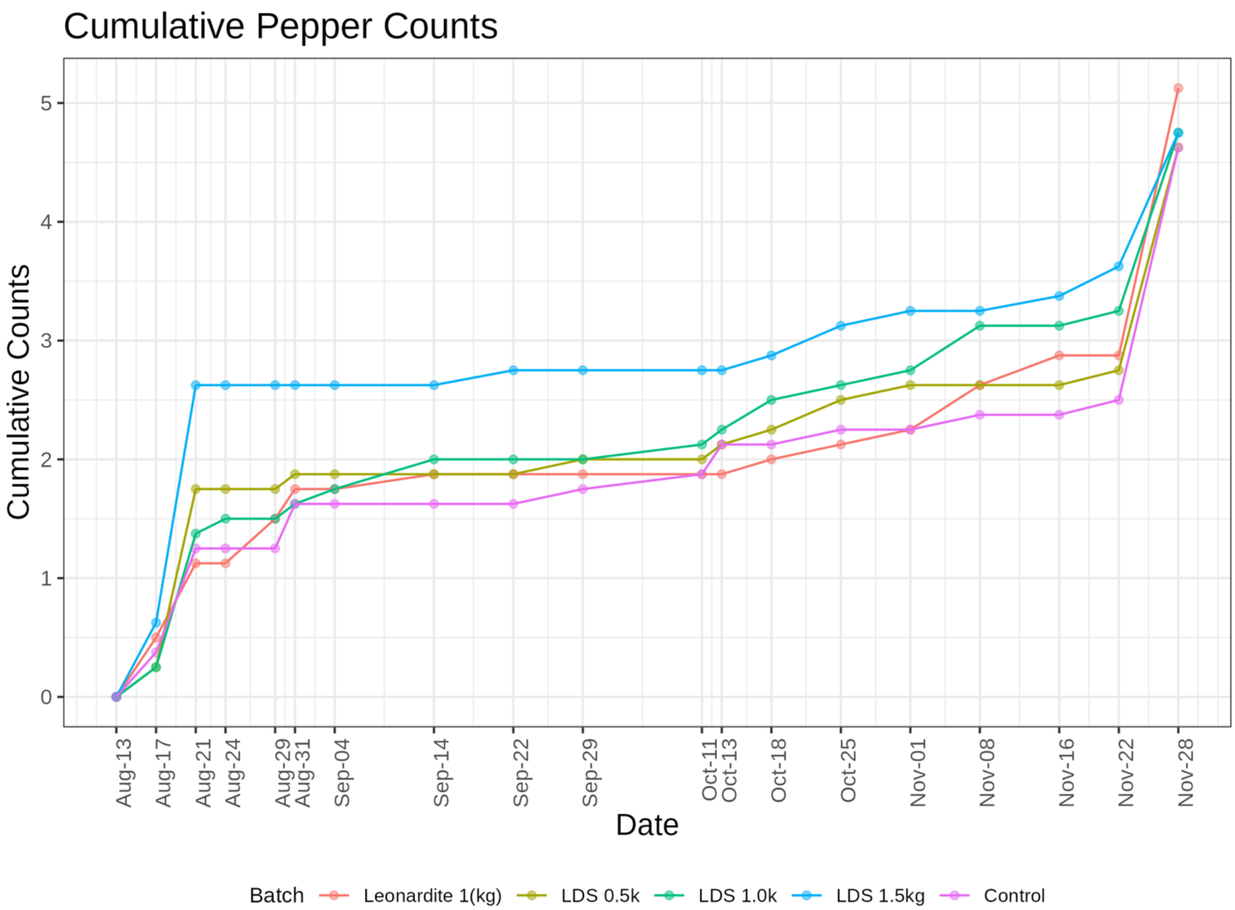
Table 1: Summary statistics for cumulative pepper counts

	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Pepper			Pepper			Pepper			Pepper			Pepper		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
Aug 13	8	0.00	0.00	8	0.00	0.00	8	0.00	0.00	8	0.00	0.00	8	0.00	0.00
Aug 17	8	0.50	0.76	8	0.25	0.46	8	0.25	0.46	8	0.63	1.06	8	0.38	0.52
Aug 21	8	1.13	0.99	8	1.75	1.28	8	1.38	1.60	8	2.63$_{r}$	0.92	8	1.25	1.16
Aug 24	8	1.13	0.99	8	1.75	1.28	8	1.50	1.77	8	2.63$_{r}$	0.92	8	1.25	1.16
Aug 29	8	1.50	1.20	8	1.75	1.28	8	1.50	1.77	8	2.63	0.92	8	1.25	1.16
Aug 31	8	1.75	1.49	8	1.88	1.25	8	1.63	1.69	8	2.63	0.92	8	1.63	1.19
Sep 4	8	1.75	1.49	8	1.88	1.25	8	1.75	1.58	8	2.63	0.92	8	1.63	1.19
Sep 14	8	1.88	1.55	8	1.88	1.25	8	2.00	1.77	8	2.63	0.92	8	1.63	1.19
Sep 22	8	1.88	1.55	8	1.88	1.25	8	2.00	1.77	8	2.75	0.71	8	1.63	1.19
Sep 29	8	1.88	1.55	8	2.00	1.20	8	2.00	1.77	8	2.75	0.71	8	1.75	1.04
Oct 11	8	1.88	1.55	8	2.00	1.20	8	2.13	1.73	8	2.75	0.71	8	1.88	0.99
Oct 13	8	1.88	1.55	8	2.13	0.99	8	2.25	1.58	8	2.75	0.71	8	2.13	0.64
Oct 18	8	2.00	1.41	8	2.25	1.16	8	2.50	1.77	8	2.88	0.99	8	2.13	0.64

	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Pepper			Pepper			Pepper			Pepper			Pepper		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Oct 25	8	2.13	1.36	8	2.50	1.31	8	2.63	1.60	8	3.13	1.25	8	2.25	0.71
Nov 1	8	2.25	1.28	8	2.63	1.51	8	2.75	1.67	8	3.25	1.58	8	2.25	0.71
Nov 8	8	2.63	1.41	8	2.63	1.51	8	3.13	2.10	8	3.25	1.58	8	2.38	0.74
Nov 16	8	2.88	1.81	8	2.63	1.51	8	3.13	2.10	8	3.38	1.51	8	2.38	0.74
Nov 22	8	2.88	1.81	8	2.75	1.49	8	3.25	2.19	8	3.63	1.51	8	2.50	0.93
Nov28	8	5.13	2.10	8	4.63	1.92	8	4.75	2.55	8	4.75	1.49	8	4.63	1.30

The table above shows the number of observations (N), mean and standard deviation (Std) of the cumulative pepper counts for each treatment level at each sampling time. Statistically significant differences in the number of peppers between pairs of treatments at the alpha=0.05 level of significance are highlighted in yellow. A subscript ‘r’ is used to denote the reference category for paired comparisons. I.e. on Aug 21st the LDS 1.5 level (mean count=2.63) is the reference level compared to the control (mean count=1.25) and Leonardite 1 kg (mean count=1.33). The results showed statistically significant differences in cumulative pepper counts comparing LDS 1.5 kg vs.(Leonardite 1kg and control) on Aug 21 and Aug 24. The results also showed statistically significant differences in cumulative pepper counts comparing LDS 1.5 kg vs control on Aug 29. Cells highlighted in yellow with a superscript ‘*’ were used to show statistically significant differences in responses for paired comparisons between treatment levels in some of the tables in the report. There were no statistically significant differences in cumulative pepper at the end of the trial.

Figure 1: Plot of the cumulative pepper counts over time



The above figure shows consitantly higher cummulative pepper counts for LDS 1.5kg compared to the other treatment levels starting Aug. 21ST, but no differences at the end of the trial. Due to low pepper counts it is hard to draw any meaningful conclusions.

Table 2: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Treatment	4	44.1	0.88	0.4846
time	18	621	40.25	<.0001
Treatment*time	72	613	0.94	0.6264

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)

The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.48) or the two-way interaction treatment*time (p-value=0.63). The time effect reveals the cumulative pepper counts are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in cumulative pepper counts between the 5 levels of treatment. A non-significant treatment*time interaction reveals the cumulative pepper counts are increasing at the same rate over time between treatments.

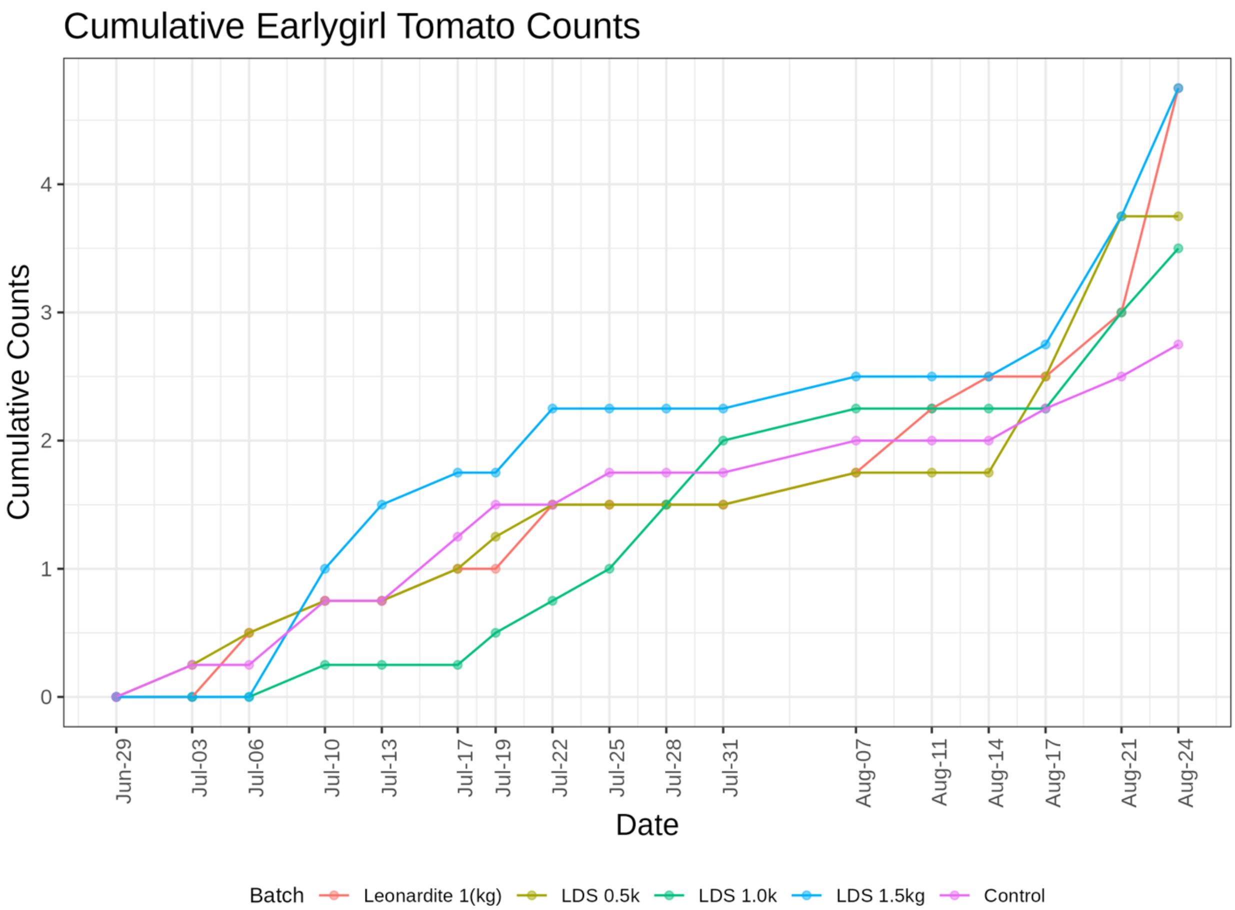
Early Girl Tomatoes

Table 3: Summary statistics for cumulative early girl tomato counts

	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Early Girl			Early Girl			Early Girl			Early Girl			Early Girl		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
Jun 29	4	0.00	0.00	4	0.00	0.00	4	0.00	0.00	4	0.00	0.00	4	0.00	0.00
Jul 3	4	0.00	0.00	4	0.25	0.50	4	0.00	0.00	4	0.00	0.00	4	0.25	0.50
Jul 6	4	0.50	0.58	4	0.50	0.58	4	0.00	0.00	4	0.00	0.00	4	0.25	0.50
Jul 10	4	0.75	0.50	4	0.75	0.96	4	0.25	0.50	4	1.00	0.00	4	0.75	0.50
Jul 13	4	0.75	0.50	4	0.75	0.96	4	0.25	0.50	4	1.50	0.58	4	0.75	0.50
Jul 17	4	1.00	0.82	4	1.00	0.82	4	0.25	0.50	4	1.75	0.50	4	1.25	0.50
Jul 19	4	1.00	0.82	4	1.25	0.96	4	0.50	1.00	4	1.75	0.50	4	1.50	0.58
Jul 22	4	1.50	1.29	4	1.50	0.58	4	0.75	0.96	4	2.25	1.26	4	1.50	0.58
Jul 25	4	1.50	1.29	4	1.50	0.58	4	1.00	0.82	4	2.25	1.26	4	1.75	0.50
Jul 28	4	1.50	1.29	4	1.50	0.58	4	1.50	1.29	4	2.25	1.26	4	1.75	0.50
Jul 31	4	1.50	1.29	4	1.50	0.58	4	2.00	2.16	4	2.25	1.26	4	1.75	0.50
Aug 7	4	1.75	0.96	4	1.75	0.50	4	2.25	2.06	4	2.50	1.29	4	2.00	0.00
Aug 11	4	2.25	0.50	4	1.75	0.50	4	2.25	2.06	4	2.50	1.29	4	2.00	0.00
Aug 14	4	2.50	0.58	4	1.75	0.50	4	2.25	2.06	4	2.50	1.29	4	2.00	0.00
Aug 17	4	2.50	0.58	4	2.50	1.00	4	2.25	2.06	4	2.75	0.96	4	2.25	0.50
Aug 21	4	3.00	0.82	4	3.75	1.26	4	3.00	2.94	4	3.75	0.50	4	2.50	0.58
Aug 24	4	4.75	1.50	4	3.75	1.26	4	3.50	2.89	4	4.75	0.50	4	2.75	0.96

The results showed statistically significant differences in cumulative early girl tomato counts comparing control (mean=2.75) vs. LDS 1.5 kg (mean=4.75) and control vs. Leonardite 1kg (mean=4.75) at the end of the trial.

Figure 2: Plot of the cumulative early girl tomato counts over time



The figure above shows higher early girl counts for LDS 1.5 kg treatment level after July 10th. At the end of the trial the cumulative early girl counts for Leonardite 1kg and LDS 1.5kg were higher than the other treatment levels. The cumulative early girl counts for Leonardite 1kg and LDS 1.5kg were statistically significantly different than the control group at the end of the trial.

