Project title:	Improving Quality and Extending the Season for Late UK Leeks
Project number:	FV 387b
Project leader:	David Norman, Precision Agronomy Ltd
Report:	Final report, 2015
Previous report:	Annual Report 2014 FV 387a
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Location of project:	Precision Agronomy, Mepal, ELY, Cambs
Industry Representative:	Patrick Allpress, Allpress Farms,
Date project commenced:	21st March 2014
Date project completed	30th November 2015

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The results and conclusions in this report are based on an investigation conducted over a two-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

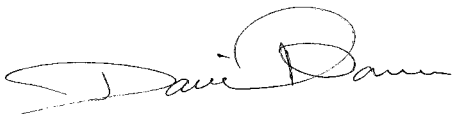
AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

David Norman

Managing Director

Precision Agronomy Ltd



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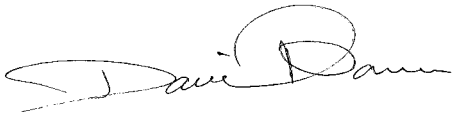
Precision Agronomy Ltd



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GROWER SUMMARY

Headline

Maleic hydrazide applied as the product Fazor, gave a highly significant reduction of bolting in late leeks produced under UK conditions in both years trials. This application technique has the potential to extend the production season of UK by 3-4 weeks, significantly reducing the dependence on leek imports, mainly from Spain, during May and June. In the second year of trials an earlier timing application of gibberellins gave a significant increase in stem length and yield whilst later or multiple applications were ineffective. Overall the effects of gibberellins were relatively inconsistent.

Background

The earlier project FV 387 examined the use of three different growth regulators on leeks applied during the autumn or in the spring. This project concluded that of the three products tested only maleic hydrazide was useful in reducing bolting and that when looking at timing spring applications were the most promising for reducing bolting without adverse crop effects, when compared with autumn applications.

In the follow-on project FV 387a maleic hydrazide was further evaluated using spring application timings only and showed great potential to reduce bolting in over-wintering leeks; however difficulties in the possible registration of maleic hydrazide for leeks led to this project being amended to include a single year's work on gibberellins. Year 2 of FV 387a therefore included looking at the effect of gibberellins on the growth, bolting and quality of UK late leeks, whilst also further examining the effects of maleic hydrazide. The results of gibberellin use were interesting and some treatments increased stem length, but because of variability within the plots there were inconsistencies and the results were not statistically significant.

The Leek Growers Association asked for more work to be done over two years to further evaluate the effects of gibberellins on stem extension in the shorter bold hardy winter leek types, whilst keeping a watching brief on the possible development of maleic hydrazide. This is a two year project extension looking at increased numbers of timings and more replicates over two seasons to investigate whether the stem extension effects can be proved more conclusively. Gibberellins are currently approved for use in two stem vegetables, rhubarb and celery to promote stem extension, but not in leeks.

Summary

Field trials were carried out over two growing seasons 2013-14 and 2014-15.

In the first season, 2014 harvest, two fields of leeks were used for the trials both of which were the variety Triton. The variety Triton F1 was chosen as it is one of the most winter hardy, and reliable leek varieties, but is also one of the shorter types and can usually only be harvested once there has been a considerable amount of spring re-growth, giving it a very short harvest window. Being able to achieve a longer stem length would open the harvest window considerably and give more reliable cropping at the end of the season. One site was with Nightlayer Leek Company, at Cottenham, near Cambridge and one was with Allpress Farms, near Chatteris.

At each site 9.7% a.i gibberellins as 0.35kg/ha product “Smartgrass” (gibberellins/GA3) were applied at each of the four timings as shown in Table 1. There were two treatments containing Fazor at 4.0kg/ha product (maleic hydrazide 60%) each of these was applied with or without a gibberellin treatment to test possible interactions. This resulted in 9 treatments including untreated controls to give 10 plots in total with three replicates within a fully randomised block design. Applications were made using an Azo precision plot sprayer with a 2M boom. Plot size was 2m by 6m, a water application volume of 400l/ha was used at each time.

Table 1. Treatments & Rates Applied

Treatments		**Hectare rates**	
	Product	**Rate ml/gm/ha**	**Water l/ha**
1	GA3 wk12	350	400
2	GA3 wk 12 & wk 14	350	400
3	GA3 wk14	350	400
4	GA 3 wk 14 & wk 16	350	400
5	GA3 wk 16	350	400
6	GA 3 wk 16 & wk 18	350	400
7	GA3 wk 12, 14, 16, & 18	350	400
8	GA3 wk 12 + Fazor wk 12	350 + 4000	400
9	Fazor wk 12	4000	400
10	Untreated		

The plots were harvested at the same time as the surrounding commercial crop, which for the Nightlayer site at Cottenham was 7th May 2014. The two centre rows of each plot were lifted by experienced leek harvest workers, the leeks were weighed, counted and 25 leeks from each plot were measured from base plate to first V (leaf break point) to give the plant height, they were then split in half and the length of the bolt stem was measured separately.

The Allpress farms site was unfortunately mistakenly destroyed just prior to the planned assessment time and so no data could be recorded, this site was successfully repeated along with the planned sites for 2015. So all the planned trials were eventually completed.

None of the treatments showed a significant effect on the leek yield, either as gross weight or as individual plant weight.

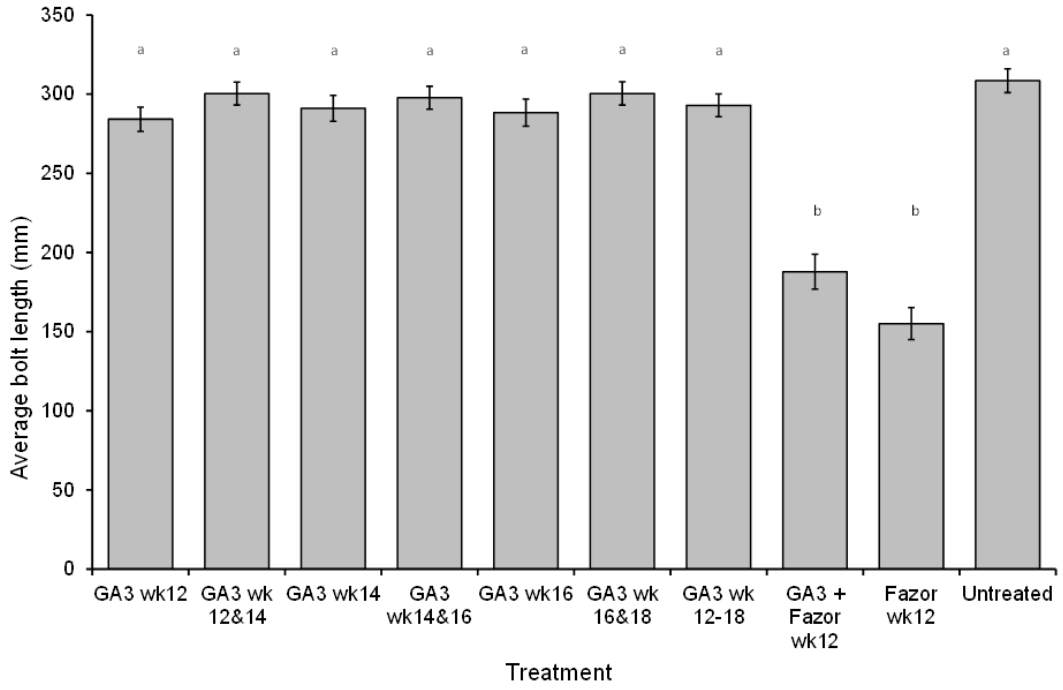


Figure 1: Treatments that contained Fazor gave a significant reduction in bolting length. So Fazor was very effective in reducing bolting either with or without the addition of gibberellin (treatments that share the same letter above the bar are not significantly different from each other)

When looking at the data on plant height, as measured by length to first V, there were no significant differences.

In the second season, 2015 harvest, three sites were used, one extra to replace the lost site from the 2013-14 season, which this time was successfully harvested. There was one site at Nightlayer Leek, at Cottenham, near Cambridge, and two at Allpress Farms at Upware.

At each site 9.7% a.i gibberellins as 0.35kg/ha product “Smartgrass” (gibberellins/GA3) were applied at each of four timings, the start times were two weeks earlier than in the 2013-14 trials, so applications were started in week 10, week beginning 2nd March and then repeated in weeks 12, 14 and week 16. Treatments are shown in Table 2. There were also two treatments containing Fazor at 4.0kg/ha product (maleic hydrazide 60%) each applied in week 12, which has been previously shown to be the best timing, each of these was applied plus or minus a gibberellin treatment to test possible interactions. This resulted in 9 treatments including untreated controls to give 10 plots in total with three replicates within a fully randomised block design. Applications were made using an Azo precision plot sprayer with a 2M boom. Plot size was 2M by 6M, a water application volume of 400l/ha was used at each time.

Table 2. Treatments & Rates Applied – All sites

Treatments		**Hectare rates**	
	Product	**Rate ml/gm/ha**	**Water l/ha**
1	GA3 wk10	350	400
2	GA3 wk 10 & wk 12	350	400
3	GA3 wk12	350	400
4	GA 3 wk 12 & wk 14	350	400
5	GA3 wk 14	350	400
6	GA 3 wk 14 & wk 16	350	400
7	GA3 wk 10, 12, 14, & 16	350	400
8	GA3 wk 12 + Fazor wk 12	350 + 4000	400
9	Fazor wk 12	4000	400
10	Untreated		

All sites were successfully harvested at the same time as the surrounding commercial crop.

Site one Nightlayer, Cottenham was harvested on the 22nd April 2015, Site two Allpress, Upware was harvested on the 24th April 2015 and site three Allpress, Upware was also harvested on 24th April 2015. The two centre rows of each plot were lifted by experienced leek harvest workers, the leeks were weighed, counted and 25 leeks from each plot were measured from base plate to first V (leaf break point) to give the plant height, they were then split in half and the length of the bolt stem was measured separately.

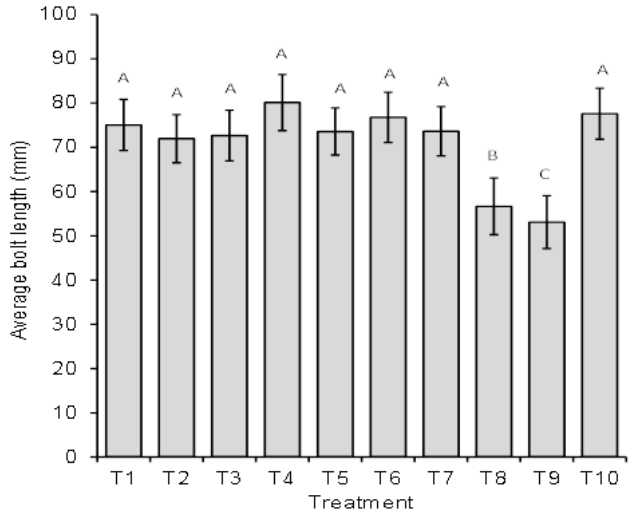


Figure 2. Mean bolt length per plant. Treatments containing Fazor (T8/T9) show significantly less bolting than treatments not containing Fazor or the untreated control (treatments which share the same letter are not significantly different from each other)

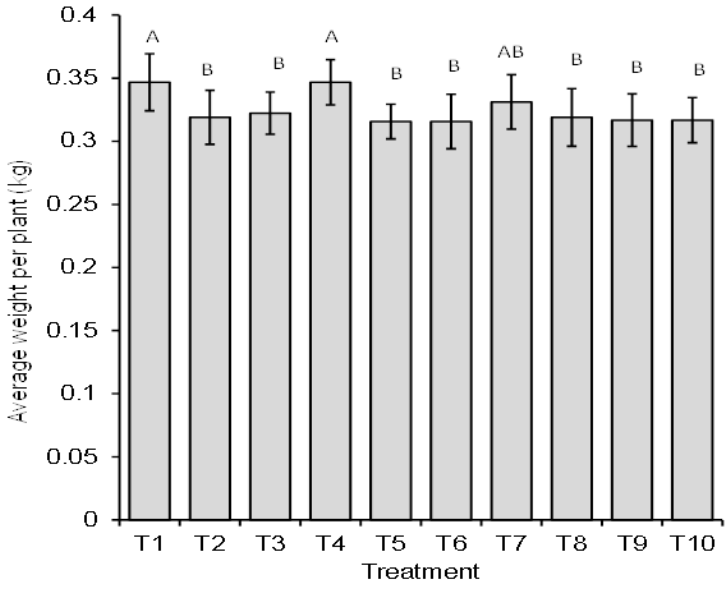


Figure 3. Average plant weight, T1 GA3 wk10 & T4 GA3 wk10+14 gave a heavier plant weight than the other treatments (treatments which share the same letter are not significantly different from each other)

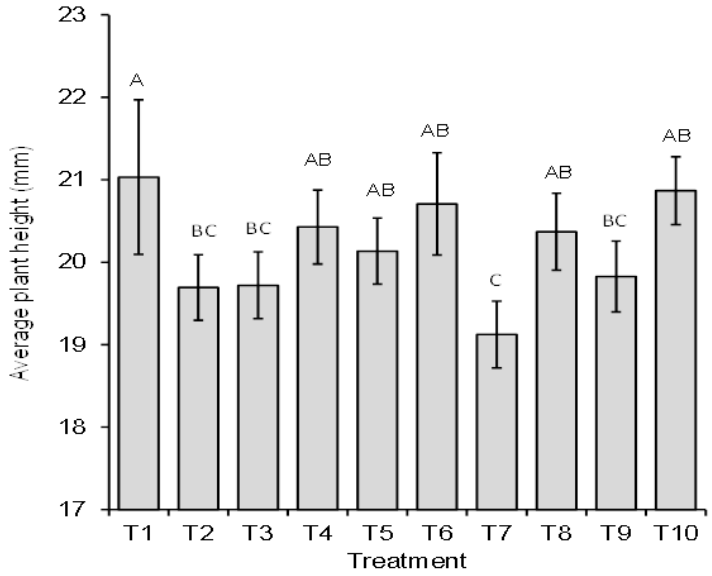


Figure 4. Average plant height. T1, GA3 wk10, the earliest timing of gibberellins gave the tallest plants (treatments which share the same letter are not significantly different from each other).

The effects of gibberellins on the increase of shank length were inconclusive in year one, with some variable results and interesting trends but no significant increase proven. In year two an earlier timing of application of gibberellins gave a significant increase in stem length and yield, whilst later timings or multiple applications were ineffective. Overall the effects of gibberellins, whilst interesting, appear too variable and without consistent trends for it to be taken forward as a possible commercial treatment.

Financial Benefits

Currently the UK supplies home grown leeks from around the 1st July until the end of April in the following year, cold storage can increase the length of supply by a few weeks into May.

Leek production in the post-Christmas period between January and May is unreliable because of the effects of severe frosty weather damaging leeks and the fact that the most frost tolerant varieties tend to have shorter stems which are lower yielding and less favoured by the market. Longer stemmed varieties, more favoured by the market tend to be more frost susceptible as well as being quicker to bolt.

Improving the quality and reliability of late leeks would reduce imports and allow more UK leeks to be grown.

Using this technique could extend the leek season by up to four weeks, potentially allowing yearlong supply of British leeks to consumers when used with the correct storage. Given

that the total value of leek production in the UK is currently worth £35,000,000 this could add a further £2-3,000,000 worth of production value to this figure.

Action Points

There are no immediate actions that growers can undertake however, the work has shown that:-

- Maleic hydrazide applied as Fazor at the correct timing reduces bolting in late leek crops
- Spring application has the best effect, around week 12 depending on conditions.
- Approval for maleic hydrazide should be pursued, with a possible collaboration with Belgium for a minor use.
- Results from gibberellins appear inconsistent.

SCIENCE SECTION

Introduction

Currently the UK supplies home grown leeks from early July until the end of April in the following year, with cold storage increasing the length of supply by a few weeks into May.

The main factor which stops field harvesting in late April/early May is the development of the seed head within the plant – bolting. If bolting could be reduced or controlled, UK leeks could potentially be marketed for an extra 3-4 weeks, reducing dependence imports and increasing UK late season production. Previous studies have looked into the effects of temperature, day length and transplanting on leek bolting (Weibe, 1994; Wurr *et al*, 1999) but to date, none have looked into the effects of applying growth regulators to reduce and delay the occurrence of bolting and none have looked at the effects of gibberellins on increasing the stem length of the more bolt resistant winter hardy leek types.

The total value of UK leek production is around £35,000,000 (source Defra hort. Stats 2013). Extending domestic production by 4 weeks could add £2.0-3.0 million gross output for UK leek growers and expand production from 1,800ha to 2,000ha.

In addition to season extension, the quality of late produced leeks could potentially be improved as the use of growth regulators have been shown to improve shelf life and storage quality when applied to other field crops (e.g. onions, carrots, parsnips and potatoes).

Growth regulators are currently used in UK onions to reduce sprouting, improve quality and shelf life, increasing the season of UK production. The same is also true of carrots and parsnips, increasing the season and improving product quality. Retailers have become mostly accepting of the use of growth regulators when used in a measured, limited time period and in a careful and responsible way.

The current range of crops, in which there is commercial use of growth regulators, do so to retain dormancy. The timing of application of growth regulators is therefore clearly at the point just before the onset of dormancy. Leeks are physiologically quite different from onions or carrots in that they are never truly physiologically dormant under UK growing conditions as they are field harvested green throughout the Winter and therefore the potential timing for the use of sprouting regulators under UK conditions is unclear and requires detailed investigation. The use of gibberellins on leeks to increase stem length has not been tested in the UK.

In the earlier project FV 387 three products were tested maleic hydrazide, mepiquat chloride and Trinexapac-ethyl. The first project demonstrated that maleic hydrazide was the best active tested, with regards to reducing bolting, however, timing was crucial, with spring applications performing better than autumn. A follow on project, FV387a was therefore designed to refine the timing of the spring application, test the rate of application and investigate whether this technique maybe integrated with storage and different varieties to provide the maximum benefit. Due to uncertainty regarding whether maleic hydrazide could be registered for use in the UK the project objectives in year two were amended to include some work on the application of gibberellins. Gibberellins promote stem extension in a range of crop and plant species, so we investigated whether they could be applied to winter hardy short stemmed leek varieties with a view to increasing stem length and making those leek varieties more attractive for the UK market. Short stemmed variety types have better winter hardiness than longer stemmed type and therefore could meet the project objective of season extension for UK leeks.

Materials and methods Year One

Methods

Two commercial crops of leeks both of variety Triton F1 were chosen for the experiments. The variety Triton F1 was chosen as it is one of the most winter hardy, and reliable leek varieties, but is also one of the shorter types and can usually only be harvested once there has been a considerable amount of spring re-growth, giving it a very short harvest window. Being able to achieve a longer stem length would open the harvest window considerably and give more reliable cropping at the end of the season.

Site One

Location: Nightlayer Leek Co Ltd, Fairview Farm, Cottenham, Cambs.

OS reference: TL 48083 71920.

Field Name: Fairview 1

Soil type: Organic loam

Drilling Date: May 7th 2013, variety Triton, seed rate 320,000/ha

Site Two

Location: Allpress Farms, Hollyhouse Farm, Horseway, Chatteris, Cambs.

OS reference: TL 46064 86916.

Field Name: Hollyhouse 58

Soil type: Peaty loam

Drilling Date: May 10th 2013, variety Triton, seed rate 333,000/ha

A standard commercial crop protection programme for weeds, pest and disease control was applied at each site and fertiliser was applied according to soil analysis. No irrigation was applied at either site.

At each site 9.7% a.i gibberellins as 0.35kg/ha product “Smartgrass” (gibberellins/GA3) were applied at each of the four timings as shown in Table 1. There were two treatments containing Fazor at 4.0kg/ha product (maleic hydrazide 60%) each plus or minus a gibberellin treatment to test possible interactions. This resulted in 9 treatments including untreated controls to give 10 plots in total with three replicates within a fully randomised block design, (see table Table 1a in Appendices) so 30 plots repeated on two sites to provide a good set of data for statistical analysis. Applications were carried out by Peter Hammond of Precision Agronomy using an Azo precision plot sprayer with a 2M boom. Plot size was 2M by 6M, a water application volume of 400l/ha was used at each time.

Treatment List

Table 1. Treatments & Rates Applied

Treatments		**Hectare rates**	
	Product	**Rate ml/gm/ha**	**Water l/ha**
1	GA3 wk12	350	400
2	GA3 wk 12 & wk 14	350	400
3	GA3 wk14	350	400
4	GA 3 wk 14 & wk 16	350	400
5	GA3 wk 16	350	400
6	GA 3 wk 16 & wk 18	350	400
7	GA3 wk 12, 14, 16, & 18	350	400
8	GA3 wk 12 + Fazor wk 12	350 + 4000	400
9	Fazor wk 12	4000	400
10	Untreated		

Table 2. Application Timing Site One, Fairview Farm.

	T1	T2	T3	T4
Operator	P Hammond	P Hammond	P Hammond	P Hammond
Date	17/03/2014	31/03/2014	15/04/2014	28/04/2014
Time	1150 – 1224	1000-1010	1000-1010	0915-0920
Temp	12	13	7	10
Wind Speed	12	7	6	2
Wind direction	E	NW	SW	S
Cloud cover	60%	Mist/haze	60%	100%

Table 3. Application Timings Site Two, Hollyhouse Farm.