Table 4: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Treatment	4	18.2	0.44	0.7747
Time	16	232	12.39	<.0001
Treatment*time	64	220	1.14	0.2401

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)

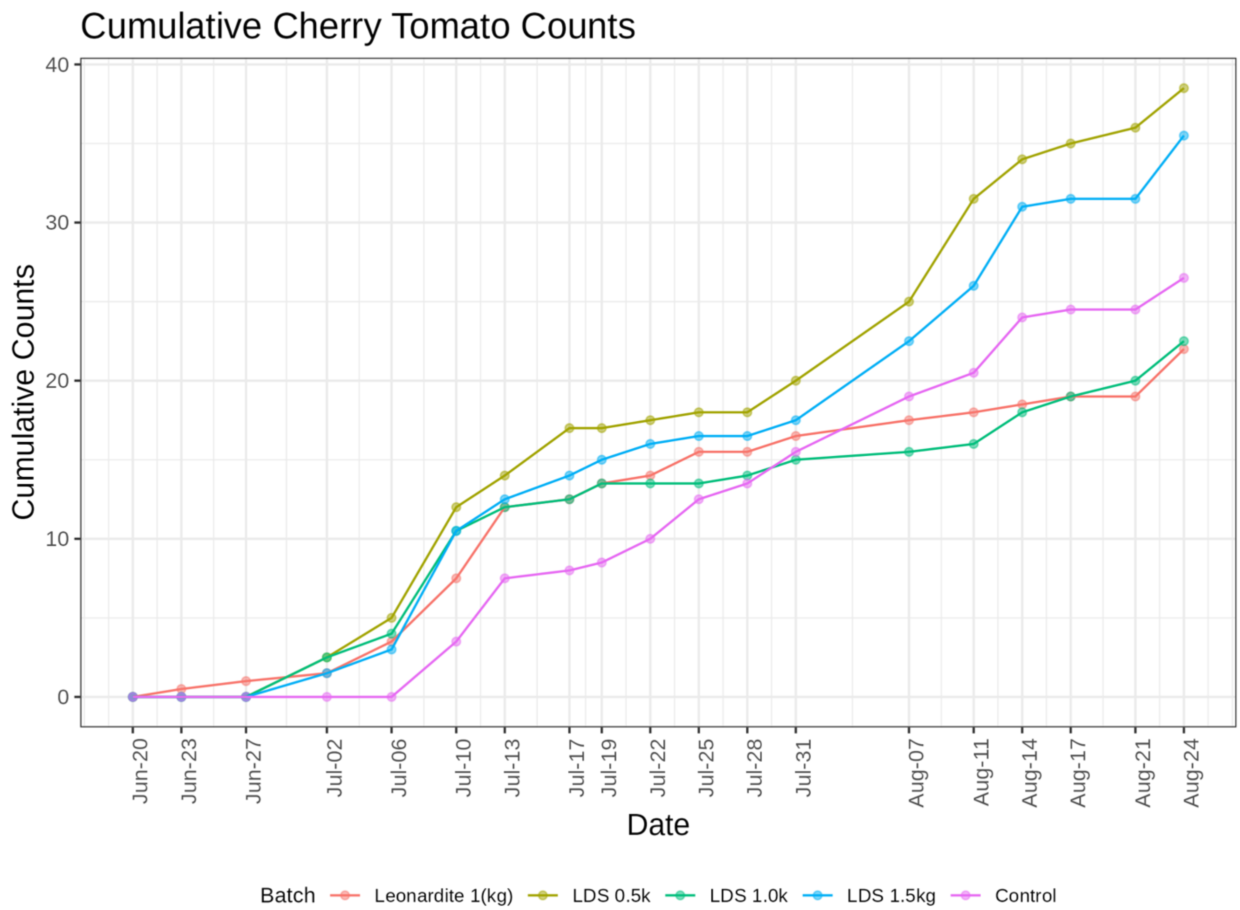
The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.77) or the two-way interaction treatment*time (p-value=0.24). The time effect reveals the cumulative early girl tomato counts are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in cumulative early girl tomato counts between the 5 levels of treatment. A non-significant treatment*time interaction reveals the cumulative early girl tomato counts are increasing at the same rate over time between treatments.

Table 5: Summary statistics for cumulative cherry tomato counts

	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Cherry Tomato			Cherry Tomato			Cherry Tomato			Cherry Tomato			Cherry Tomato		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
Jun 20	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00
Jun 23	2	0.50	0.71	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00
Jun 27	2	1.00	1.41	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2	0.00	0.00
Jul 2	2	1.50	2.12	2	2.50	2.12	2	2.50	2.12	2	1.50	0.71	2	0.00	0.00
Jul 6	2	3.50	0.71	2	5.00	0.00	2	4.00	1.41	2	3.00	0.00	2	0.00	0.00
Jul 10	2	7.50	0.71	2	12.00	5.66	2	10.50	0.71	2	10.50	6.36	2	3.50	4.95
Jul 13	2	12.00	1.41	2	14.00	5.66	2	12.00	1.41	2	12.50	9.19	2	7.50	10.61
Jul 17	2	12.50	2.12	2	17.00	2.83	2	12.50	2.12	2	14.00	9.90	2	8.00	11.31
Jul 19	2	13.50	0.71	2	17.00	2.83	2	13.50	3.54	2	15.00	9.90	2	8.50	12.02
Jul 22	2	14.00	0.00	2	17.50	3.54	2	13.50	3.54	2	16.00	9.90	2	10.00	14.14
Jul 25	2	15.50	0.71	2	18.00	2.83	2	13.50	3.54	2	16.50	9.19	2	12.50	17.68
Jul 28	2	15.50	0.71	2	18.00	2.83	2	14.00	2.83	2	16.50	9.19	2	13.50	17.68
Jul 31	2	16.50	0.71	2	20.00	5.66	2	15.00	1.41	2	17.50	9.19	2	15.50	20.51
Aug 7	2	17.50	0.71	2	25.00	7.07	2	15.50	0.71	2	22.50	7.78	2	19.00	19.80
Aug 11	2	18.00	0.00	2	31.50	7.78	2	16.00	0.00	2	26.00	8.49	2	20.50	20.51
Aug 14	2	18.50	0.71	2	34.00	5.66	2	18.00	2.83	2	31.00	12.73	2	24.00	24.04
Aug 17	2	19.00	0.00	2	35.00	5.66	2	19.00	1.41	2	31.50	13.44	2	24.50	24.75
Aug 21	2	19.00	0.00	2	36.00	7.07	2	20.00	2.83	2	31.50	13.44	2	24.50	24.75
Aug 24	2	22.00	1.41	2	38.50	9.19	2	22.50	4.95	2	35.50	14.85	2	26.50	26.16

The analysis failed to detect any differences in cumulative cherry tomato counts at the end of the trial. This was mainly due to a small sample size of n=2 plants and large variation in the data. The results showed the cumulative cherry tomato counts for LDS 0.5kg (mean=38.5) and LDS 1.5kg (mean=35.5) were noticeably higher than the other treatment levels at the end of the trial.

Figure 3: Plot of the cumulative cherry tomato counts over time



The figure above shows higher cumulative cherry tomato counts for LDS 0.5kg and LDS 1.5kg treatment levels throughout the trial. The parallel lines show a similar rate of cumulative counts between all treatment levels.

Table 6: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Treatment	4	5.08	0.21	0.9225
Time	18	89.1	11.56	<.0001
Treatment*time	72	86.7	0.68	0.9535

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)

The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.93) or the two-way interaction treatment*time (p-value=0.95). The time effect reveals the cumulative cherry tomato counts are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in cumulative cherry tomato counts between the 5 levels of treatment. A non-significant treatment*time interaction reveals the cumulative cherry tomato counts are increasing at the same rate over time between treatments.

Pepper Heights

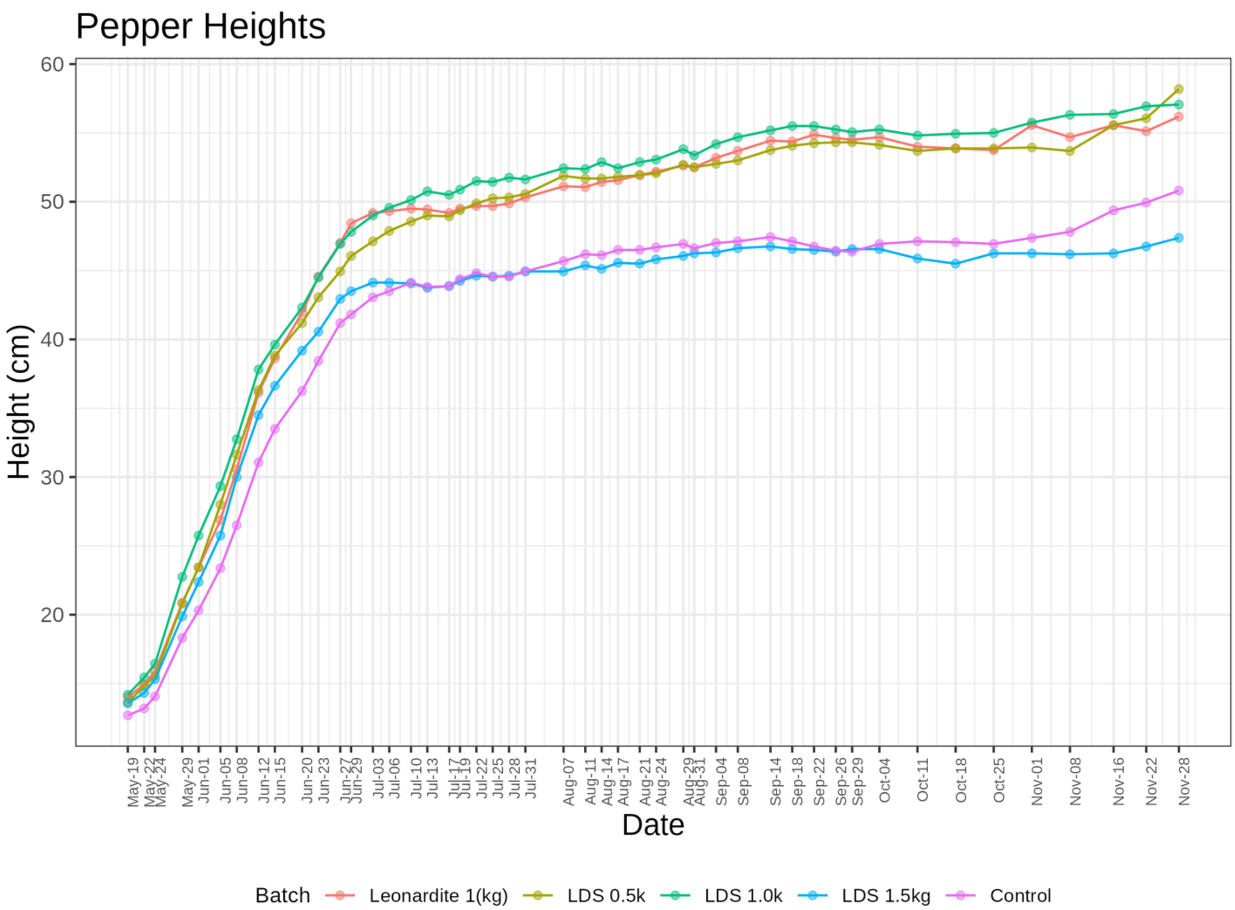
Table 7: Summary statistics for pepper heights

	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Pepper Height (cm)			Pepper Height (cm)			Pepper Height (cm)			Pepper Height (cm)			Pepper Height (cm)		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
May19	8	14.00	1.89	8	13.63	1.27	8	14.19	1.03	8	13.56	1.82	8	12.69	0.92
May 22	8	14.94	2.43	8	14.81	1.19	8	15.44	1.15	8	14.31	1.77	8	13.19	0.96
May 24	8	15.88	2.60	8	15.56	1.45	8	16.44	1.37	8	15.31	1.85	8	14.06	1.05
May 29	8	20.88	3.68	8	20.81	1.69	8	22.75	2.22	8	19.88	2.01	8	18.31	1.41
Jun 1	8	23.44	3.72	8	23.44	2.21	8	25.75	2.56	8	22.38	1.85	8	20.31	1.83
Jun 5	8	26.88	3.56	8	28.00	2.88	8	29.34	3.47	8	25.75	1.65	8	23.38	2.05
Jun 8	8	30.56	3.98	8	31.63	4.25	8	32.75	4.22	8	30.00	2.58	8	26.50	2.00
Jun 12	8	36.13	4.13	8	36.31	5.22	8	37.81	4.20	8	34.50	3.30	8	31.06	2.13
Jun 15	8	38.63	4.28	8	38.81	6.50	8	39.63	4.47	8	36.63	3.18	8	33.50	2.04
Jun 20	8	41.94	4.66	8	41.19	7.31	8	42.31	5.18	8	39.19	4.14	8	36.25	2.54
Jun 23	8	44.56	4.81	8	43.06	8.38	8	44.50	5.19	8	40.56	4.81	8	38.44	2.96
Jun 27	8	47.00	4.68	8	44.94	8.83	8	46.94	6.01	8	42.94	4.44	8	41.19	3.28
Jun 29	8	48.44	5.05	8	46.06	9.47	8	47.81	6.51	8	43.50	4.43	8	41.81	3.80
Jul 3	8	49.19	5.40	8	47.13	10.62	8	49.00	7.10	8	44.13	4.54	8	43.06	4.24
Jul 6	8	49.31	5.98	8	47.88	11.18	8	49.56	7.04	8	44.13	4.79	8	43.50	4.03
Jul 10	8	49.50	5.79	8	48.56	11.77	8	50.13	7.18	8	44.06	5.07	8	44.13	4.61
Jul 13	8	49.44	6.34	8	49.00	12.88	8	50.75	7.34	8	43.75	4.98	8	43.81	4.62
Jul 17	8	49.19	6.46	8	48.94	12.94	8	50.50	7.32	8	43.88	5.31	8	43.88	4.76
Jul 19	8	49.50	6.85	8	49.38	13.28	8	50.88	7.51	8	44.25	5.06	8	44.38	4.93
Jul 22	8	49.69	7.00	8	49.88	13.52	8	51.50	7.79	8	44.63	4.98	8	44.81	4.99
Jul 25	8	49.69	6.97	8	50.25	14.07	8	51.44	8.02	8	44.56	5.04	8	44.56	5.00
Jul 28	8	49.88	6.90	8	50.31	13.66	8	51.75	8.19	8	44.63	5.07	8	44.56	4.66
Jul 31	8	50.31	7.01	8	50.56	13.59	8	51.63	8.28	8	44.94	4.88	8	44.94	4.78
Aug 7	8	51.13	6.98	8	51.88	14.02	8	52.44	8.88	8	44.94	4.89	8	45.69	4.59

	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Pepper Height (cm)			Pepper Height (cm)			Pepper Height (cm)			Pepper Height (cm)			Pepper Height (cm)		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Aug 11	8	51.06	6.99	8	51.69	13.82	8	52.38	8.88	8	45.38	4.88	8	46.19	4.56
Aug 14	8	51.44	6.75	8	51.69	14.03	8	52.88	9.05	8	45.13	4.69	8	46.13	4.52
Aug 17	8	51.56	6.91	8	51.81	14.06	8	52.44	9.09	8	45.56	5.00	8	46.50	4.35
Aug 21	8	51.94	6.91	8	51.94	14.19	8	52.88	9.28	8	45.50	5.37	8	46.50	4.50
Aug 24	8	52.19	6.72	8	52.06	14.03	8	53.06	9.20	8	45.81	5.32	8	46.69	4.22
Aug 29	8	52.63	7.02	8	52.69	14.55	8	53.81	9.40	8	46.06	5.03	8	46.94	4.38
Aug 31	8	52.50	6.68	8	52.50	14.69	8	53.38	9.98	8	46.25	5.06	8	46.63	3.91
Sep 4	8	53.19	6.54	8	52.75	14.29	8	54.19	9.39	8	46.31	4.57	8	47.00	3.96
Sep 8	8	53.69	6.34	8	53.00	14.26	8	54.69r	9.63	8	46.63	4.55	8	47.13	3.87
Sep 14	8	54.44	6.27	8	53.75	13.87	8	55.19	9.45	8	46.75r	4.17	8	47.44	4.37
Sep 18	8	54.38	6.17	8	54.06	13.49	8	55.50	9.10	8	46.56r	3.96	8	47.13	5.42
Sep 22	8	54.88	6.00	8	54.25	13.19	8	55.50	9.03	8	46.50r	3.91	8	46.75	5.59
Sep 26	8	54.63	6.04	8	54.31	13.33	8	55.25	9.06	8	46.38r	4.07	8	46.44	6.37
Sep 29	8	54.50	6.16	8	54.31	13.05	8	55.06	9.06	8	46.56r	4.03	8	46.38	6.49
Oct 4	8	54.69	6.34	8	54.13	12.81	8	55.25	8.49	8	46.56r	4.01	8	46.94	6.76
Oct 11	8	54.00	6.51	8	53.69	12.67	8	54.81	7.73	8	45.88r	3.96	8	47.13	6.97
Oct 18	8	53.88	6.29	8	53.88	13.29	8	54.94	7.67	8	45.50r	4.08	8	47.06	6.61
Oct 25	8	53.75	7.02	8	53.88	14.37	8	55.00	7.52	8	46.25r	4.31	8	46.94	6.17
Nov 1	8	55.56	5.61	8	53.94	14.15	8	55.75	8.26	8	46.25r	4.23	8	47.38	6.16
Nov 8	8	54.69	5.95	8	53.69	15.28	8	56.31	8.90	8	46.19r	4.37	8	47.81	6.34
Nov 16	8	55.56	4.75	8	55.56	16.62	8	56.38	9.08	8	46.25r	4.49	8	49.38	5.87
Nov 22	8	55.13	5.30	8	56.06	17.72	8	56.94	9.59	8	46.75r	4.36	8	49.94	6.21
Nov 28	8	56.19	5.33	8	58.19	18.74	8	57.06	10.01	8	47.38r	4.90	8	50.81	5.99

The results showed statistically significant differences in pepper heights comparing LDS 1.5 kg (mean=47.4) vs. Leonardite 1kg (mean=56.2), LDS 1.5 kg (mean=47.4) vs. LDS 0.5kg (mean=58.2) and LDS 1.5 kg (mean=47.4) vs. LDS 1kg (mean=57.1) at the end of the trial. It is worth noting for the LDS fertilizer type, a lower application rate of 0.5kg resulted in over 20% higher pepper plant heights compared to the 1.5kg application rate.