	T1	T2	T3	T4
Operator	P Hammond	P Hammond	P Hammond	Not applied due to crop destruction
Date	17/03/2014	31/03/2014	15/04/2014	
Time	1330 - 1400	1115-1125	1100-1115	
Temp	13	13	9	
Wind Speed	13	7	7	
Wind direction	E	NW	SW	
Cloud cover	60%	75% High & wispy	40%	

Harvest Assessments (Fairview site only)

The plots were harvested at the normal crop maturity time for the surrounding commercial crop on the 7th May 2014. The two centre rows of each plot were lifted by experienced leek harvest workers, the leeks were bulk weighed and counted to give mean leek weight and yield. 25 leeks from each plot were measured for length from base plate to first V (leaf break point), giving 75 measurements per treatment. The same amount of leeks per plot were then cut open and measured for bolting length. There were no visible differences in flag quality at harvest between the treated and untreated leeks.

Harvest Assessment – Hollyhouse site

Unfortunately when we came to do the harvest assessments at the Hollyhouse site the trial plots had been mistakenly destroyed by cultivation just hours before. This is despite the plots being well marked, this was apparently due to a communication error. There is therefore no harvest data for this site. This trial site was be repeated in the spring of 2015 to replace the lost data.

Statistical analyses.

The effects of treatment on plant height and bolt length were analysed using a generalised linear mixed model (GLMM) with a gamma distribution and a log link function. For both models treatment nested within replicate was used as a random factor. Yield data were

analysed by taking the average plant weight per bag for each plot in each site. These data were then analysed using a GLMM with a negative binomial distribution and a log link function. In all models, non-significant terms were removed in a step-wise manner to give minimum adequate models. Post-hoc pairwise comparisons of treatments used the sequential Bonferroni method to control for multiple comparisons. All statistics were performed in SPSS (v.21 SPSS Inc., Chicago, IL, U.S.A.).

Results

Yield data were analysed by taking the average plant weight per bag for each plot in each site. These data were then analysed using a GLMM with a negative binomial distribution and a log link function. In all models, non-significant terms were removed in a step-wise manner to give minimum adequate models. None of the treatments showed a significant effect on gross yield or individual leek weight.

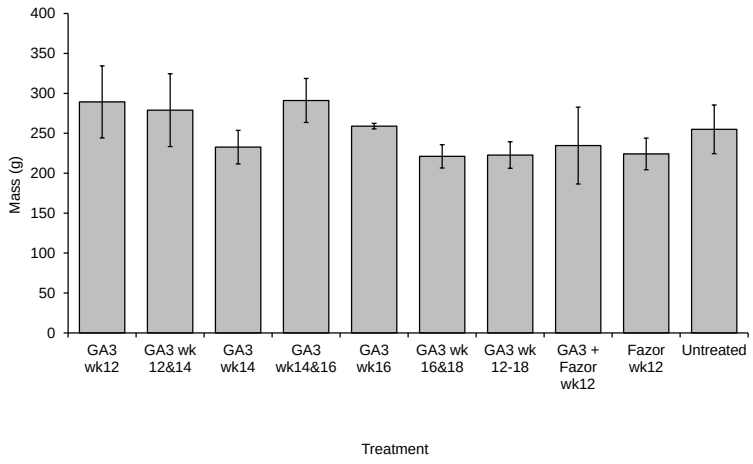


Figure 1. Mean individual leek weight +- standard error

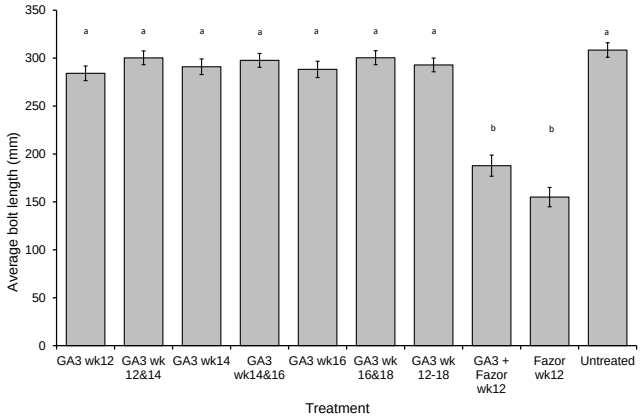


Figure 2. The mean ± standard error of bolt length per plant for each of the 10 treatments. Letters above each bar represent significant pairwise comparisons. Treatments containing Fazor showed a significant relationship with bolt length ($F_{9, 738}$ = 9.56, P<0.001; figure 2). All non-Fazor treatments showed significantly longer bolt lengths than treatments 8 and 9 (8: GA3 + Fazor application at week 12, 9: Fazor only application at week 12); (P < 0.003 for all pairwise comparisons). Fazor was therefore very effective in reducing the amount of bolting, when applied on its own or with a gibberellin treatment (treatments which share the same letter are not significantly different from each other)

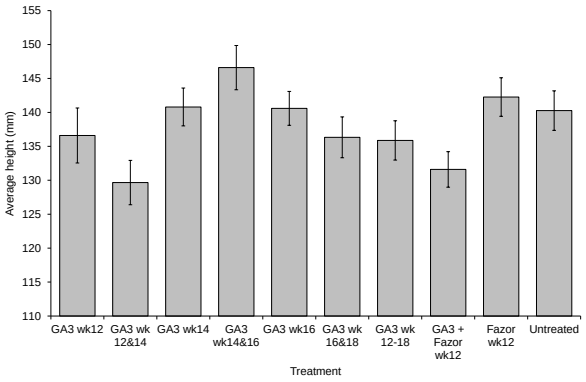


Figure 3. Plant height as length from base plate to first V. There was no significant effect of treatment on plant height ($F_{9, 711}$ = 0.001, P = 1.00; figure 3). Although treatments on week14+16 produced the longest leek this result was not statistically significant.

Materials and methods Year Two

Methods

Three commercial field crops of leeks were chosen, two of the variety Triton F1 and one of the variety Lexton, to represent a taller type for the experiments.

Site One

Location: Nightlayer Leek Co Ltd, Fairview Farm, Cottenham, Cambs.

OS reference: TL 48083 71920.

Field Name: Fairview 6

Soil type: Organic loam

Drilling Date: May 11th 2014, variety Triton, seed rate 320,000/ha

Site Two

Location: Allpress Farms, Hubbersteds Farm, Upware, Cambs.

OS reference: TL 54230 68179.

Field Name: Hubbersteds 74

Soil type: Peaty loam

Drilling Date: May 15th 2014, variety Triton, seed rate 333,000/ha

Site Three

Location: Allpress Farms, Hubbersteds Farm, Upware, Cambs.

OS reference: TL 55054 68443.

Field Name: Hubbersteds 65

Soil type: Peaty loam

Drilling Date: May 12th 2014, variety Lexton, seed rate 333,000/ha

A standard commercial crop protection programme for weeds, pest and disease control was applied at each site and fertiliser was applied according to soil analysis. No irrigation was applied at any site.

At each site 9.7% a.i gibberellins as 0.35kg/ha product “Smartgrass” (gibberellins/GA3) were applied at each of the four timings, the start times were two weeks earlier than in the 2014 trials, so applications were started in week 10, week beginning 2nd March and then repeated in weeks 12, 14 and week 16. Treatments are shown in Table 4. There were also two treatments containing Fazor at 4.0kg/ha product (maleic hydrazide 60%) each applied in week 12, which has been previously shown to be the best timing, each of these was applied plus or minus a gibberellin treatment to test possible interactions. This resulted in 9 treatments including untreated controls to give 10 plots in total with three replicates within a fully randomised block design, (see table 1b Appendices) so 30 plots repeated on three sites to provide a good set of data for statistical analysis. Applications were carried out by Peter Hammond of Precision Agronomy using an Azo precision plot sprayer with a 2M boom. Plot size was 2M by 6M, a water application volume of 400l/ha was used at each time.

Table 4. Treatments & Rates Applied – All sites

Treatments		Hectare rates	
	Product	**Rate ml/gm/ha**	**Water l/ha**
1	GA3 wk10	350	400
2	GA3 wk 10 & wk 12	350	400
3	GA3 wk12	350	400
4	GA 3 wk 12 & wk 14	350	400
5	GA3 wk 14	350	400
6	GA 3 wk 14 & wk 16	350	400
7	GA3 wk 10, 12, 14, & 16	350	400
8	GA3 wk 12 + Fazor wk 12	350 + 4000	400
9	Fazor wk 12	4000	400
10	Untreated		

Table 5. Application Timing Site One, Fairview Farm.

	T1	**T2**	**T3**	**T4**
Operator	P Hammond	P Hammond	P Hammond	P Hammond
Date	05/03/2015	19/03/2015	30/03/2015	10/04/2015
Time	1430-1440	1353-1414	1027-1035	0944-0949
Temp	9	7	8	10
Wind Speed	14	12	17	8
Wind direction	E	NE	NW	SE
Cloud cover	70%	100%	60%	0%

Table 6. Application Timings Site Two, Hubbersted Farm Hub 74.

	T1	**T2**	**T3**	**T4**
Operator	P Hammond	P Hammond	P Hammond	P Hammond
Date	06/03/2015	19/03/2015	30/03/2015	10/04/2015
Time	1337-1349	1244-1307	1159-1209	1055-1100
Temp	8	7	8	13
Wind Speed	16	13	15	9
Wind direction	NE	NE	NW	SE
Cloud cover	0%	100%	90%	5%

Table 7. Application Timings Site Three, Hubbersted Farm Hub 65.

	T1	T2	T3	T4
Operator	P Hammond	P Hammond	P Hammond	P Hammond
Date	06/03/2015	19/03/2015	30/03/2015	10/04/2015
Time	1225-1235	1210-1224	1110-1119	1027-1032
Temp	8	7	8	13
Wind Speed	16	13	15	9
Wind direction	NE	NE	NW	SE
Cloud cover	30%	100%	80%	10%

Harvest Assessments

All sites were successfully harvested at the normal harvest time, including the trial being repeated from 2014 due to being destroyed prior to harvest. Site one, Fairview Farm 6 was harvested on the 22nd April 2015, site two on Hubbersteds farm 74 was harvested on the 24th April 2015, site three Hubbersteds farm 65 was harvested on the 24th April 2015.

The two centre rows of each plot were lifted by experienced leek harvest workers, the leeks were bulk weighed and counted to give mean leek weight and yield. 25 leeks from each plot were measured for length from base plate to first V (leaf break point), giving 75 measurements per treatment. The same amount of leeks per plot were then cut open and measured for bolting length. There were no visible differences in flag quality at harvest between the treated and untreated leeks.

Statistical analyses.

Plant height and bolt length data were analysed using a generalised linear mixed model (GLMM) with a gamma distribution and log link function. Yield data were analysed by taking the average weight of plants measured for each plot at each site. These data were analysed using a GLMM with a guassian distribution and an identity link. Replicate nested within site was included as a random factor in all three models. For each model, non-significant terms were removed in a step-wise manner to give minimum adequate models. Post-hoc pairwise comparisons of treatments used the least significant difference method to control for multiple comparisons. All statistics were performed in SPSS (v.21 SPSS Inc., Chicago, IL, U.S.A.).