Figure 4: Plot of the mean pepper heights over time



The above plot shows lower pepper plant heights after June 27th for the control and LDS 1.5kg treatment levels compared to the other treatment levels. The LDS 1.5kg level resulted in lower pepper plant heights than the control level at the end of the trial.

Table 8: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Treatment	4	39	1.72	0.1659
time	46	1606	96.82	<.0001
Treatment*time	184	1597	1.08	0.2238

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)

The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.17) or the two-way interaction treatment*time (p-value=0.22). The time effect reveals the mean pepper heights are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in mean pepper heights between the 5 levels of treatment. A non-significant treatment*time interaction reveals the mean pepper heights are increasing at the same rate over time between treatments.

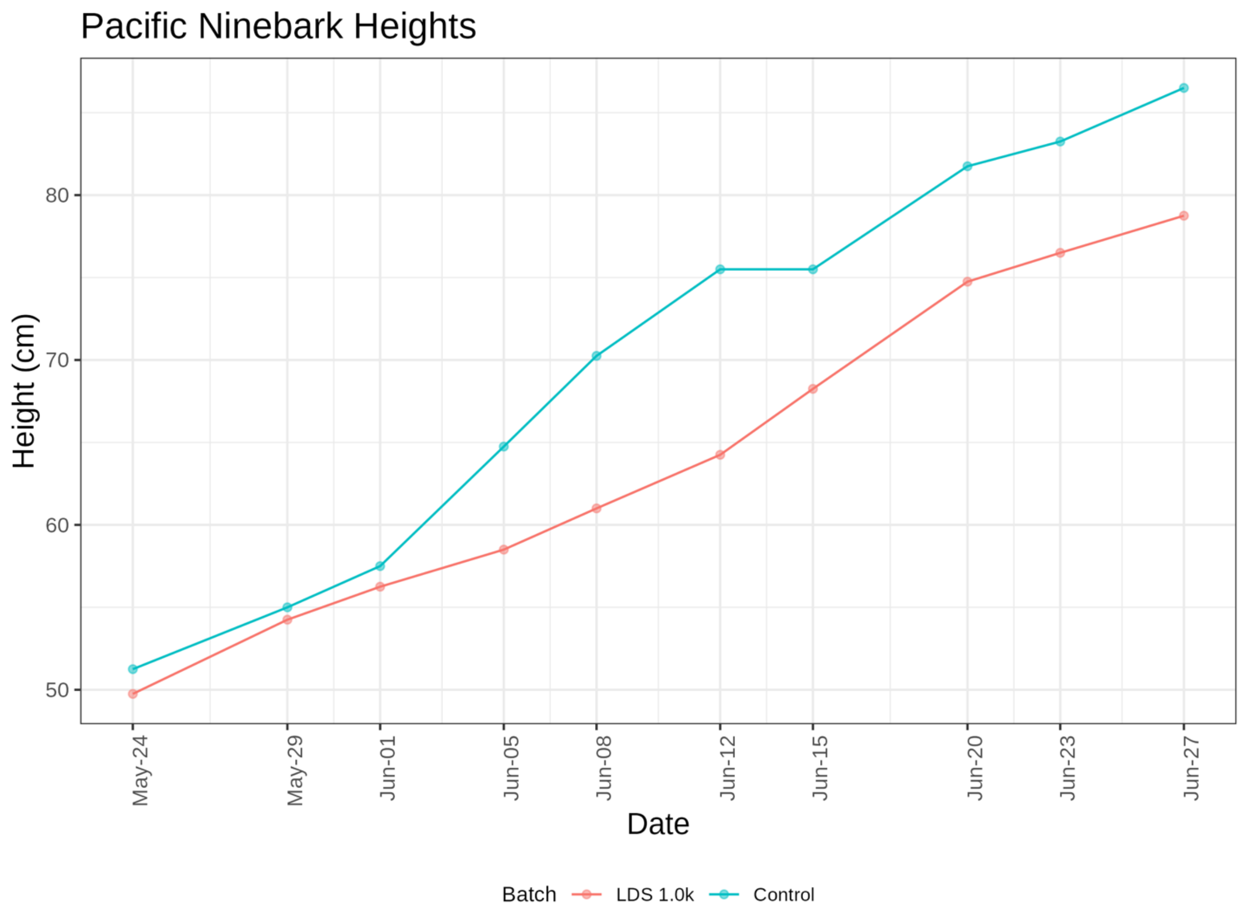
Pacific ninebark

Table 9: Summary statistics for Pacific ninebark heights

	treatment					
	LDS 1.0k			Control		
	Pacific Ninebark			Pacific Ninebark		
	N	Mean	Std	N	Mean	Std
Time						
May 24	4	49.75	11.27	4	51.25	3.10
May 29	4	54.25	12.47	4	55.00	2.16
Jun 1	4	56.25	13.72	4	57.50	3.11
Jun 5	4	58.50	16.30	4	64.75	5.32
Jun 8	4	61.00	18.13	4	70.25	6.29
Jun 12	4	64.25	19.97	4	75.50	9.11
Jun 15	4	68.25	20.11	4	75.50	5.80
Jun 20	4	74.75	20.84	4	81.75	9.22
Jun 23	4	76.50	19.76	4	83.25	10.44
Jun 27	4	78.75	21.78	4	86.50	12.61

The results failed to detect any statistically significant differences in Pacific ninebark heights at the end of the trial. There were only two levels of treatment for this trial. The control level (mean=86.5) resulted in 10% higher plants compared to the LDS 1.0kg level (mean=78.8).

Figure 5: Plot of the Pacific Ninebark heights over time



The above plot shows on average 10% higher Pacific ninebark heights for the control level compared to the LDS 1.0kg level.

Table 10: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
treatment	1	6.22	0.39	0.5523
time	9	53.9	13.42	<.0001
treatment*time	9	53.9	1.32	0.2507

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)

The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.55) or the two-way interaction treatment*time (p-value=0.25). The time effect reveals the mean Pacific ninebark heights are increasing for both treatments over time. Since there is no treatment effect we can't say there is a difference in mean Pacific ninebark heights between the 2 levels of treatment. A non-significant treatment*time interaction reveals the mean Pacific ninebark heights are increasing at the same rate over time between treatments.

Tomato Height (Cherry Tomatoes)

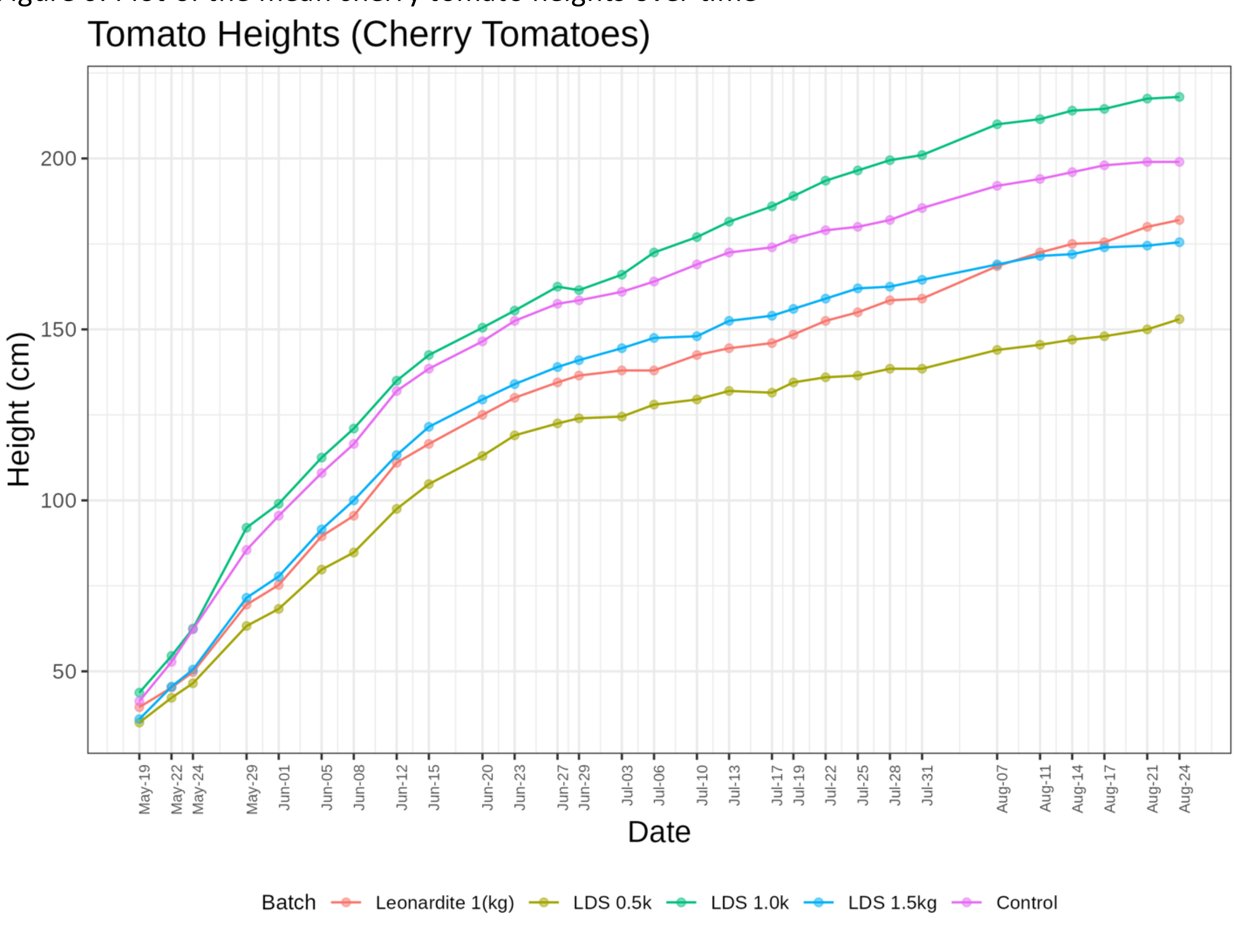
Table 11: Summary statistics for cherry tomato heights

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Tomato Height			Tomato Height			Tomato Height			Tomato Height			Tomato Height		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
May 19	2	39.50	6.36	2	35.00	0.71	2	43.75	1.77	2	36.00	2.83	2	41.25	1.77
May 22	2	45.25	8.84	2	42.25	0.35	2	54.50	1.41	2	45.50	2.83	2	52.75	0.35
May 24	2	49.75	10.96	2	46.50	0.71	2	62.50	2.12	2	50.50	4.24	2	62.25	1.06
May 29	2	69.50	14.85	2	63.25	3.89	2	92.00	11.31	2	71.50	7.07	2	85.50	4.24
Jun 1	2	75.25	11.67	2	68.25	6.72	2	99.00	7.78	2	77.75	7.42	2	95.50	3.54
Jun 5	2	89.50	10.61	2	79.75	8.13	2	112.50	7.78	2	91.50	7.07	2	108.00	5.66
Jun 8	2	95.50	13.44	2	84.75	13.08	2	121.00	8.49	2	100.00	9.90	2	116.50	10.61
Jun 12	2	111.00	11.31	2	97.50	14.85	2	135.00	7.07	2	113.25	12.37	2	132.00	11.31
Jun 15	2	116.50	9.19	2	104.75	15.91	2	142.50	4.95	2	121.50	9.19	2	138.50	12.02
Jun 20	2	125.00	7.07	2	113.00	19.80	2	150.50	4.95	2	129.50	9.19	2	146.50	19.09
Jun 23	2	130.00	8.49	2	119.00	19.80	2	155.50	7.78	2	134.00	7.07	2	152.50	21.92
Jun 27	2	134.50	7.78	2	122.50	21.92	2	162.50	6.36	2	139.00	9.90	2	157.50	21.92
Jun 29	2	136.50	7.78	2	124.00	22.63	2	161.50	4.95	2	141.00	8.49	2	158.50	23.33
Jul 3	2	138.00	8.49	2	124.50	23.33	2	166.00	7.07	2	144.50	7.78	2	161.00	26.87
Jul 6	2	138.00	7.07	2	128.00	25.46	2	172.50	7.78	2	147.50	7.78	2	164.00	29.70
Jul 10	2	142.50	10.61	2	129.50	26.16	2	177.00	11.31	2	148.00	9.90	2	169.00	32.53
Jul 13	2	144.50	10.61	2	132.00	28.28	2	181.50	12.02	2	152.50	4.95	2	172.50	36.06
Jul 17	2	146.00	9.90	2	131.50	27.58	2	186.00	11.31	2	154.00	4.24	2	174.00	42.43
Jul 19	2	148.50	10.61	2	134.50	27.58	2	189.00	12.73	2	156.00	4.24	2	176.50	41.72
Jul 22	2	152.50	10.61	2	136.00	28.28	2	193.50	13.44	2	159.00	4.24	2	179.00	43.84
Jul 25	2	155.00	11.31	2	136.50	28.99	2	196.50	13.44	2	162.00	2.83	2	180.00	45.25
Jul 28	2	158.50	12.02	2	138.50	30.41	2	199.50	14.85	2	162.50	2.12	2	182.00	46.67
Jul 31	2	159.00	11.31	2	138.50	30.41	2	201.00	16.97	2	164.50	0.71	2	185.50	45.96

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Tomato Height			Tomato Height			Tomato Height			Tomato Height			Tomato Height		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Aug 7	2	168.50	14.85	2	144.00	31.11	2	210.00	18.38	2	169.00	0.00	2	192.00	49.50
Aug 11	2	172.50	14.85	2	145.50	28.99	2	211.50	20.51	2	171.50	0.71	2	194.00	50.91
Aug 14	2	175.00	14.14	2	147.00r	28.28	2	214.00	22.63	2	172.00	0.00	2	196.00	50.91
Aug 17	2	175.50	13.44	2	148.00r	26.87	2	214.50	24.75	2	174.00	0.00	2	198.00	49.50
Aug 21	2	180.00	19.80	2	150.00r	24.04	2	217.50	24.75	2	174.50	0.71	2	199.00	50.91
Aug 24	2	182.00	21.21	2	153.00	21.21	2	218.00	24.04	2	175.50	2.12	2	199.00	50.91

The results show a statistically significant difference in mean cherry tomato heights between LDS 0.5kg (mean=153.0) and LDS 1.0kg (mean=218.0) at the end of the trial. Cherry tomato heights were 42% higher with the LDS 1.0kg level compared to LDS 0.5kg level.

Figure 6: Plot of the mean cherry tomato heights over time



The above plot shows higher mean cherry tomato heights for the LDS 1.0kg compared to the other treatment levels throughout the trial. Surprisingly, the control level resulted in consistently higher cherry tomato heights compared to Leonardite 1kg, LDS 1.5kg and LDS 0.5kg levels throughout the trial.

Table 12: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
treatment	4	5.22	1.72	0.2771
time	28	140	75.40	<.0001
treatment*time	112	138	0.87	0.7795

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)
The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.28) or the two-way interaction treatment*time (p-value=0.78). The time effect reveals the mean cherry tomato heights are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in mean cherry tomato heights between the 5 levels of treatment. A non-significant treatment*time interaction reveals the mean cherry tomato heights are increasing at the same rate over time between treatments.

Tomato Heights (Early Girls)

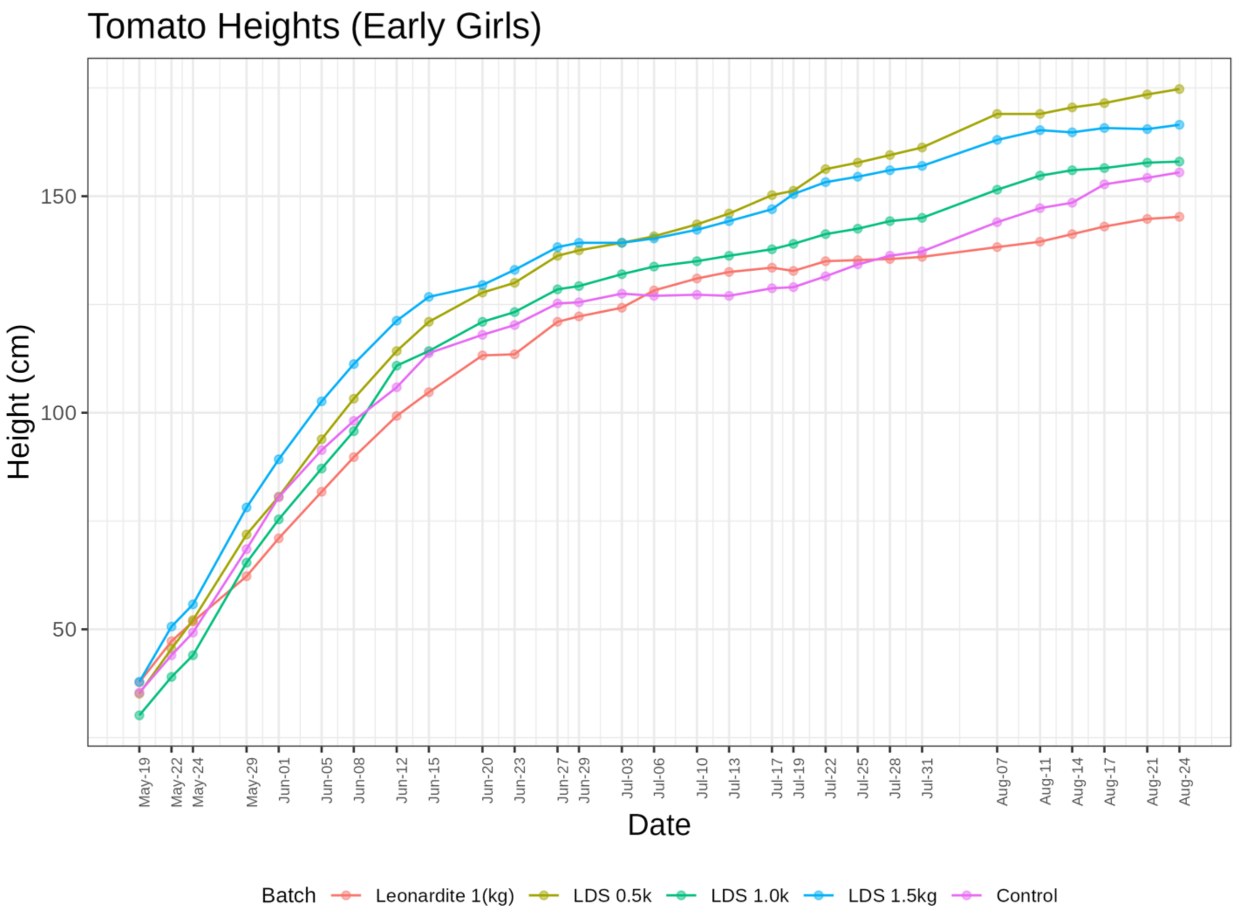
Table 13: Summary statistics for early girl tomato heights

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Tomato Height			Tomato Height			Tomato Height			Tomato Height			Tomato Height		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
May 19	4	37.75	5.04	4	35.13	1.49	4	30.13	3.01	4	37.88	3.33	4	35.38	2.69
May 22	4	47.25	7.66	4	45.50	0.00	4	39.00	5.21	4	50.63	3.97	4	44.00	3.08
May 24	4	51.75	9.44	4	52.13	1.31	4	44.00	6.52	4	55.75	3.52	4	49.25	3.93
May 29	4	62.25	19.36	4	71.88	2.56	4	65.38	4.71	4	78.13	2.72	4	68.50	5.18
Jun 1	4	71.00	22.01	4	80.63	3.82	4	75.38	6.56	4	89.25	3.66	4	80.50	4.43
Jun 5	4	81.75	21.95	4	93.88	7.67	4	87.13	8.48	4	102.63	7.94	4	91.38	6.13
Jun 8	4	89.75	21.81	4	103.25	10.14	4	95.75	8.66	4	111.25	7.37	4	98.13	7.27

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Tomato Height			Tomato Height			Tomato Height			Tomato Height			Tomato Height		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Jun 12	4	99.25	17.19	4	114.25	11.30	4	110.88	4.73	4	121.25	11.93	4	105.88	6.86
Jun 15	4	104.75	16.15	4	121.00	14.45	4	114.25	7.68	4	126.75	17.04	4	113.75	8.06
Jun 20	4	113.25	11.27	4	127.75	17.06	4	121.00	5.60	4	129.50	17.52	4	118.00	6.98
Jun 23	4	113.50	10.97	4	130.00	18.53	4	123.25	5.56	4	133.00	17.64	4	120.25	7.85
Jun 27	4	121.00	11.40	4	136.25	18.64	4	128.50	4.65	4	138.25	16.98	4	125.25	9.11
Jun 29	4	122.25	9.88	4	137.50	17.92	4	129.25	5.62	4	139.25	16.92	4	125.50	8.23
Jul 3	4	124.25	9.67	4	139.25	17.97	4	132.00	3.92	4	139.25	16.15	4	127.50	8.50
Jul 6	4	128.25	10.63	4	140.75	20.27	4	133.75	4.03	4	140.25	16.50	4	127.00	9.20
Jul 10	4	131.00	12.94	4	143.50	20.76	4	135.00	5.77	4	142.25	17.63	4	127.25	8.66
Jul 13	4	132.50	12.87	4	146.00	19.92	4	136.25	7.27	4	144.25	17.56	4	127.00	8.83
Jul 17	4	133.50	12.92	4	150.25	16.68	4	137.75	8.66	4	147.00	14.99	4	128.75	10.56
Jul 19	4	132.75	13.60	4	151.25	16.52	4	139.00	9.42	4	150.50	13.82	4	129.00r	11.69
Jul 22	4	135.00*	13.98	4	156.25*	14.43	4	141.25	10.53	4	153.25	10.31	4	131.50r	13.40
Jul 25	4	135.25	14.29	4	157.75r	13.60	4	142.50	9.75	4	154.50	10.47	4	134.25	14.66
Jul 28	4	135.50	15.07	4	159.50r	11.96	4	144.25	11.47	4	156.00	10.98	4	136.25	17.95
Jul 31	4	136.00r	14.49	4	161.25*	11.35	4	145.00	11.20	4	157.00	11.69	4	137.25*	20.56
Aug 7	4	138.25r	11.09	4	169.00*	11.34	4	151.50	16.34	4	163.00	14.79	4	144.00*	25.94
Aug 11	4	139.50r	12.23	4	169.00*	12.36	4	154.75	18.14	4	165.25	16.92	4	147.25*	30.32
Aug 14	4	141.25r	12.50	4	170.50*	12.66	4	156.00	18.65	4	164.75	16.46	4	148.50*	30.13
Aug 17	4	143.00r	13.83	4	171.50	13.63	4	156.50	18.59	4	165.75	17.06	4	152.75	33.26
Aug 21	4	144.75r	14.52	4	173.50	15.00	4	157.75	19.50	4	165.50	17.14	4	154.25	32.29
Aug 24	4	145.25r	15.24	4	174.75	16.46	4	158.00	19.88	4	166.50	17.02	4	155.50	32.42

The results show a statistically significant difference in mean early girl tomato heights between Leonardite 1.0kg (mean=145.3) vs. LDS 0.5kg (mean=174.8) and Leonardite 1.0kg vs. LDS 1.5kg (mean=166.5) at the end of the trial. The early girl tomato heights for the LDS 0.5kg level were about 20% higher than the Leonardite 1.0kg level at the end of the trial.

Figure 7: Plot of the mean early girl tomato heights over time



The above plot shows similar growth rates between treatment levels for early girl tomatoes throughout the trial. The LDS 0.5kg and LDS 1.5kg treatment levels revealed higher early girl tomato heights throughout the trial and resulted in 20 % higher heights compared to the Leonardite 1.0kg level at the end of the trial.

Table 14: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
treatment	4	16.2	1.62	0.2179
time	28	411	88.22	<.0001
treatment*time	112	401	0.98	0.5478

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.

(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant) The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.22) or the two-way interaction treatment*time (p-value=0.55). The time effect reveals the mean early girl tomato heights are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in mean early girl tomato heights between the 5 levels of treatment. A non-significant treatment*time interaction reveals the mean early girl tomato heights are increasing at the same rate over time between treatments.

Red Cedar Height

Table 15: Summary statistics for red cedar heights

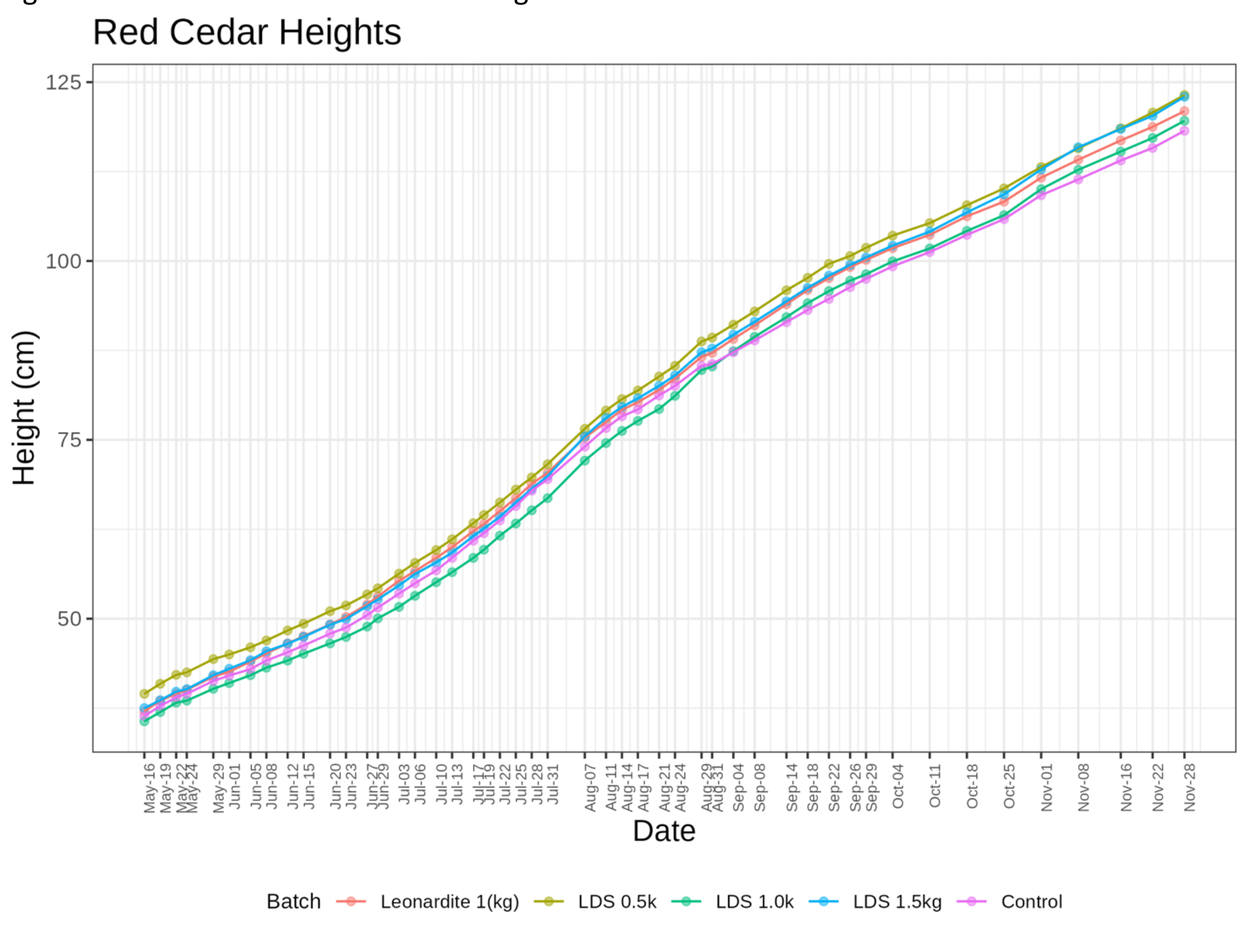
	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Red Cedar			Red Cedar			Red Cedar			Red Cedar			Red Cedar		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
May 16	10	37.05	5.47	10	39.50	3.06	10	35.65	3.79	10	37.50	5.55	10	36.40	2.70
May 19	10	38.55	5.74	10	40.90	3.24	10	36.95	4.16	10	38.60	5.68	10	37.80	2.62
May 22	10	39.50	5.93	10	42.15	3.32	10	38.25	4.46	10	39.80	5.68	10	39.00	2.78
May 24	10	40.05	5.97	10	42.50	3.31	10	38.55	4.62	10	40.15	5.72	10	39.50	2.64
May 29	10	41.90	6.33	10	44.35	3.46	10	40.20	4.62	10	42.10	6.06	10	41.30	2.85
Jun 1	10	42.60	6.49	10	45.00	3.46	10	41.00	4.61	10	43.00	6.14	10	42.05	2.80
Jun 5	10	44.00	6.39	10	46.00	3.67	10	42.10	4.80	10	44.20	6.12	10	42.95	2.78
Jun 8	10	45.15	6.34	10	46.95	3.81	10	43.15	4.88	10	45.45	6.33	10	44.15	2.93
Jun 12	10	46.55	6.14	10	48.35	3.78	10	44.15	5.07	10	46.50	6.25	10	45.30	3.03
Jun 15	10	47.55	6.04	10	49.30	3.79	10	45.10	4.90	10	47.45	6.29	10	46.25	3.04
Jun 20	10	49.20	5.81	10	51.05	3.83	10	46.55	5.10	10	49.15	6.11	10	47.90	3.19
Jun 23	10	50.25	5.61	10	51.85	3.89	10	47.45	5.14	10	49.95	6.15	10	48.75	3.39
Jun 27	10	52.00	5.40	10	53.40	3.82	10	48.90	5.33	10	51.75	5.87	10	50.50	3.57
Jun 29	10	53.10	5.26	10	54.25	3.99	10	50.05	5.51	10	52.70	5.97	10	51.55	3.72
Jul 3	10	55.30	5.09	10	56.30	3.78	10	51.65	5.57	10	54.65	5.99	10	53.50	3.85
Jul 6	10	56.65	5.16	10	57.80	3.88	10	53.20	5.41	10	56.25	6.23	10	54.95	4.24
Jul 10	10	58.50	5.28	10	59.60	3.75	10	55.10	5.64	10	57.85	6.18	10	56.75	4.50
Jul 13	10	60.00	5.27	10	61.10	3.89	10	56.50	5.84	10	59.25	6.15	10	58.50	4.42