Results

Treatments with Fazor showed a highly significant effect on bolt length ($F_{9,2240}$ = 31.8; P < 0.001; Fig. 4). Both treatments including Fazor, either as a combined treatment with GA3 at week 12 (treatment 8) or single treatment of Fazor at week 12 (treatment 9) gave the shortest bolt length compared to all other treatments (P<0.01 for all pairwise comparisons), however treatment 9 (Fazor only) still gave a marginally shorter bolt length compared to the combined Fazor and GA3 of treatment 8 (P = 0.045 for pairwise comparisons)

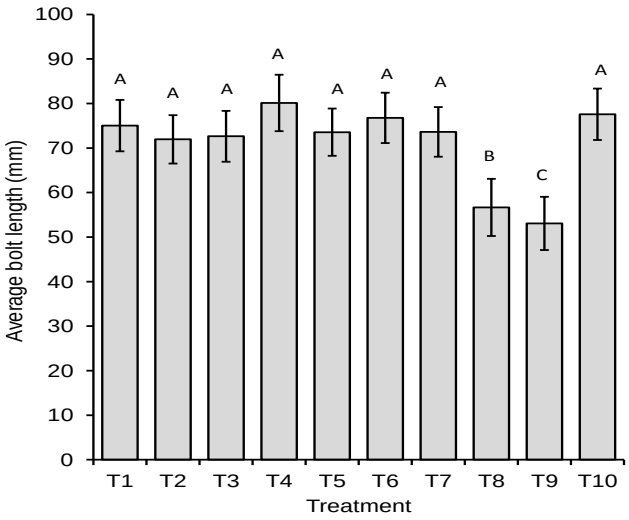


Figure 4. Mean bolt length ± standard error per plant. Treatments varied in application timing and/or composition of either GA3 or Fazor. Treatment 10 represents the untreated control. Different letters above the bars represent significant pairwise comparisons between treatments (P < 0.05) (treatments which share the same letter are not significantly different from each other)

Gibberellin treatment also showed a significant effect on plant height ($F_{9,2240}$ = 2.48; P = 0.008; Fig. 2), with treatment 1 (GA3 applied at week 10) giving the tallest plants. Treatments 4 (GA3 wk12&14), 5 (GA3 wk14), 6 (GA3 wk 14&16), 8 (GA3 + Fazor wk12) and 10 (the untreated control), however, showed no significant difference from treatment 1 with respect to plant height. Treatment 7 (GA3 wk 10&12&14&16) gave the shortest plants, significantly shorter than almost all other treatments, including the untreated control.

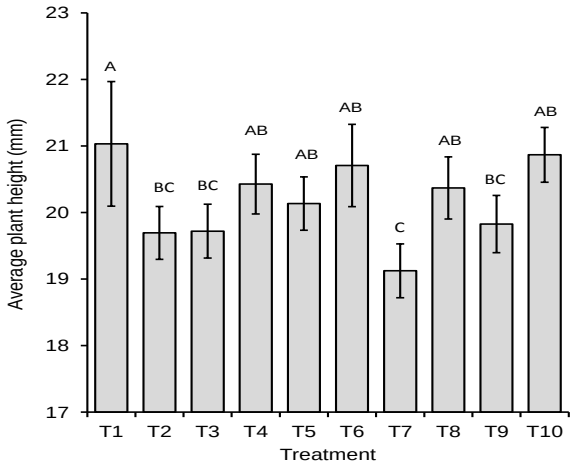


Figure 5. Average plant height ± standard error per plant. Treatments varied in application timing and/or composition of either GA3 or Fazor. Treatment 10 represents the untreated control. Different letters above the bars represent significant pairwise comparisons between treatments ($P < 0.05$) (treatments which share the same letter are not significantly different from each other)

Gibberellin treatment also showed a significant effect on yield ($F_{9,80} = 2.35$; $P = 0.021$; Fig 3), with treatments 1 (GA3 applied at week 10) and 4 (GA3 wk12&14) giving the highest yields. All other treatments (2, 3, 5, 6, 7, 8, 9 and the untreated control 10) gave very similar yields, significantly less than treatments 1 and 4.

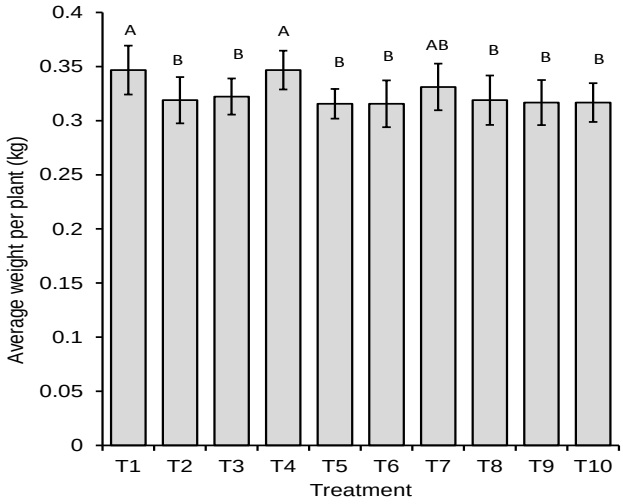


Figure 6. Average weight per plant ± standard error of a known number of plants bulk weighed per plot per site. Treatments varied in application timing and/or composition of either GA3 or Fazor. Treatment 10 represents the untreated control. Different letters above the bars represent significant pairwise comparisons between treatments ($P < 0.05$) (treatments which share the same letter are not significantly different from each other)

Discussion

With regards to yield it is somewhat encouraging that there was no reduction in yield caused by any of the treatments, either containing maleic hydrazide or gibberellins or combinations of both, as this means none of the treatments had a negative effect on the crop in either year of trials or at any site.

Looking at the results for bolting, over both years and at all the 4 sites the applications of Fazor in 12 week gave a highly significant reduction in bolting. The winter and spring of 2014 were especially mild with few frosts recorded and the warm spring weather meant that many commercial leek crops were running to seed (bolting) very quickly, any technique to slow down bolting would increase the harvest window and would have meant that more leeks would have made a marketable grade. In fact many commercial crop were lost to bolting and had to be destroyed rather than being harvested (the factor that lead to the loss of one trial site!). In 2015 although it was a much colder spring, there was still some bolting evident in the crop and the application of Fazor still gave a significant bolt reduction.

There was a concern that gibberellins would make bolting happen more quickly but this did not appear to be the case in all these trials as the bolt length in the treated plots was very consistent at between 250-300mm where Fazor had not been applied. Where Fazor was applied together with gibberellins, as in treatment 8, there was still a significant bolt reduction. There was also therefore no negative interaction between maleic hydrazide and gibberellins in any of the trials over both years.

With regards to plant stem length measured as the length between the base plate and first V, there were no differences between treatments in 2014, there was quite a large variation in plant length at this site at Nightlayer Leeks, Cottenham, as is typical with this type of leek and with only a single site to harvest the data set was fairly small. In 2015 we ran three sites and started the gibberellin treatments 2 weeks earlier. We gained a better, larger data set, the 2015 data set was analysed as a whole, including all 3 of the 2015 sites together and overall, treatment 1, the earlier treatment timing, produced a significantly longer leek when using pair wise comparison to all the other treatments over all the sites. However, this treatment 1 did not produce a significantly longer leek than the untreated control. There was also no real consistent trend in the data for stem length increase with gibberellin application in the same way there was for maleic hydrazide application with bolting reduction. However, the stem length increase recorded did also give treatment 1 an increase in yield over the untreated and all the other treatments apart from treatment 7, which was 4 applications of gibberellins including the earlier timing. It is not clear why multiple treatments of

gibberellins, do not increase the elongation effects, in fact the trend is the opposite, in that the greatest number of application timings, treatment 7 actually produced the shortest leeks. It would seem that one well timed treatment would possibly have a better effect than a number of sequential treatments.

Conclusions

Fazor (maleic hydrazide) applied at around week 12 (mid-March), gave a significant reduction in bolting of leeks, whilst having no effect on yield or plant stem height as measured to the first V. It would appear that gibberellins applied in week 10 (early-March) can give an increase in plant stem length and yield, although there is some variation in site effect and the effects of gibberellins are rather inconsistent, without showing an obvious trend. Gibberellins applied after this time do not have an effect on length or yield and multiple applications may have a negative effect. It is not known what the effects might be of even earlier application, or even an autumn application as these were not tried.

Knowledge and Technology Transfer

The results of this project will be presented to the leek growers' association technical group 2016 spring meeting.

Glossary

Bolting

The appearance of a flower stalk in the centre of the plant, this particularly occurs with biennial plants such as alliums in the second season of growth.

Softness

A good quality leek should have a firm straight shank, a soft or flabby shank is unacceptable

Telescoping

Re-growth of the leaf sheath tops after trimming causing the tops of the leek to form a pyramid shape rather than be flat.

First V

The first leaf break from the shank.

Stem length

Being a measurement from the base plate to first V.

References

The use of Fazor in potatoes: Dow Agrosciences (2009) http://www.dowagro.com/uk/media/potato/20090819.htm <date accessed: 14-07-2011>

Dow AgroSciences Fazor label. http://msdssearch.dow.com/PublishedLiteratureDAS/dh_04fd/0901b803804fd696.pdf?filepath=/uk/pdfs/noreg/011-01286.pdf&fromPage=GetDoc <date accessed: 14-07-2011>

Weibe, J.H. (1994) Effects of temperature and daylength on bolting of leek (Allium porrum L.) Scientia Horticulturae 59:177-185

Wurr, D., Fellows, J.R., Hambidge, A.J. & Fuller, M.P (1999) Growth, development and bolting of early leeks in the UK. *The Journal of Horticultural Science & Biotechnology* **74**:140-146.