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Red Cedar			Red Cedar			Red Cedar			Red Cedar			Red Cedar		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Jul 17	10	62.25	5.39	10	63.35	3.76	10	58.50	5.98	10	61.55	6.09	10	60.90	4.60
Jul 19	10	63.25	5.34	10	64.50	3.92	10	59.65	5.98	10	62.60	6.08	10	61.95	4.74
Jul 22	10	65.05	5.24	10	66.25	3.91	10	61.60	5.88	10	64.25	6.20	10	63.75	4.81
Jul 25	10	66.85	5.28	10	68.05	4.08	10	63.30	6.01	10	66.25	6.08	10	65.75	4.83
Jul 28	10	68.85	5.37	10	69.75	4.22	10	65.15	5.76	10	68.15	6.18	10	67.90	4.86
Jul 31	10	70.40	5.44	10	71.60	4.05	10	66.85	5.69	10	69.95	6.21	10	69.50	5.10
Aug 7	10	75.30	5.80	10	76.55	4.80	10	72.10	5.74	10	75.50	6.47	10	74.05	5.10
Aug 11	10	77.50	6.10	10	79.10	4.56	10	74.55	5.40	10	78.05	6.57	10	76.65	5.12
Aug 14	10	79.20	6.05	10	80.70	4.66	10	76.25	5.42	10	79.60	6.82	10	78.30	5.23
Aug 17	10	80.25	6.10	10	81.90	4.68	10	77.65	5.40	10	80.80	6.51	10	79.25	5.25
Aug 21	10	82.00	6.08	10	83.85	4.89	10	79.30	5.54	10	82.55	6.47	10	81.20	5.56
Aug 24	10	83.55	6.45	10	85.35	5.08	10	81.15	5.54	10	84.00	6.48	10	82.55	6.05
Aug 29	10	86.60	7.00	10	88.75	5.56	10	84.75	5.71	10	87.25	6.39	10	85.35	6.53
Aug 31	10	87.15	7.01	10	89.30	5.65	10	85.25	5.70	10	87.75	6.37	10	85.60	6.40
Sep 4	10	89.10	7.02	10	91.10	5.73	10	87.40	5.86	10	89.70	6.42	10	87.25	6.76
Sep 8	10	91.00	7.27	10	92.95	5.73	10	89.40	5.66	10	91.50	6.50	10	88.90	7.11
Sep 14	10	93.95	7.59	10	95.90	5.99	10	92.15	5.93	10	94.35	6.58	10	91.45	7.06
Sep 18	10	95.95	7.44	10	97.65	6.09	10	94.10	5.99	10	96.25	6.85	10	93.15	7.19
Sep 22	10	97.60	7.67	10	99.60	6.59	10	95.80	6.06	10	97.95	6.94	10	94.70	7.23
Sep 26	10	99.15	7.82	10	100.70	6.65	10	97.25	6.18	10	99.45	7.34	10	96.35	7.11
Sep 29	10	100.15	7.68	10	101.85	6.79	10	98.15	6.05	10	100.50	7.36	10	97.50	7.18
Oct 4	10	101.80	7.78	10	103.55	7.04	10	99.95	6.38	10	102.15	7.54	10	99.25	6.82
Oct 11	10	103.65	7.72	10	105.30	7.67	10	101.75	6.59	10	104.10	7.77	10	101.25	7.07
Oct 18	10	106.25	7.55	10	107.80	7.78	10	104.20	6.75	10	106.80	7.71	10	103.65	7.12
Oct 25	10	108.30	7.70	10	110.15	7.52	10	106.40	7.13	10	109.30	7.97	10	105.85	7.26
Nov 1	10	111.65	7.46	10	113.15	7.73	10	110.05	7.35	10	112.80	8.40	10	109.20	7.82
Nov 8	10	114.15	7.23	10	115.75	7.63	10	112.75	7.46	10	115.90	8.49	10	111.40	8.04
Nov 16	10	116.85	6.77	10	118.55	7.81	10	115.30	7.83	10	118.45	8.92	10	114.05	8.47

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	Red Cedar			Red Cedar			Red Cedar			Red Cedar			Red Cedar		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Nov 22	10	118.75	6.40	10	120.75	7.76	10	117.20	8.31	10	120.30	8.95	10	115.80	8.90
Nov 28	10	120.95	6.14	10	123.20	8.27	10	119.60	8.93	10	122.95	9.67	10	118.20	9.10

The results failed to detect any statistically significant differences in red cedar heights between treatment levels at the end of the trial. The mean red cedar heights for all treatment levels are about 120 cm. Notice the very consistent standard deviations between the treatment levels with values ranging from 6-9 cm.

Figure 8: Plot of the mean red cedar heights over time



The above plot shows very consistent red cedar height growth for all treatment levels over time.

Table 16: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
treatment	4	46	0.63	0.6456
time	47	2113	583.28	<.0001
treatment*time	188	2110	0.75	0.9937

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)
The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.65) or the two-way interaction treatment*time (p-value=0.99). The time effect reveals the mean red cedar heights are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in mean red cedar heights between the 5 levels of treatment. A non-significant treatment*time interaction reveals the mean red cedar heights are increasing at the same rate over time between treatments.

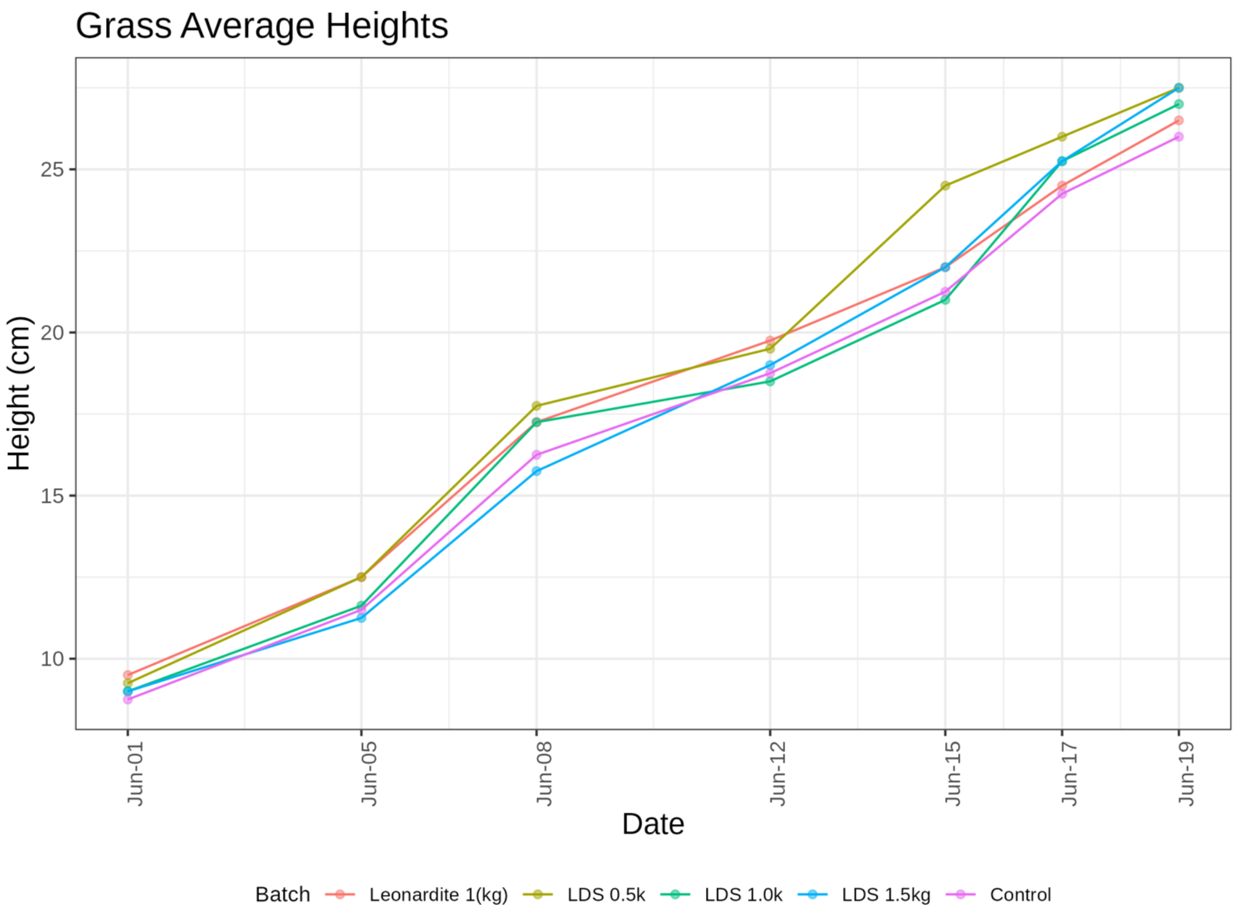
Average Grass Height

Table 17: Summary statistics for average grass heights

	treatment														
	Leonardite 1(kg)			**LDS 0.5k**			**LDS 1.0k**			**LDS 1.5kg**			**Control**		
	Grass Average			**Grass Average**			**Grass Average**			**Grass Average**			**Grass Average**		
	N	**Mean**	**Std**	**N**	**Mean**	**Std**	**N**	**Mean**	**Std**	**N**	**Mean**	**Std**	**N**	**Mean**	**Std**
Time															
Jun 1	2	9.50	0.00	2	9.25	0.35	2	9.00	0.00	2	9.00	0.00	2	8.75	0.35
Jun 5	2	12.50	0.00	2	12.50	0.71	2	11.63	0.53	2	11.25$_r$	0.35	2	11.50	0.71
Jun 8	2	17.25	0.35	2	17.75*	0.35	2	17.25	0.35	2	15.75$_r$	1.06	2	16.25*	0.35
Jun 12	2	19.75	0.35	2	19.50	0.71	2	18.50	0.00	2	19.00	0.71	2	18.75	1.77
Jun 15	2	22.00	0.00	2	24.50$_r$	0.00	2	21.00	0.00	2	22.00	1.41	2	21.25	0.35
Jun 17	2	24.50	0.71	2	26.00$_r$	0.71	2	25.25	0.35	2	25.25	0.35	2	24.25	0.35
Jun 19	2	26.50	0.00	2	27.50	0.00	2	27.00	0.00	2	27.50	0.71	2	26.00$_r$	0.71

The results showed statistically significant differences in mean grass heights between control (mean=26.0) vs LDS 0.5kg (mean=27.5) and control (mean=26.0) vs. LDS 1.5kg (mean=27.5) at the end of the trial. Due to a small sample of n=2 and standard deviation=0 for some treatment levels, these findings may not be reliable. The average grass heights are about 27 cm for all levels of treatment.

Figure 9: Plot of the mean grass heights over time



The above plot shows very consistent average grass heights for all treatment levels over time.

Table 18: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
treatment	4	12	9.60	0.0010
time	6	27.6	1048.23	<.0001
treatment*time	24	23	2.06	0.0444

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)
The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant effects due to time (p-value < 0.01), treatment (p-value <0.01) and the two-way interaction treatment*time (p-value=0.04). Due to a statistically significant two-way interaction between and treatment and time we can't say that one grass height is consistently higher or lower for all days. We need to look for differences in grass heights between for all pairs of treatment levels on each day to come to any conclusions. See table 17 above.

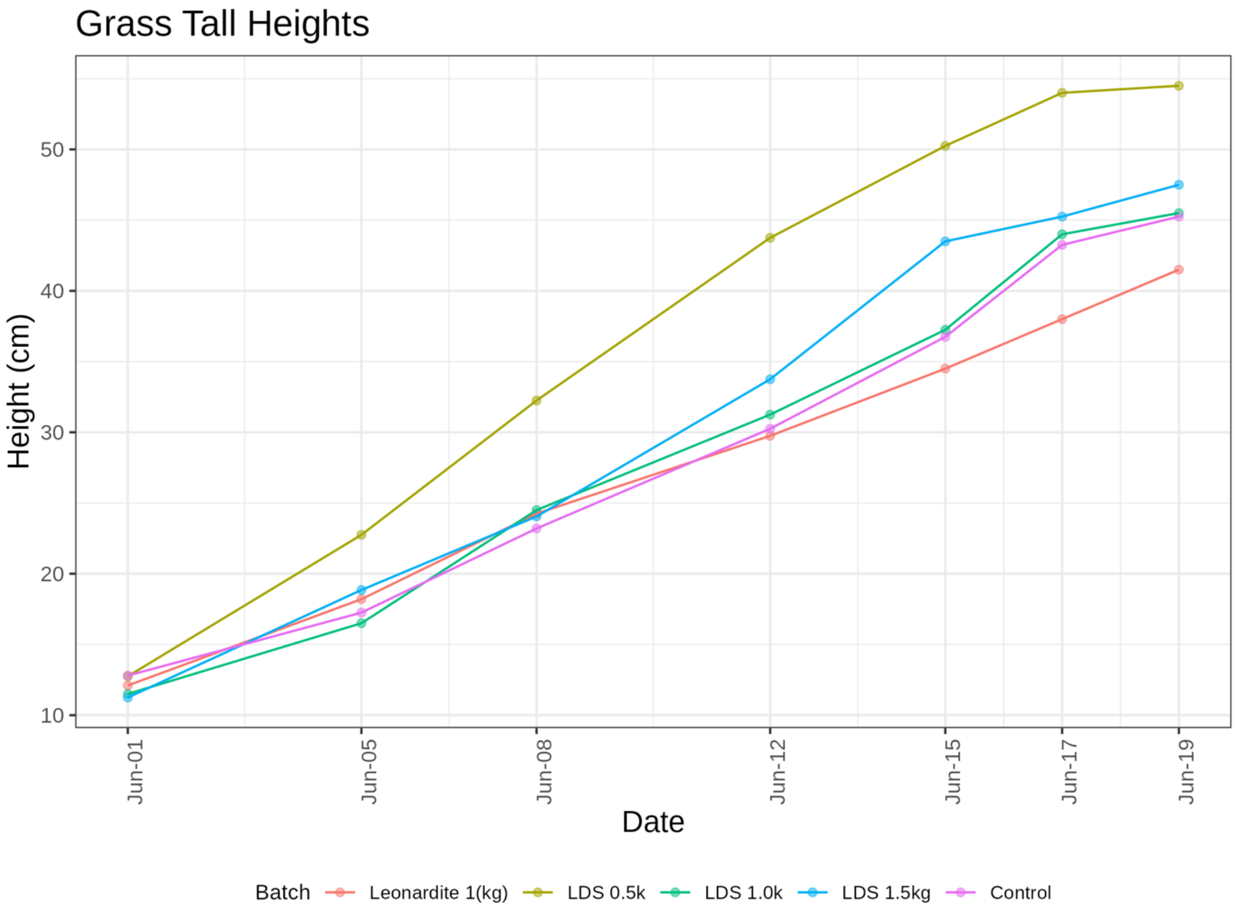
Tall Grass Height

Table 19: Summary statistics for tall grass heights

	treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	grass_tall			grass_tall			grass_tall			grass_tall			grass_tall		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time															
Jun 1	2	12.10	0.14	2	12.75	1.06	2	11.50	0.14	2	11.25	0.35	2	12.80	1.13
Jun 5	2	18.20	0.99	2	22.75	3.46	2	16.50	1.84	2	18.85	0.49	2	17.25	2.47
Jun 8	2	24.25	1.77	2	32.25_r	1.06	2	24.50	3.54	2	24.05	1.91	2	23.20	1.13
Jun 12	2	29.75	0.35	2	43.75_r	0.35	2	31.25	3.18	2	33.75	0.35	2	30.25	2.47
Jun 15	2	34.50	0.71	2	50.25_r	3.18	2	37.25^*	3.89	2	43.50	1.41	2	36.75	3.89
Jun 17	2	38.00^*	1.41	2	54.00_r	0.00	2	44.00	4.24	2	45.25^*	10.96	2	43.25	1.77
Jun 19	2	41.50	0.71	2	54.50_r	0.71	2	45.50	4.95	2	47.50	10.61	2	45.25	1.06

The results showed statistically significant differences in mean tall grass heights between:
LDS 0.5kg (mean=54.50) vs. Leonardite 1kg (mean=41.5)
LDS 0.5k (mean=54.50) vs. LDS 1.0k (mean=45.5)
LDS 0.5k (mean=54.50) vs. LDS 1.5k (mean=47.5)
LDS 0.5k (mean=54.50) vs. Control (mean=45.3)
LDS 0.5kg showed the highest mean tall grass height at the end of the trial.

Figure 10: Plot of the mean tall grass heights over time



The above plot shows very consistent growth rates for tall grass heights between treatment levels over time. The LDS 0.5kg treatment level were about 15-20% higher than all other treatment levels at the end of the trial.

Table 20: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
treatment	4	5.79	6.27	0.0263
time	6	27.8	94.74	<.0001
treatment*time	24	23.6	1.09	0.4208

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)
The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant effects due to time (p-value <0.01), treatment (p-value <0.03). The two-way interaction treatment*time (p-value=0.42) was not statistically significant telling us the tall grass heights are increasing at the same rate over time. The statistically significant treatment effect reveals the mean grass heights for the LDS 0.5kg treatment is consistently higher (about 15-20%) than LDS 1.0kg, LDS 1.5kg and control for all days in the trial. No other plant trial was able to come to this conclusion.

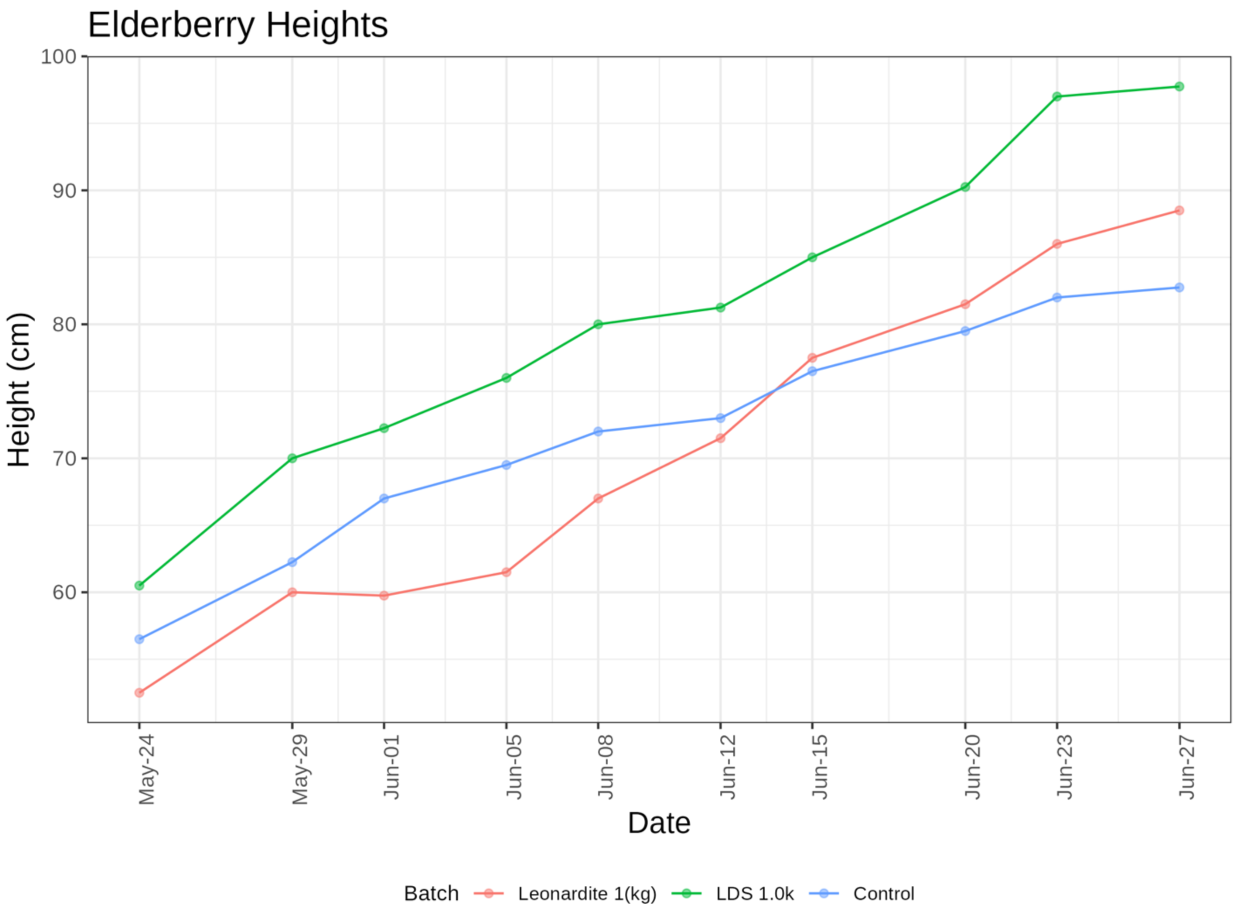
Elderberry Height

Table 21: Summary statistics for elderberry heights

	treatment								
	Leonardite 1(kg)			LDS 1.0k			Control		
	Elderberry			Elderberry			Elderberry		
	N	Mean	Std	N	Mean	Std	N	Mean	Std
Time									
May 19	4	52.50	4.80	4	60.50	6.86	4	56.50	5.32
May 22	4	60.00	1.63	4	70.00	12.68	4	62.25	8.62
May 24	4	59.75	4.03	4	72.25	12.34	4	67.00	6.16
May 29	4	61.50	5.45	4	76.00	15.51	4	69.50	6.66
Jun 1	4	67.00	4.69	4	80.00	18.11	4	72.00	9.42
Jun 5	4	71.50	3.87	4	81.25	20.37	4	73.00	12.83
Jun 8	4	77.50	5.80	4	85.00	21.31	4	76.50	14.71
Jun 12	4	81.50	9.98	4	90.25	24.85	4	79.50	20.40
Jun 15	4	86.00	10.17	4	97.00	20.45	4	82.00	20.80
Jun 20	4	88.50	12.07	4	97.75	18.01	4	82.75	22.29

The results failed to detect any statistically significant differences in elderberry heights at the end of the trial. There were only three levels of treatment for this trial. The LDS 1.0kg level (mean=97.8) resulted in 12% higher elderberry plants compared to the Leonardite 1.0kg level (mean=88.5) and about 20% higher elderberry plants compared to the control (mean=82.8).

Figure 11: Plot of the mean elderberry heights over time



The above plot shows very consistent elderberry height growth for all treatment levels over time, but we can clearly see the elderberry plants with the LDS 1.0kg treatment level being always 12-20% higher than the Leonardite 1kg and control treatment levels.

Table 22: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
treatment	2	9.78	0.81	0.4726
time	9	80.8	14.34	<.0001
treatment*time	18	80.5	0.73	0.7676

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)
The table above shows the partial effect tests for treatment, time and the two-way interaction between treatment and time. The results show a statistically significant and effect due to time (p-value < 0.01), no effect of treatment (p-value=.47) or the two-way interaction treatment*time (p-value=0.77). The time effect reveals the mean elderberry heights are increasing for all treatments over time. Since there is no treatment effect we can't say there is a difference in mean elderberry heights between the 3 levels of treatment. A non-significant treatment*time interaction reveals the mean elderberry heights are increasing at the same rate over time between treatments.

Yellow Cedar Cuttings Rooting data

Table 23: Summary statistics for yellow cedar cuttings rooting data.

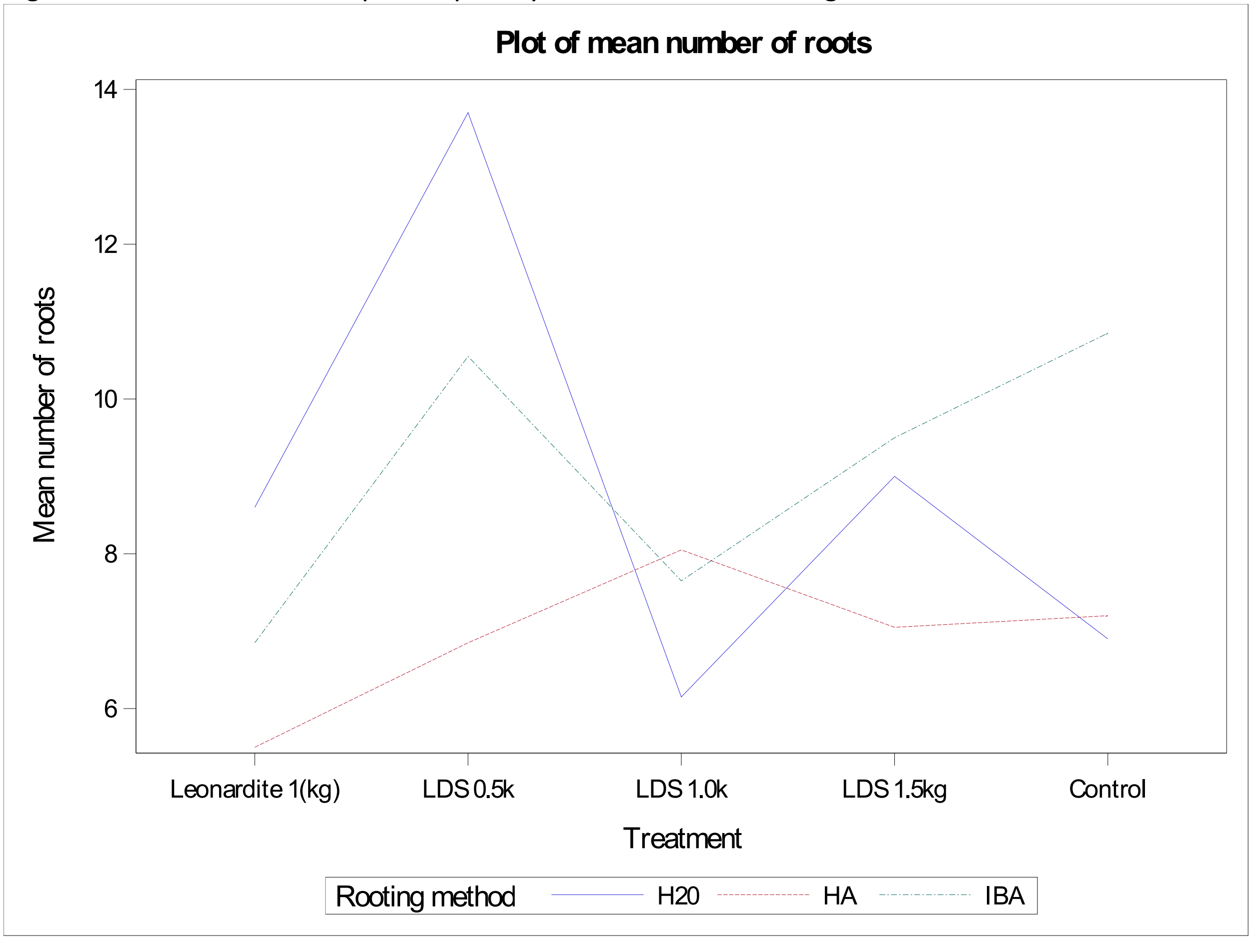
	Treatment														
	Leonardite 1(kg)			LDS 0.5k			LDS 1.0k			LDS 1.5kg			Control		
	roots			roots			roots			roots			roots		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std
Rooting Method															
H20	20	8.60	8.79	20	13.70	8.45	20	6.15	5.23	20	9.00	9.40	20	6.90	8.14
HA	20	5.50	6.07	20	6.85	7.35	20	8.05	9.04	20	7.05	8.25	20	7.20	5.93
IBA	20	6.85	3.65	20	10.55	7.57	20	7.65	6.96	20	9.50	8.51	20	10.85	10.57

The results showed the highest number of mean roots using rooting method H20 and treatment LDS 0.5k (mean=13.70). For the H20 rooting method, treatment LDS 0.5k produced 60%, 120%, 50 % and 100% more roots than treatments Leonardite 1kg (mean=8.6), LDS 1.0k (mean=6.2), LDS 1.5k (mean=9) and the control group (mean=6.9) respectively.

Other statistically findings are listed beklow
H2O Leonardite 1kg vs H20 LDS 0.5k
IBA Leonardite 1kg vs H20 LDS 0.5k
HA Leonardite 1kg vs H20 LDS 0.5k
HA Leonardite 1kg vs IBA LDS 0.5k
HA Leonardite 1kg vs IBA Control
H20 LDS 0.5kg vs HA LDS 0.5kg
H20 LDS 0.5k vs H20 LDS 1.0k
H20 LDS 0.5k vs IBA LDS 1.0k
H20 LDS 0.5k vs HA LDS 1.0k

H20 LDS 0.5k vs H20 LDS 1.5k (p-value 0.057)
H20 LDS 0.5k vs HA LDS 1.5k
H20 LDS 0.5k vs H20 Control
H20 LDS 0.5k vs HA Control
H20 LDS 1.0k vs IBA control (p-value=0.057)

Figure 12: Number of roots profile plot by treatment and rooting method



The profile plot above shows how the mean number of roots varies between treatments and rooting methods. The H20 rooting method with treatment LDS 0.5k produced higher mean number of roots while increasing the treatment to LDS 1.0k resulted in much lower counts of roots.