DEFRA Basic Hort Stats

https://www.gov.uk/government/publications/basic-horticultural-statistics

Appendices

Year One Trial Data

Table 1a. Plot layout Year One (both sites)

5	10	7	9	4	1	3	2	8	6	
6	4	8	1	10	2	9	5	7	3	
1	2	3	4	5	6	7	8	9	10	2m
									6m	

Table 2a. Measured length to first V and bolt length (mm) Rep 1, Site 1

Rep 1	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
plant	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	105	280	105	280	135	350	135	320	150	270	125	320	120	280	135	130	145	250	155	270
2	80	360	100	350	115	350	125	260	140	310	135	300	130	165	120	120	120	120	150	340
3	105	300	100	240	135	200	130	270	140	300	120	300	130	320	125	300	120	175	150	270
4	110	340	115	280	155	240	120	340	170	320	105	240	110	240	125	180	95	130	140	330
5	100	240	125	350	130	340	110	320	125	190	110	190	130	270	100	230	120	140	140	330
6	100	340	90	350	120	250	170	190	145	240	105	200	155	310	110	125	110	130	110	225
7	90	260	70	350	100	350	140	310	110	170	140	270	125	280	175	155	110	220	130	290
8	90	220	100	350	195	350	170	250	120	40	140	340	125	340	160	165	110	260	100	340
9	100	300	120	350	170	350	165	240	120	200	120	320	120	280	110	120	110	80	110	310
10	110	420	95	240	180	120	170	260	130	340	150	330	130	300	155	120	130	50	135	210
11	125	190	90	320	165	320	125	350	125	290	110	210	105	260	105	210	115	180	130	350
12	170	350	80	350	145	260	150	350	145	140	115	260	115	230	120	215	115	250	120	350
13	95	220	100	350	160	350	100	350	140	300	145	290	115	310	150	280	130	160	160	350
14	95	220	125	270	160	90	165	350	140	320	140	350	130	290	100	100	120	145	130	350
15	105	240	110	260	130	350	135	350	125	240	140	350	130	250	120	210	110	310	150	350
16	100	280	115	230	100	350	115	350	110	270	215	350	120	350	145	260	165	350	120	350
17	90	280	125	280	135	350	220	350	155	130	130	350	115	350	110	100	155	170	130	350
18	105	270	105	350	140	350	170	350	160	300	130	350	115	350	150	250	155	90	150	350
19	90	220	115	350	160	350	170	350	125	350	135	350	100	350	145	190	130	270	145	350
20	100	350	125	350	155	350	130	350	165	350	100	350	155	350	145	60	100	60	120	350
21	110	300	90	325	130	210	125	350	105	350	100	350	135	350	125	190	130	140	130	350
22	115	200	155	150	140	350	140	350	155	350	120	350	155	350	135	145	150	50	115	350
23	90	200	120	260	160	280	190	350	155	350	145	350	120	350	110	350	135	70	120	350
24	90	320	85	220	175	180	125	350	165	350	150	350	120	350	145	350	135	20	125	350
25	85	350	120	310	135	330	140	350	150	350	125	350	135	350	145	350	120	80	155	350
Total	2555	7050	2680	7515	3625	7370	3635	8010	3470	6820	3250	7770	3140	7625	3265	4905	3135	3900	3320	8165
Average	102	282	107	301	145	295	145	320	139	273	130	311	126	305	131	196	125	156	133	327

Table 3a. Measured length to first V and bolt length (mm) Rep 2, Site 1

Rep 2	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	130	300	140	260	140	270	120	230	140	270	140	155	135	260	155	290	140	130	140	220
2	155	190	80	190	120	280	140	190	165	310	175	330	110	275	125	320	140	180	170	270
3	200	290	150	190	175	330	145	220	105	200	145	240	130	170	120	270	190	165	150	190
4	220	250	150	250	175	235	175	340	170	220	125	290	130	300	160	210	150	230	120	300
5	180	250	145	340	130	300	220	180	150	290	235	220	180	180	120	330	140	100	180	220
6	190	215	120	320	120	310	185	330	145	300	180	200	120	120	160	250	160	110	230	300
7	110	300	110	300	150	250	145	240	150	230	140	320	170	310	155	120	165	50	220	245
8	120	195	140	340	140	285	110	120	125	330	185	300	140	250	180	180	185	270	120	170
9	160	220	140	330	145	250	105	245	170	330	130	260	120	210	115	240	130	250	150	165
10	175	260	130	130	145	225	135	200	95	330	130	325	110	170	160	290	145	320	180	290
11	140	310	110	170	130	160	140	310	145	330	155	320	155	220	170	175	180	250	130	26
12	165	310	130	200	145	350	120	350	140	240	140	340	130	280	130	340	145	240	135	300
13	160	260	105	240	150	350	115	350	110	330	140	200	140	330	150	170	150	170	125	330
14	120	320	100	350	110	350	140	350	145	220	125	270	90	230	120	340	155	345	130	220
15	155	250	150	350	160	350	140	350	135	290	140	350	130	340	110	220	130	210	170	110
16	150	350	145	350	120	350	120	350	150	180	100	350	110	320	130	250	145	210	140	350
17	200	350	165	350	125	350	150	350	160	340	120	350	130	350	160	300	145	50	185	350
18	160	350	170	350	120	350	125	350	100	350	130	350	120	350	160	260	220	40	130	350
19	140	350	155	350	175	350	125	350	140	350	140	350	120	350	150	190	160	230	180	350
20	120	350	150	350	150	350	145	350	100	350	150	350	105	350	130	250	195	165	140	350
21	180	350	130	350	170	350	145	350	110	350	120	350	160	350	110	180	210	210	145	350
22	160	350	150	350	195	350	115	350	150	350	150	350	155	350	140	130	110	130	110	350
23	175	350	150	350	105	350	165	350	135	350	135	350	160	350	105	350	170	100	155	350
24	190	350	140	350	135	350	140	350	130	350	110	350	145	350	130	350	145	120	100	350
25	125	350	130	350	125	350	200	350	145	350	175	350	175	350	120	350	140	160	140	350
Total	3980	7420	3385	7460	3555	7795	3565	7505	3410	7540	3615	7620	3370	7115	3465	6355	3945	4435	3775	6856
Average	159	297	135	298	142	312	143	300	136	302	145	305	135	285	139	254	158	177	151	274

Table 4a. Measured length to first V and bolt length (mm) Rep 3, Site 1

Rep 3	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	105	300	180	170	145	200	140	250	155	280	80	150	255	220	120	145	150	150	140	325
2	155	330	135	300	155	220	150	230	130	260	120	180	130	300	110	160	145	30	95	330
3	130	200	150	330	105	280	130	345	155	220	120	250	150	260	130	170	155	90	125	265
4	140	220	95	155	130	180	135	200	170	125	130	280	135	330	135	90	140	85	170	230
5	105	300	130	270	155	290	110	250	100	160	180	320	120	305	170	60	190	235	90	280
6	175	100	140	165	145	170	135	230	190	330	125	190	140	170	130	30	165	210	130	340
7	150	210	130	290	120	270	110	230	185	330	135	230	120	260	140	60	145	110	120	300
8	145	225	135	310	140	240	190	260	160	300	155	230	140	320	135	80	140	170	130	210
9	145	265	140	300	125	340	135	240	110	285	160	240	175	310	195	120	120	90	110	280
10	150	190	195	320	130	240	180	200	130	100	180	320	125	290	80	190	130	120	135	300
11	170	110	130	230	180	250	130	300	160	210	100	120	185	190	110	50	145	220	155	350
12	150	220	170	270	145	195	180	230	190	190	120	220	140	160	115	55	130	110	130	350
13	130	280	135	295	135	140	165	180	160	340	120	220	135	240	120	80	165	60	130	350
14	110	180	120	290	125	210	120	200	125	280	130	340	165	210	125	105	150	115	150	350
15	155	210	125	350	100	210	140	290	120	350	150	350	130	250	125	110	135	155	170	350
16	210	350	190	350	110	220	120	245	120	350	105	350	120	260	100	40	145	80	155	350
17	120	350	100	350	210	200	160	250	150	350	135	350	110	350	100	40	130	90	120	350
18	180	350	160	350	120	350	225	230	150	350	130	350	170	350	150	50	160	20	150	350
19	140	350	150	350	170	350	150	350	160	350	140	350	140	350	155	130	150	225	145	350
20	160	350	165	350	140	350	205	350	145	350	160	350	130	350	100	270	155	40	150	350
21	145	350	175	350	115	350	180	350	140	350	100	350	120	350	100	180	130	70	135	350
22	120	350	195	350	145	350	150	350	120	350	120	350	170	350	110	300	110	10	185	350
23	150	350	110	350	100	350	160	350	145	350	145	350	170	350	115	190	110	105	120	350
24	210	350	125	350	110	350	135	350	150	350	160	350	130	350	150	90	150	350	140	350
25	160	350	180	350	125	350	160	350	145	350	160	350	175	350	120	30	145	350	145	350
Total	3710	6840	3660	7545	3380	6655	3795	6810	3665	7260	3360	7140	3680	7225	3140	2825	3590	3290	3425	8110
Average	148	274	146	302	135	266	152	272	147	290	134	286	147	289	126	113	144	132	137	324

Table 5a. Measured length to first V and bolt length (mm) Replicate Means and Standard Errors. Site one

Plot	Treatment	V length	Mean	Bolt	mean	std err bolt length	std err plant height
1	GA3 wk12	10245	136.6	21310	284.1333	7.672563341	4.053871467
2	GA3 wk 12&14	9725	129.6666667	22520	300.2667	7.217279898	3.267824763
3	GA3 wk14	10560	140.8	21820	290.9333	8.142145573	2.793235071
4	GA3 wk14&16	10995	146.6	22325	297.6667	7.235630888	3.264332734
5	GA3 wk16	10545	140.6	21620	288.2667	8.523678378	2.50037835
6	GA3 wk 16&18	10225	136.3333333	22530	300.4	7.292325968	3.007997348
7	GA3 wk 12-18	10190	135.8666667	21965	292.8667	7.166723235	2.896679263
8	GA3 + Fazor wk12	9870	131.6	14085	187.8	10.97960435	2.618644172
9	Fazor wk12	10670	142.2666667	11625	155	10.09593621	2.84160425
10	Untreated	10520	140.2666667	23131	308.4133	7.546757393	2.909898195

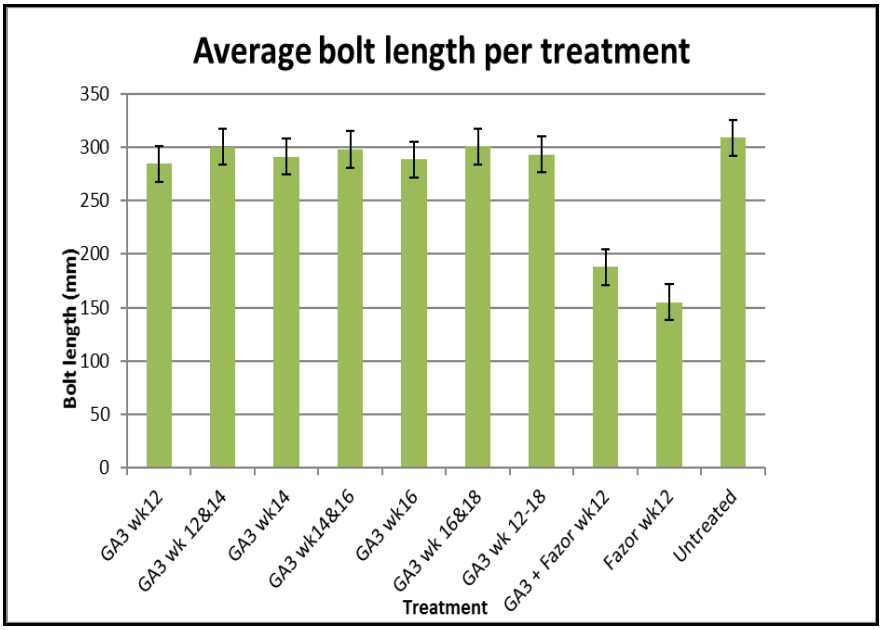


Figure 1a. Average bolt length Site 1 Year 1.

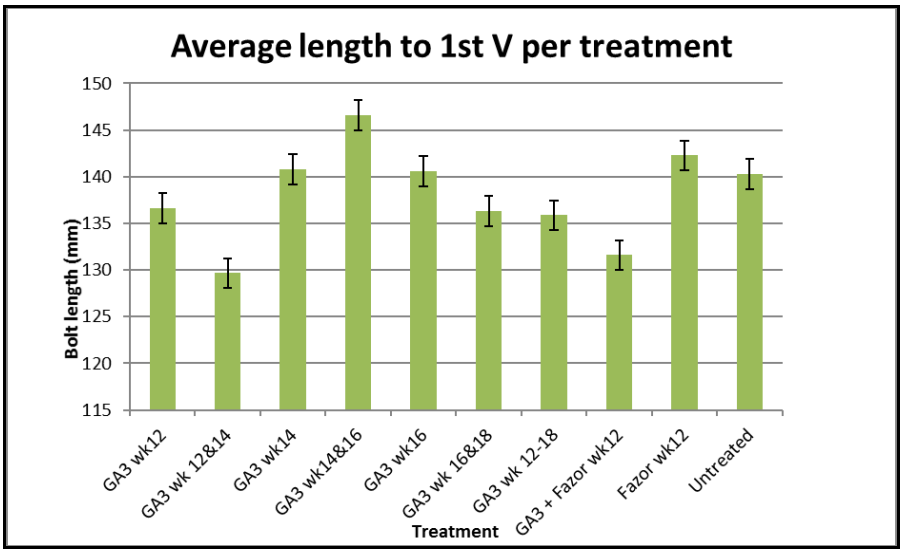


Figure 2a. Stem length to first V. Site 1 Year 1

Table 6a. Plot weights and mean plant weights per treatment. Site 1 Year 1

Rep 1	Weight (kg)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	66	59	67	69	73	75	83	95	78	80
	Weight	20.68	22.04	18.99	19.89	19.93	18.39	19.68	21.08	15.56	17.09
	Sling	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Total (kg)		19.93	21.29	18.24	19.14	19.18	17.64	18.93	20.33	14.81	16.34
Average		0.30	0.36	0.27	0.28	0.26	0.24	0.23	0.21	0.19	0.20
mean gm		301.9697	360.8475	272.2388	277.3913	262.7397	235.2	228.0723	214	189.8718	204.25
Rep 2	Weight (kg)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	63	83	81	53	88	72	84	58	83	74
	Weight	23.45	23.39	19.03	19	22.93	17.77	16.86	19.68	19.34	23.68
	Sling	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Total (kg)		22.7	22.64	18.28	18.25	22.18	17.02	16.11	18.93	18.59	22.93
Average		0.36	0.27	0.23	0.34	0.25	0.24	0.19	0.33	0.22	0.31
mean gm		360.3175	272.7711	225.679	344.3396	252.0455	236.3889	191.7857	326.3793	223.9759	309.8649
Rep 3	Weight (kg)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	100	101	94	92	77	89	80	117	89	92
	Weight	21.3	21.28	19.56	23.9	20.93	17.82	20.63	19.88	23.78	23.82
	Sling	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Total (kg)		20.55	20.53	18.81	23.15	20.18	17.07	19.88	19.13	23.03	23.07
Average		0.21	0.20	0.20	0.25	0.26	0.19	0.25	0.16	0.26	0.25
mean gm		205.5	203.2673	200.1064	251.6304	262.0779	191.7978	248.5	163.5043	258.764	250.7609

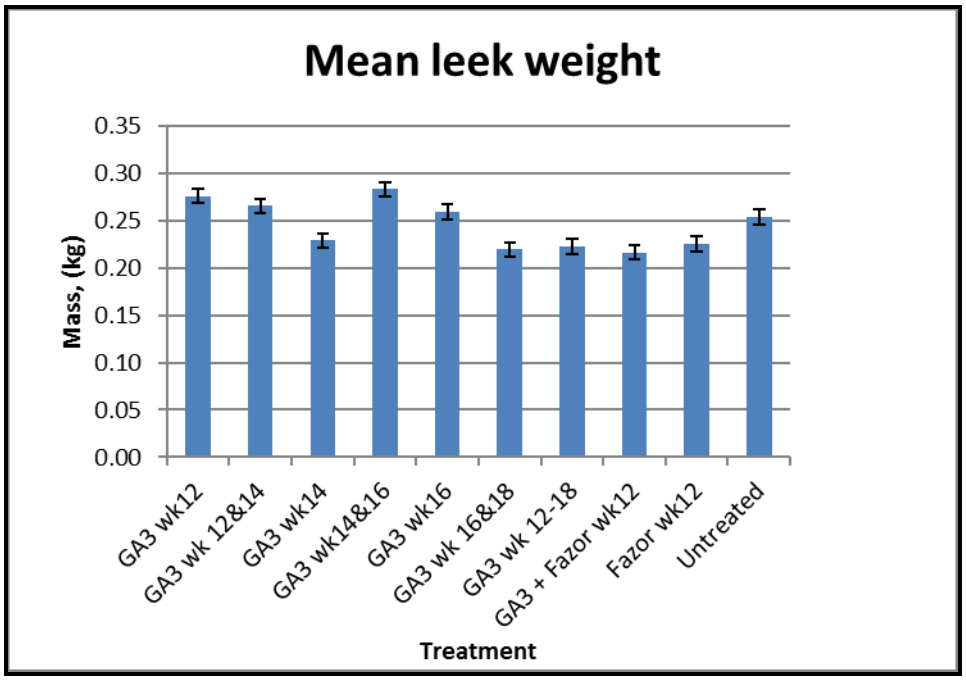
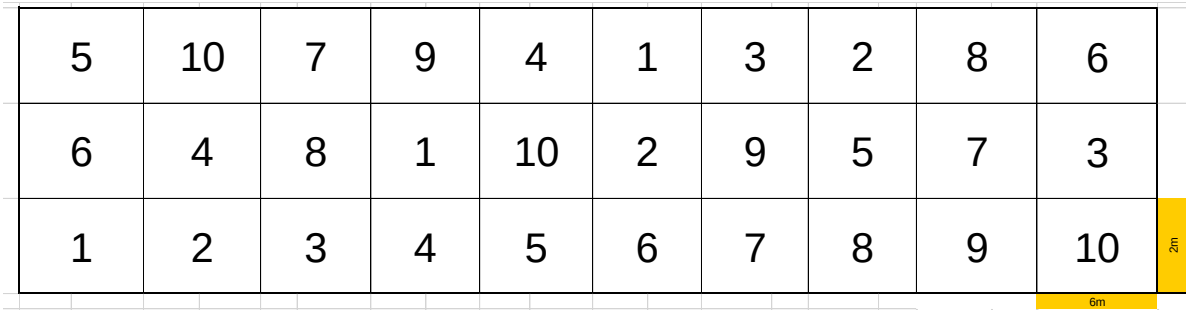


Figure 3a. Mean leek weight. Site 1 Year 1.

Year Two Trial Data

Table 1b. Plot layout Year Two (all sites)



Year two Data, Site One – Fairview 6

Table 2b. Measured length to first V and bolt length (mm) Rep 1, Site One Year 2

Rep 1	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	15	30	14	40	16	10	14	0	12	30	18	15	12	10	14	0	11	10	15	80
2	16	20	17	0	11	20	13	45	19	60	19	30	15	30	18	0	13	25	23	50
3	11	10	13	10	20	20	16	30	18	25	17	20	21	35	13	0	12	0	16	30
4	17	10	18	110	10	0	16	20	16	20	10	0	15	40	16	0	13	0	16	0
5	23	50	15	0	12	30	17	30	13	10	13	35	15	10	17	0	11	0	16	10
6	20	30	21	0	18	10	14	10	19	40	18	0	11	20	18	0	12	0	18	30
7	20	0	20	20	14	30	14	0	11	15	14	30	15	20	14	0	16	0	16	30
8	16	20	14	10	14	20	14	30	13	20	18	20	12	20	14	0	15	0	15	30
9	15	30	14	10	15	20	17	30	14	20	13	20	15	40	14	0	12	0	13	30
10	13	25	15	30	15	30	22	85	16	30	15	25	16	40	19	30	11	0	16	0
11	11	10	12	30	14	10	17	0	17	70	18	40	14	35	21	0	12	0	14	20
12	12	40	13	30	15	60	17	0	15	25	16	60	16	40	17	0	17	0	16	10
13	14	10	15	10	15	0	17	25	15	20	12	0	16	85	22	60	13	0	15	45
14	12	20	14	10	12	60	11	25	11	20	15	0	14	0	10	0	16	0	19	10
15	13	20	15	35	19	50	13	50	20	50	16	20	15	10	16	0	15	0	19	50
16	17	30	11	25	14	25	15	0	14	10	14	30	13	70	14	0	14	0	18	50
17	16	50	17	35	12	30	16	25	12	30	17	0	14	20	14	0	14	0	19	25
18	18	0	20	0	10	15	12	30	15	40	12	10	17	50	11	0	14	0	16	70
19	15	15	17	23	13	40	16	30	14	10	13	0	13	25	14	0	17	0	20	0
20	13	30	16	30	14	10	14	40	15	10	16	25	13	20	15	0	18	0	16	10
21	14	60	21	10	12	20	15	30	17	20	11	10	16	0	14	0	22	0	17	60
22	18	20	13	40	16	15	16	30	11	10	13	20	14	10	13	0	14	0	17	75
23	18	20	16	30	10	10	14	0	15	10	16	30	12	40	13	0	14	0	17	80
24	14	10	20	60	11	15	17	90	15	40	20	70	16	70	18	0	13	0	24	40
25	16	50	16	40	21	40	16	0	17	60	14	25	10	15	17	0	14	0	15	0
Total	387	610	397	638	353	590	383	655	374	695	378	535	360	755	386	90	353	35	426	835
Average	15	24	16	26	14	24	15	26	15	28	15	21	14	30	15	4	14	1	17	33

Table 3b. Measured length to first V and bolt length (mm) Rep 2, Site 1 Year 2

Rep 2	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	13	0	13	30	15	55	14	30	11	15	13	30	11	25	17	20	17	30	17	40
2	15	10	14	20	20	30	12	55	15	30	13	0	14	40	14	0	18	20	14	10
3	13	20	15	20	16	15	14	20	17	40	11	20	11	20	14	0	13	20	13	25
4	13	40	12	30	13	20	15	30	14	20	12	50	18	20	15	0	14	20	12	0
5	19	100	13	10	16	25	12	30	17	40	19	15	14	20	12	0	12	0	18	30
6	15	40	15	10	15	20	13	30	18	0	13	40	13	50	13	0	16	0	17	30
7	16	20	11	10	17	20	15	20	11	10	16	15	10	15	13	0	17	0	14	20
8	13	25	13	10	18	40	13	20	17	10	18	0	14	40	13	0	15	0	17	0
9	16	40	13	10	13	40	14	20	16	10	10	20	13	0	13	0	13	0	14	30
10	16	40	15	10	13	25	17	60	12	20	12	30	13	30	12	0	11	0	14	0
11	14	20	11	30	14	45	11	0	18	15	10	30	13	40	13	0	13	0	14	20
12	13	40	15	50	14	50	13	10	17	15	14	50	13	25	12	0	12	0	13	20
13	15	35	12	40	15	70	16	35	11	25	14	20	13	0	17	0	13	0	13	30
14	12	20	12	20	14	40	14	20	14	10	17	40	13	20	15	0	16	0	14	30
15	12	25	14	0	19	25	17	50	14	90	18	10	15	60	12	0	15	0	13	30
16	11	10	11	30	16	20	14	20	14	20	15	10	15	0	12	0	13	0	11	35
17	15	30	13	40	21	25	12	15	16	15	18	0	13	0	14	0	12	0	13	40
18	13	20	11	20	16	50	16	50	15	0	13	25	12	0	9	0	13	0	12	0
19	178	45	11	20	14	45	11	10	15	50	15	40	13	15	15	0	15	0	15	35
20	14	30	13	20	17	20	16	10	17	10	19	55	16	35	10	0	15	0	16	30
21	14	50	18	40	14	50	17	25	18	60	14	20	12	25	14	0	14	0	13	0
22	13	15	14	10	14	20	12	50	15	120	13	0	13	0	14	0	15	0	14	30
23	13	25	17	20	17	40	22	30	13	30	13	180	16	35	18	0	14	0	16	40
24	13	20	13	20	16	50	14	45	17	10	16	25	14	30	15	0	14	0	14	30
25	13	40	16	20	13	15	18	20	14	10	15	20	16	30	14	0	14	0	15	25
Total	512	760	335	540	390	855	362	705	376	675	361	745	338	575	340	20	354	90	356	580
Average	20	30	13	22	16	34	14	28	15	27	14	30	14	23	14	1	14	4	14	23