Table 24: Type 3 partial fixed effect tests

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Treatment	4	285	1.75	0.1386
Rooting Method	2	285	2.32	0.1005
Treatment*rooting method	8	285	1.21	0.2936

Num DF- Numerator degrees of freedom in the F test
Den DF- Denominator degrees of freedom in the F Test
F Value- Value of the F test statistic
Pr> F- P-value of the F statistic.
(A p-value less than the level of significance alpha=0.05 is deemed to be statistically significant)
The table above shows the partial effect tests for treatment, rooting method and the two-way interaction between treatment and rooting method. The results show no effects of treatment (p-value=.14), rooting method (p-value=.1) or the two-way interaction treatment*rooting method (p-value=0.29). Since there are no statistically significant differences in main effects due to treatment or rooting method we can't say there is an overall difference in the mean number of roots between the 5 levels of treatment or 3 rooting methods. A non-significant treatment*rooting method interaction reveals the mean number of roots are changing at the same rate between treatments and rooting methods .

Power Analysis

Table 23: Power and Sample Size analyses for each plant type

Plant Type	Power	Sample Size/Treatment level
Cherry Tomato Counts	.80	6
Early Girl Tomato Counts	.85	6
Pepper Counts	.80	128
Pepper Height	.82	9
Cherry Tomato Height	.93	4
Early Girl Tomato Height	.86	7
Elderberry	.82	17
Tall Grass	.88	3
Pacific Nine Bark	.80	52
Grass Average	.88	Need more data
Red Cedar	.80	30

Power analyses were run to determine the minimal sample size needed (for each treatment level) to detect statistically significant differences between treatments at the end of the trial. An 80% power cutoff was used. The results from table 23 show the minimum sample sizes/treatment varies between 3 and 128. I.e. For Cherry tomato counts the total sample size would be 6* 5= 30 samples since there are 5 treatment levels.

Appendix

A formal statistical analysis could not be performed for cherry tomato weights and early girl tomato weights due to no replicates in the data sets. Sets of visual plots were created to display the findings for each these trials as seen below.

Figure 12: Plot of the mean cherry tomato weights over time

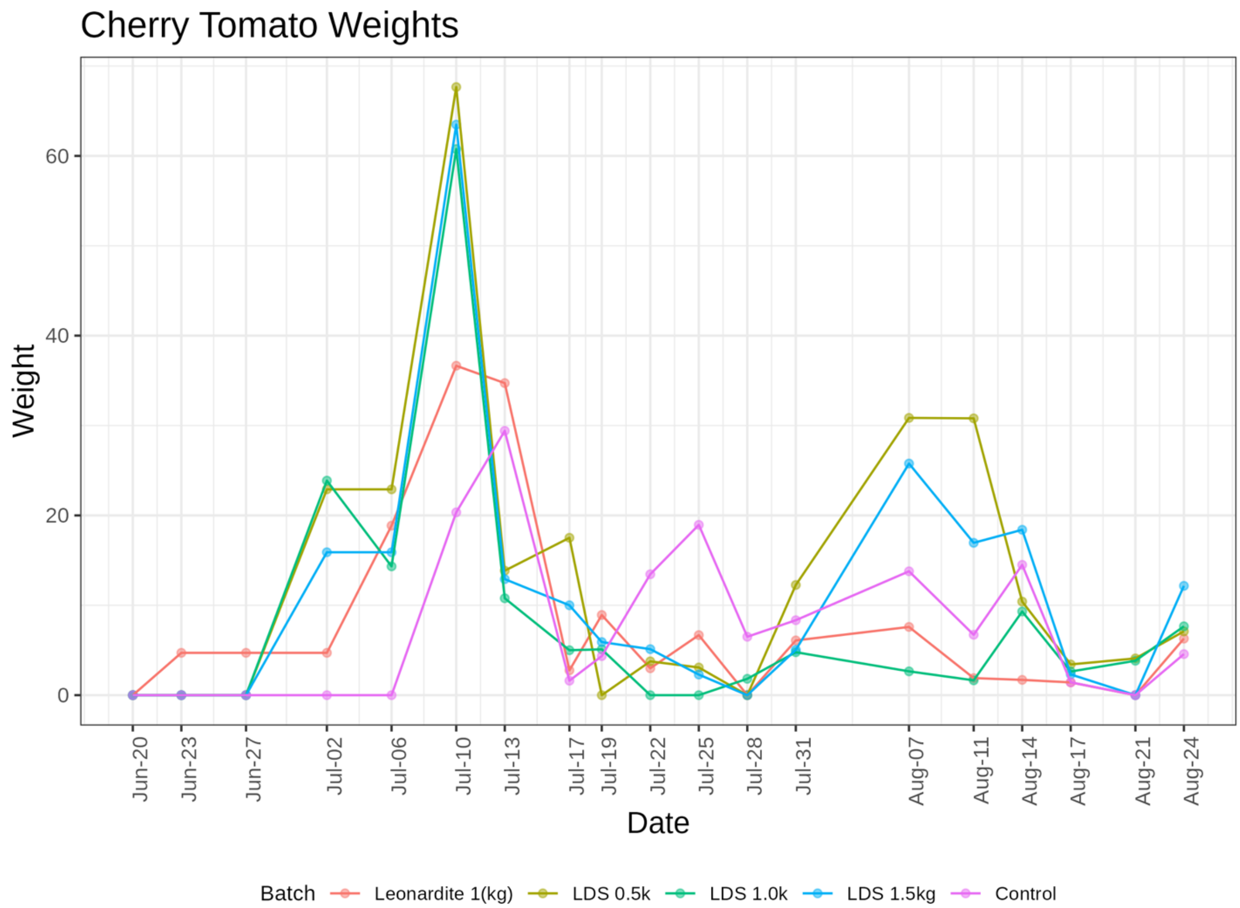
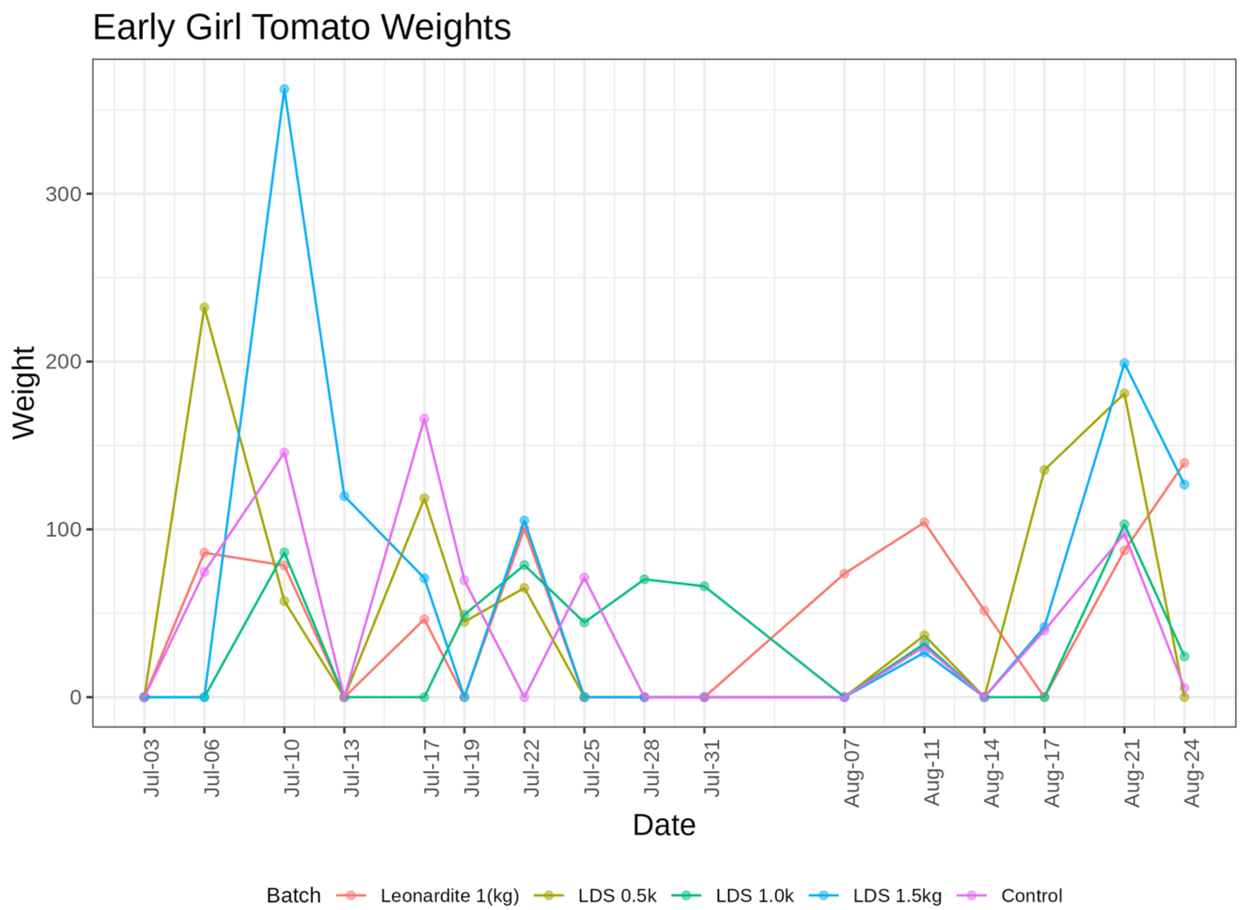