Table 4b. Measured length to first V and bolt length (mm) Rep 3, Site 1 Year 2

Rep 3	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	14	45	12	0	14	10	16	20	18	25	15	20	15	20	21	40	15	10	15	15
2	15	0	11	35	13	15	12	10	18	20	19	40	14	50	16	0	15	0	15	20
3	16	40	14	40	18	70	14	30	16	20	23	50	15	10	16	20	16	0	15	20
4	14	40	16	30	16	15	11	30	15	20	20	35	11	15	16	20	15	0	17	30
5	18	30	14	20	16	15	15	20	16	30	21	70	15	30	17	0	16	0	20	160
6	11	0	15	20	14	20	15	20	16	20	23	50	11	20	16	0	14	0	17	25
7	19	0	16	10	13	10	17	20	13	10	16	40	12	30	13	10	11	0	17	25
8	15	30	14	80	12	0	19	30	17	30	15	50	13	25	14	20	13	0	12	0
9	14	65	11	0	15	10	13	30	14	40	13	30	14	25	13	0	12	0	17	30
10	17	0	22	65	14	40	13	15	16	20	19	45	11	15	17	0	11	0	17	0
11	16	0	19	30	16	30	15	20	16	20	16	25	13	50	12	0	11	0	20	40
12	11	40	12	20	15	25	19	25	17	20	18	50	13	30	14	0	13	0	16	55
13	14	25	11	10	16	50	12	0	15	20	16	50	14	20	12	0	17	0	12	20
14	17	0	15	0	15	30	13	25	21	60	19	100	12	30	17	0	15	0	15	25
15	17	35	14	40	21	100	13	40	13	10	12	0	14	70	13	0	13	0	15	30
16	125	20	11	30	18	30	21	60	16	10	14	40	12	20	15	10	16	0	23	50
17	17	25	13	0	16	20	14	30	15	30	15	50	9	20	17	10	13	0	22	20
18	17	50	14	10	15	10	16	20	20	10	16	50	14	0	11	10	15	0	14	30
19	19	20	15	25	13	50	16	15	15	20	14	20	14	10	18	0	13	0	18	25
20	12	0	14	20	18	40	16	20	18	30	17	90	13	15	24	0	14	0	18	30
21	11	10	10	15	13	55	15	20	16	30	21	35	12	20	13	0	13	0	18	0
22	18	60	12	15	17	25	15	15	15	30	18	15	14	40	11	0	11	0	19	50
23	16	30	16	25	17	20	17	50	21	20	16	20	15	40	13	0	16	0	12	20
24	16	30	16	30	15	20	15	55	14	0	13	20	12	20	15	0	12	0	12	0
25	12	30	15	30	21	50	18	20	18	15	15	0	12	20	12	0	12	0	20	20
Total	491	625	352	600	391	760	380	640	409	560	424	995	324	645	376	140	342	10	416	740
Average	20	25	14	24	16	30	15	26	16	22	17	40	13	26	15	6	14	0	17	30

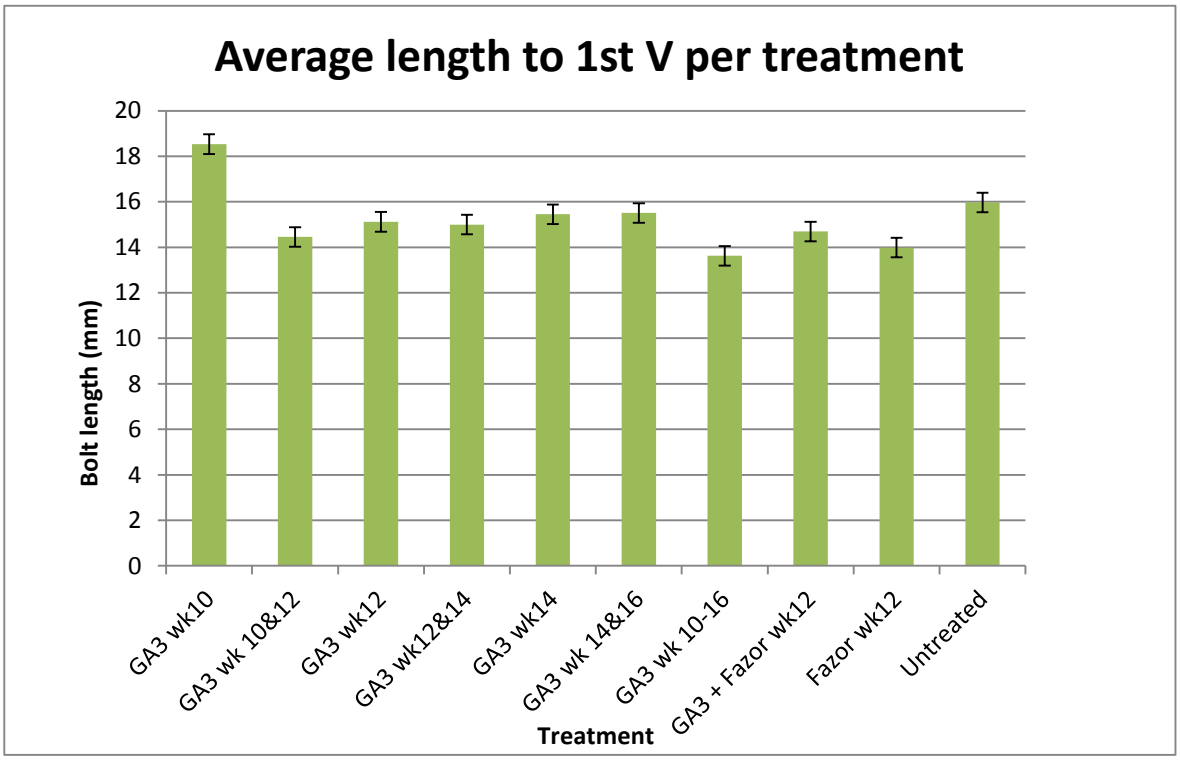


Figure 1b. Average length to first V. Site 1 year 2

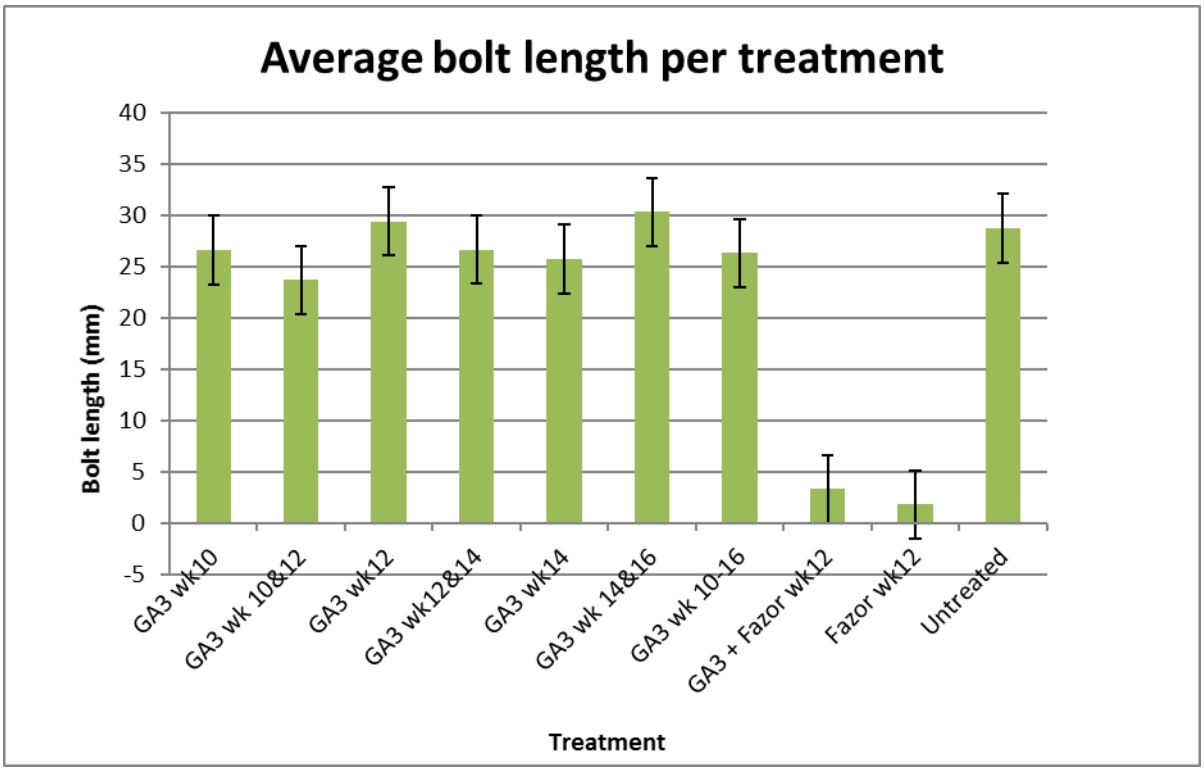


Figure 2b. Average bolt length. Site 1 year 2

Table 6b. Plot weights and mean plant weights per treatment. Site 1 year 2

Rep 1		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	79	68	65	73	68	72	65	62	67	55
	Weight	23.41	21.09	17.83	20.28	17.65	15.89	16.41	15.3	17.2	14.26
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		22.58	20.26	17	19.45	16.82	15.06	15.58	14.47	16.37	13.43
Average		0.29	0.30	0.26	0.27	0.25	0.21	0.24	0.23	0.24	0.24