Figure 13: Plot of the mean early girl tomato weights over time



Yellow Cedar Cuttings Rooting data

Figure 14: Plot of cumulative root counts by rooting method over all treatments

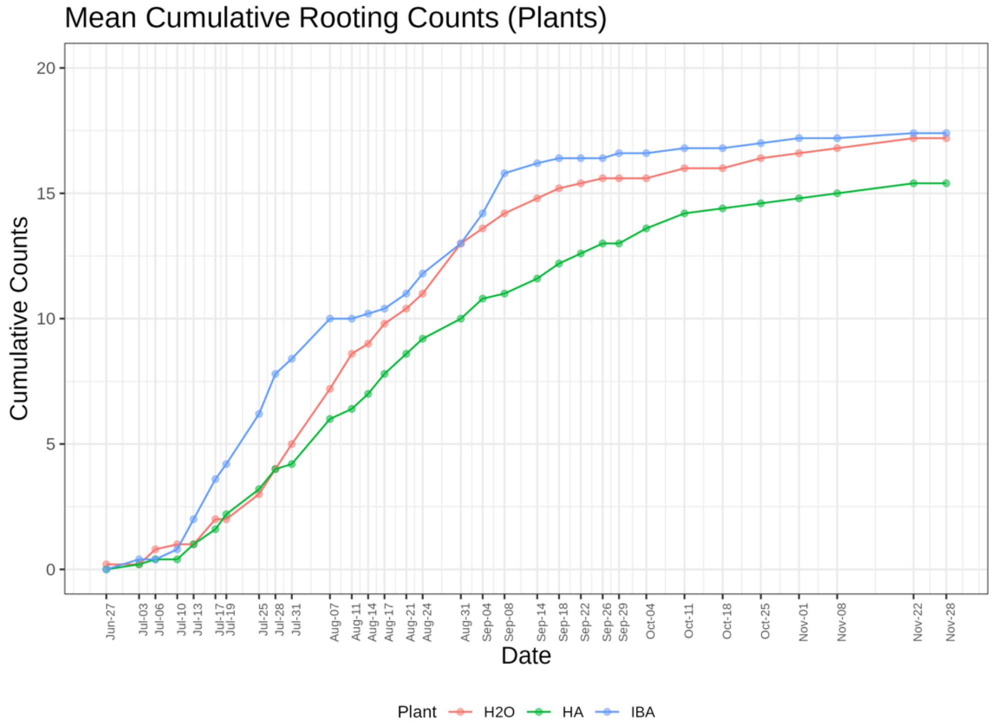


Figure 15: Plot of cumulative root counts for Leondarite 1kg

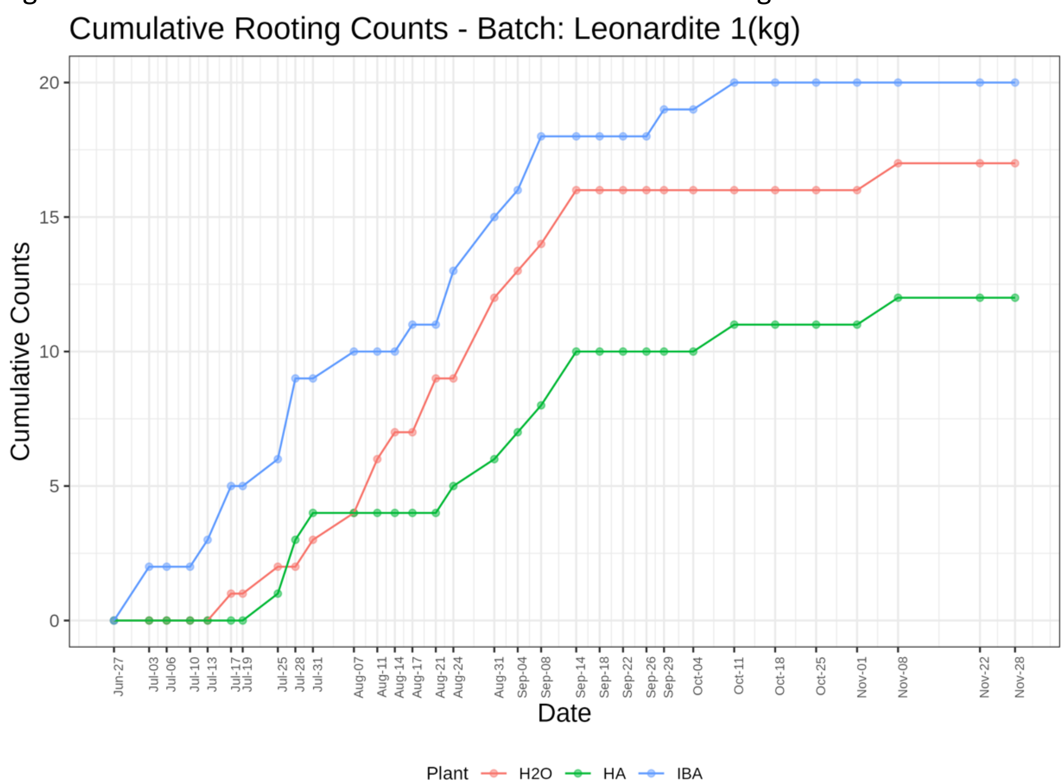


Figure 16: Plot of cumulative root counts for LDS 0.5 kg

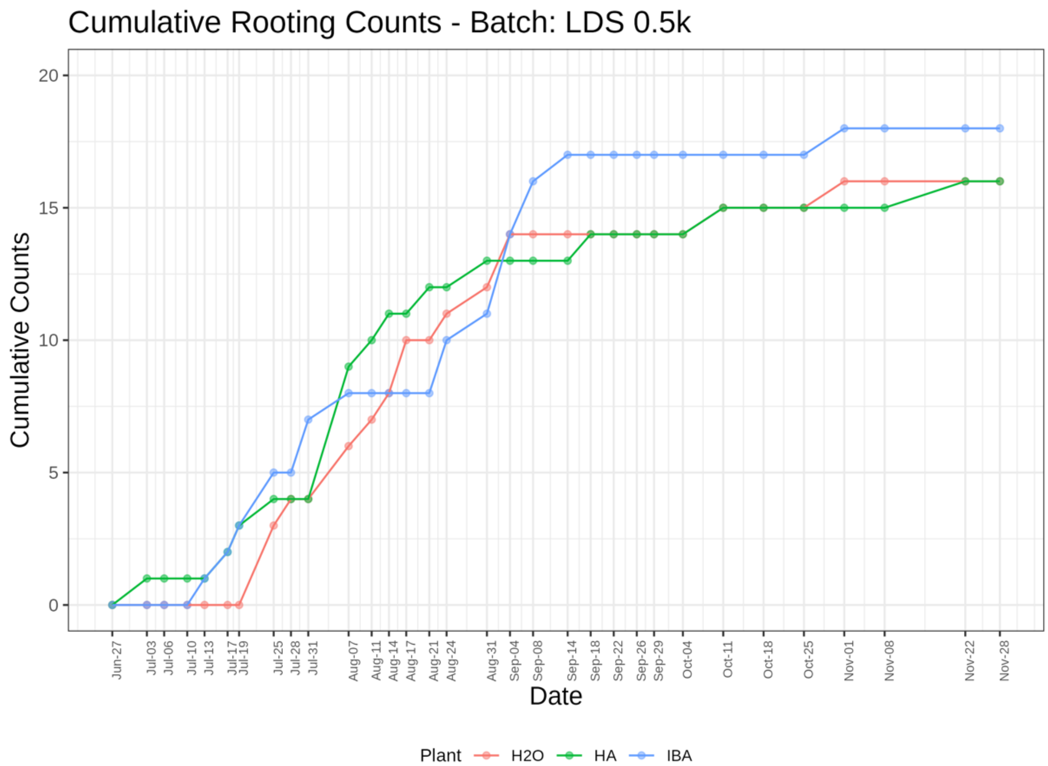


Figure 17: Plot of cumulative root counts for LDS 1.0 kg

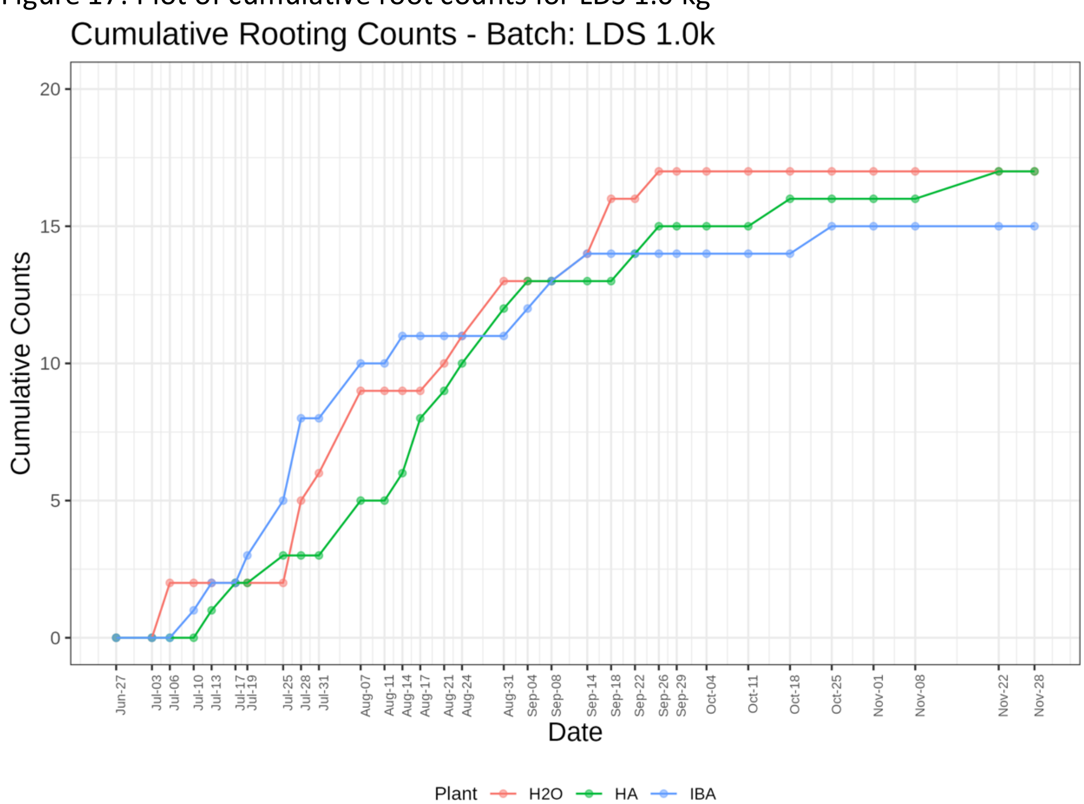


Figure 18: Plot of cumulative root counts for LDS 1.5 kg

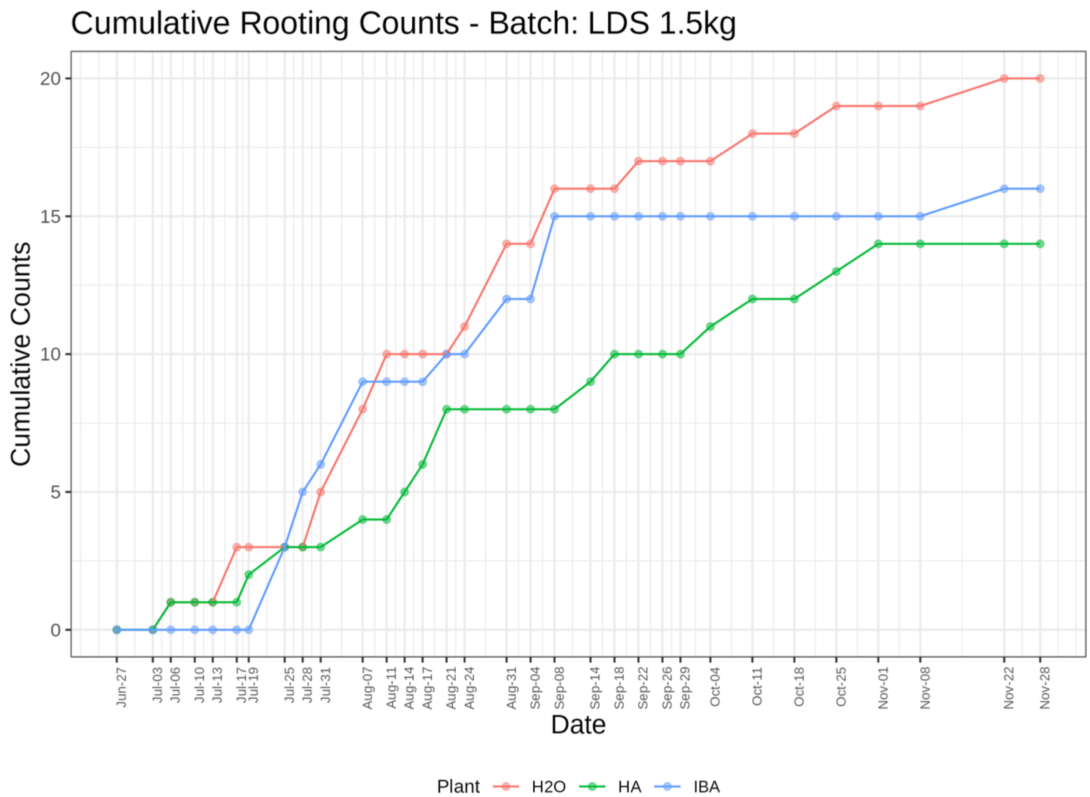


Figure 19: Plot of cumulative root counts for Control

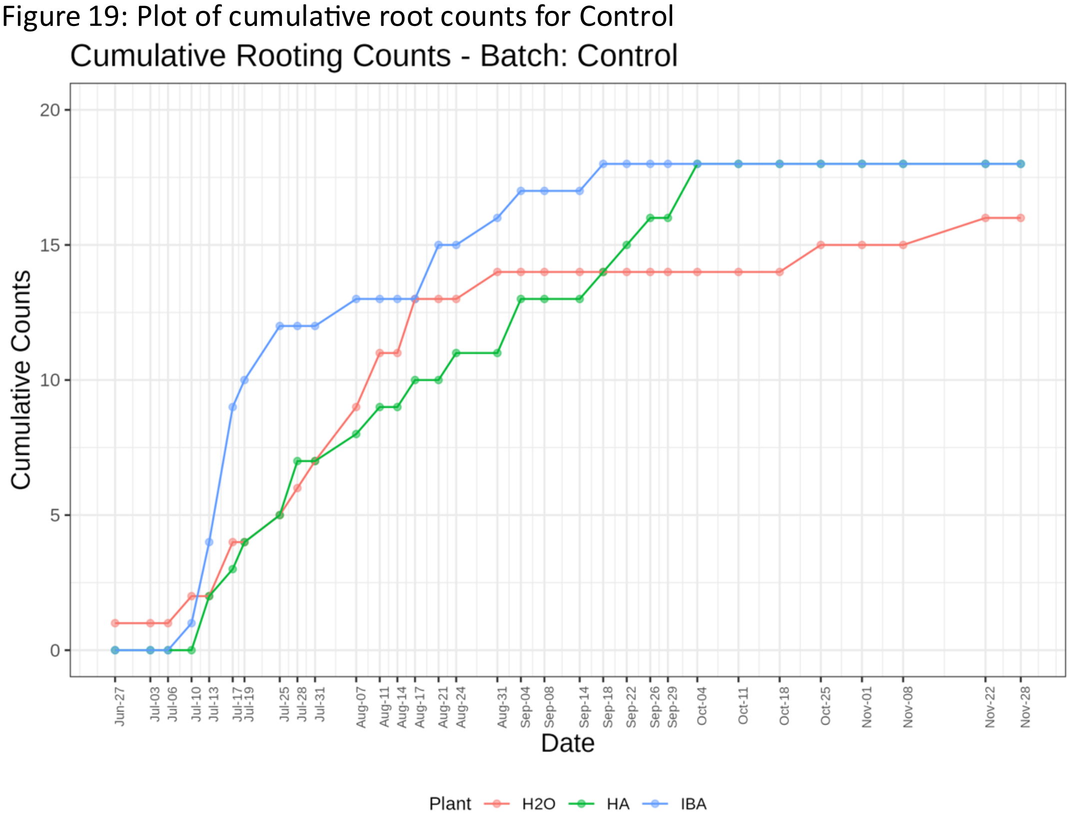


Figure 20: Plot of cumulative root counts for rooting method H_2O

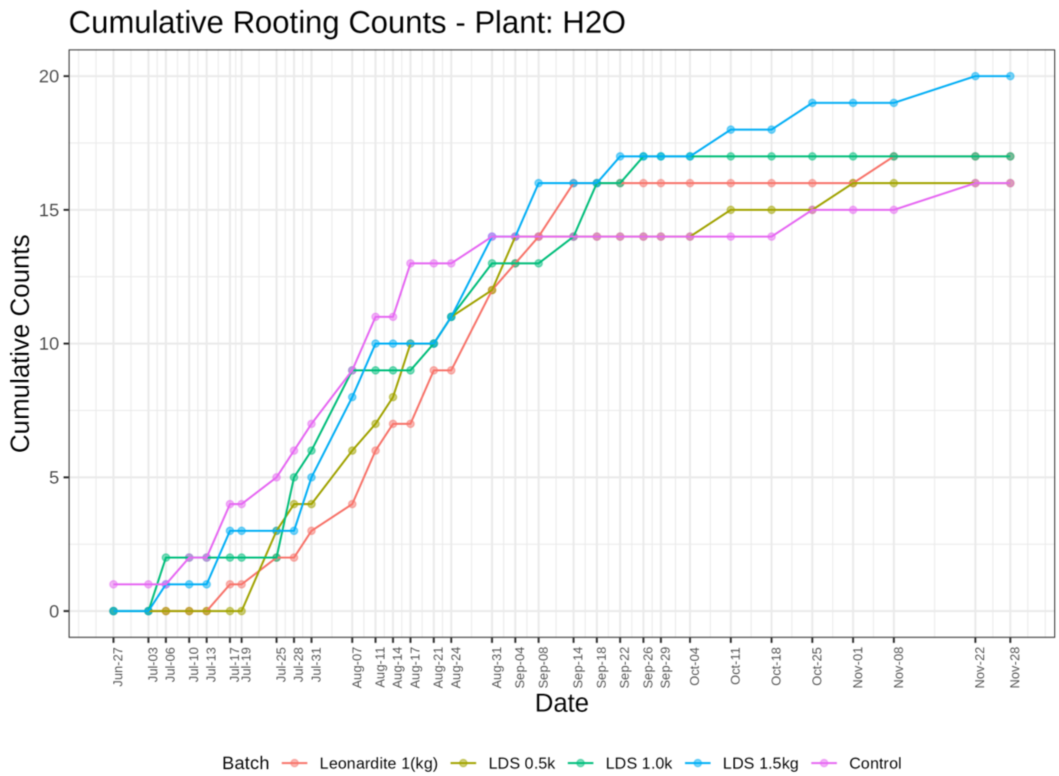


Figure 21: Plot of cumulative root counts for rooting method HA

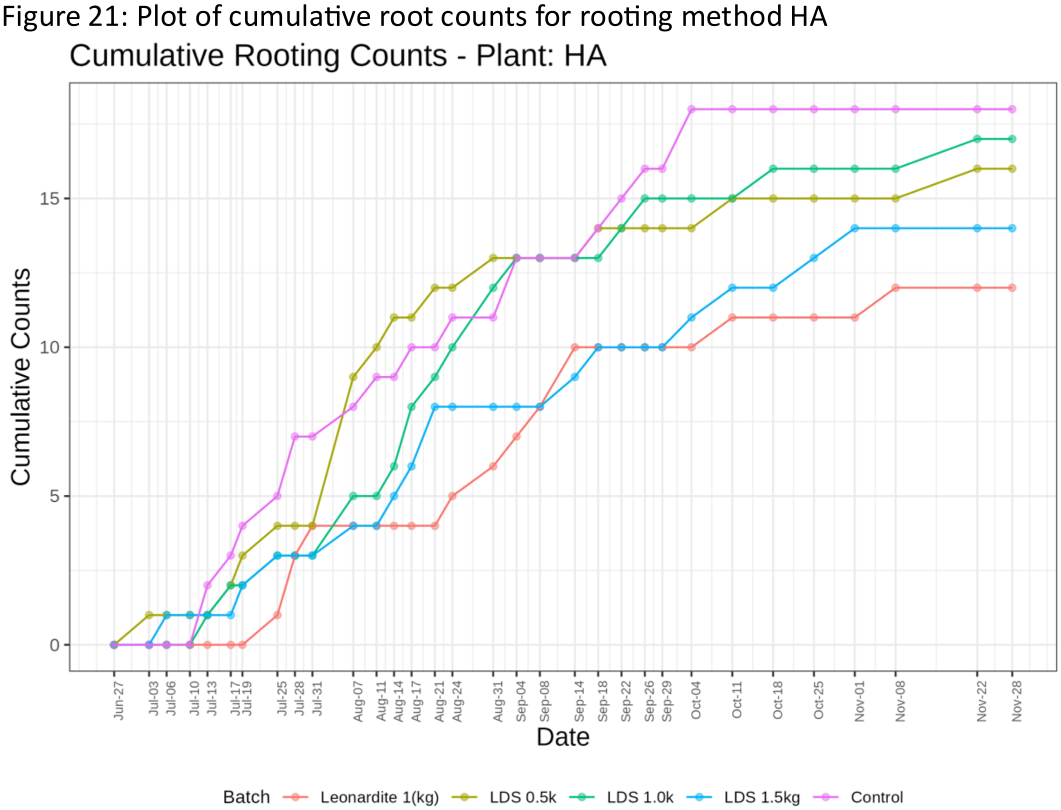


Figure 22: Plot of cumulative root counts for rooting method IBA