Rep 2		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	69	70	74	59	47	68	50	71	83	74
	Weight	19.19	16.39	18.07	18.01	14.42	21.04	14.2	17.86	19.93	18.63
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		18.36	15.56	17.24	17.18	13.59	20.21	13.37	17.03	19.1	17.8
Average		0.27	0.22	0.23	0.29	0.29	0.30	0.27	0.24	0.23	0.24

Rep 3		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	87	69	64	89	75	86	69	60	75	92
	Weight	22.38	16.31	20.69	25.93	21.29	19.29	18.35	14.57	19.42	24.73
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		21.55	15.48	19.86	25.1	20.46	18.46	17.52	13.74	18.59	23.9
Average		0.25	0.22	0.31	0.28	0.27	0.21	0.25	0.23	0.25	0.26

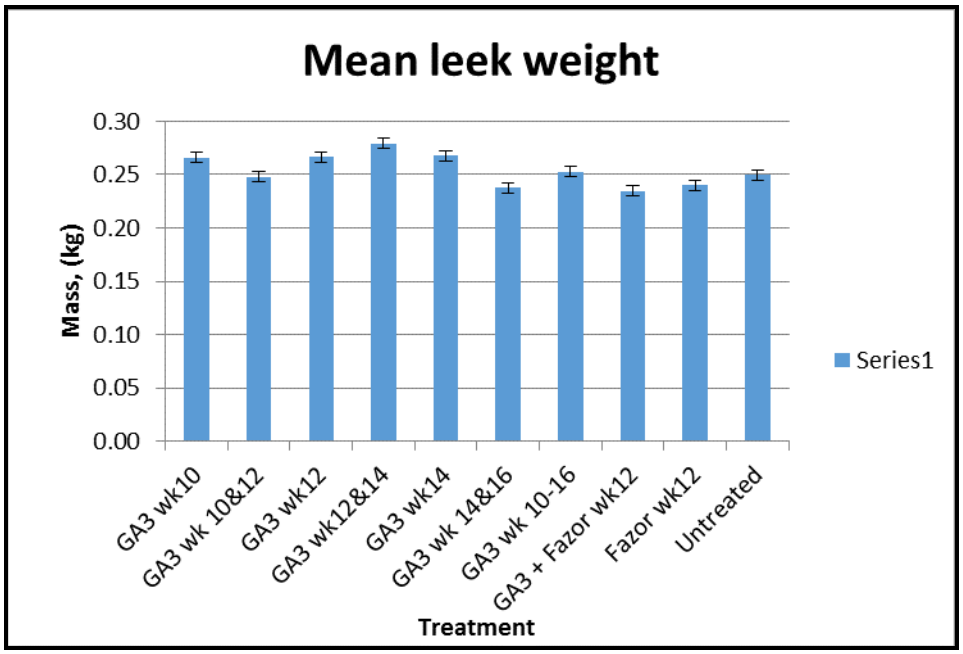


Figure 3b. Mean leek weight. Site 1 year 2

Year two Data, Site Two – Hubbersteds 74

Table 7b. Measured length to first V and bolt length (mm) Rep 1. Site 2 year 2

Rep 1	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	12	20	16	75	14	40	21	10	13	10	2	10	17	60	20	20	21	10	24	30
2	15	90	17	30	16	30	18	25	19	10	14	60	14	30	13	10	15	10	18	60
3	15	0	16	10	18	40	16	25	16	50	17	20	18	30	16	20	19	10	24	20
4	14	75	12	160	14	0	18	65	16	0	18	50	13	0	13	0	12	10	15	40
5	21	125	15	10	18	40	21	10	16	0	16	40	14	0	13	0	18	0	14	30
6	20	85	17	20	14	0	13	25	16	70	11	50	17	0	16	10	13	0	15	35
7	21	15	16	10	14	30	16	15	15	10	13	25	20	30	13	0	19	0	14	20
8	17	25	14	40	19	40	17	25	20	35	16	10	17	30	14	30	17	0	15	40
9	12	20	19	30	14	7	14	25	19	45	14	15	16	210	14	0	20	0	20	30
10	18	10	16	30	16	0	15	0	21	0	15	30	16	30	20	30	18	0	16	10
11	16	15	19	30	17	50	10	10	19	30	13	30	19	20	14	0	18	0	19	30
12	16	30	16	145	16	20	14	30	18	40	17	70	18	0	14	0	16	0	23	15
13	19	25	16	30	15	20	16	65	15	25	119	10	14	0	20	0	17	0	19	10
14	16	0	13	10	14	0	14	45	17	55	13	30	20	20	18	0	16	0	21	70
15	12	10	15	50	17	20	19	25	18	20	18	10	20	45	18	0	16	0	22	100
16	11	25	18	30	19	10	21	40	17	0	18	90	18	110	15	10	15	0	16	50
17	18	60	18	30	17	120	14	40	15	10	15	25	21	90	15	0	19	0	18	135
18	10	35	16	0	17	40	13	30	14	25	17	35	20	50	18	0	17	0	22	50
19	14	40	18	30	17	50	14	25	23	90	16	30	15	30	17	0	13	0	20	45
20	17	35	15	45	22	60	17	50	22	200	18	30	17	10	18	0	18	0	18	20
21	15	0	19	20	16	35	17	15	17	35	12	25	13	40	14	0	19	0	18	70
22	20	20	17	30	15	20	21	10	16	10	15	30	18	30	15	0	18	0	18	30
23	14	120	17	30	21	10	17	30	16	30	12	30	14	40	16	30	15	0	26	130
24	14	30	18	55	20	20	13	0	18	0	15	10	17	10	15	0	14	0	23	35
25	19	45	18	10	17	60	16	30	18	30	13	25	12	20	16	10	21	0	13	70
Total	396	955	411	960	417	762	405	670	434	830	467	790	418	935	395	170	424	40	471	1175
Average	16	38	16	38	17	30	16	27	17	33	19	32	17	37	16	7	17	2	19	47

Table 8b. Measured length to first V and bolt length (mm) Rep 2. Site 2 year 2

Rep 2	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	19	60	20	0	19	40	16	30	19	50	17	40	18	60	17	50	21	10	20	70
2	19	30	15	60	16	40	16	50	25	10	19	60	23	70	20	10	16	20	20	100
3	18	70	15	50	20	60	19	20	16	100	19	110	16	10	20	170	17	40	22	0
4	17	90	16	10	17	120	20	20	20	10	17	40	20	60	17	30	17	20	18	30
5	15	50	22	40	17	130	20	20	20	20	14	10	23	30	15	0	19	10	17	20
6	18	40	16	10	22	40	19	50	20	65	19	120	20	60	15	0	17	30	18	30
7	14	10	16	150	16	10	19	20	23	150	15	130	15	10	17	0	19	20	19	60
8	14	40	20	30	15	70	19	30	20	30	22	30	15	150	18	0	20	0	15	10
9	18	30	20	10	17	0	23	20	18	90	15	100	21	25	23	0	22	0	21	130
10	16	30	17	30	14	50	17	20	24	50	18	40	15	20	16	0	18	0	16	20
11	16	30	20	110	15	50	15	0	26	110	18	30	20	180	16	0	17	0	19	20
12	19	30	17	20	16	50	18	120	18	50	17	90	16	10	19	0	16	0	23	80
13	26	10	22	90	22	0	22	20	17	80	17	60	21	210	21	0	16	0	17	40
14	20	0	17	20	23	50	12	40	18	160	19	40	19	40	20	0	16	0	21	10
15	17	20	17	60	16	10	15	20	18	10	21	100	18	0	17	0	19	0	17	50
16	17	40	21	80	16	15	24	40	13	20	19	40	16	0	17	0	22	0	15	10
17	18	50	15	10	17	25	17	180	20	10	20	10	17	0	14	0	16	0	20	30
18	25	40	18	70	17	70	19	50	16	20	23	60	18	70	13	0	17	0	21	40
19	19	60	17	70	17	55	23	20	17	10	15	200	14	10	17	0	21	0	17	10
20	23	80	19	300	18	10	17	50	16	60	17	10	18	30	15	0	23	0	16	50
21	19	20	17	60	18	30	14	55	22	10	18	80	16	10	13	0	17	0	12	20
22	18	150	23	10	17	40	14	20	20	20	22	90	20	30	16	0	16	0	19	10
23	21	10	16	160	19	85	19	30	20	45	19	50	14	10	27	0	20	0	18	80
24	16	350	21	60	16	50	20	350	24	210	17	40	16	20	18	0	16	0	15	20
25	15	40	21	10	21	35	19	30	14	45	22	165	16	20	22	0	17	0	20	20
Total	457	1380	458	1520	441	1135	456	1305	484	1435	459	1745	445	1135	443	260	455	150	456	960
Average	18	55	18	61	18	45	18	52	19	57	18	70	18	45	18	10	18	6	18	38

Table 9b. Measured length to first V and bolt length (mm) Rep 3. Site 2 year 2

Rep 3	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	17	210	21	20	14	45	18	10	18	60	18	30	17	0	15	10	18	10	20	15
2	16	30	23	30	18	20	15	70	16	40	26	50	19	110	23	10	20	10	19	10
3	20	10	21	10	18	50	15	100	16	30	22	30	18	10	23	10	21	15	20	20
4	17	30	23	20	16	30	18	0	16	40	17	70	19	30	18	40	21	55	15	25
5	20	35	20	30	17	40	14	40	24	190	16	20	22	30	18	20	21	0	16	10
6	17	40	19	130	22	40	25	50	20	50	14	30	20	50	19	0	21	0	19	45
7	19	0	15	40	23	50	22	20	21	10	18	20	22	40	16	0	16	0	16	20
8	14	10	14	20	22	70	18	10	16	20	17	35	17	50	15	0	17	0	18	50
9	21	60	21	30	19	190	14	30	25	30	21	30	16	40	18	0	18	0	23	10
10	14	50	15	110	18	40	27	90	23	10	20	10	22	100	16	0	18	0	22	230
11	17	70	16	10	19	70	15	15	16	90	21	20	16	20	20	0	21	0	15	20
12	22	10	21	90	15	50	19	30	21	30	19	0	19	30	18	0	15	0	16	40
13	19	30	21	30	18	10	17	40	17	10	20	30	15	80	26	0	20	0	15	60
14	26	0	21	10	18	90	20	10	17	70	15	0	16	40	15	0	22	0	23	130
15	17	10	21	30	16	10	20	10	17	10	17	10	21	75	20	0	15	0	19	25
16	21	50	17	10	17	0	19	10	18	30	20	0	17	50	17	0	17	0	18	70
17	19	80	20	100	25	50	22	20	21	20	16	80	18	20	17	0	17	0	18	60
18	15	10	18	130	18	0	21	10	19	30	17	40	19	30	18	0	16	0	21	10
19	22	60	21	70	18	30	23	50	20	85	19	10	17	80	23	0	21	0	20	30
20	24	10	16	40	16	80	19	40	14	70	18	120	20	10	14	0	17	0	16	30
21	23	30	15	20	18	0	17	80	16	10	22	20	14	30	17	0	17	0	17	30
22	23	20	20	170	14	70	20	0	21	40	21	70	16	15	18	0	18	0	18	70
23	18	45	18	30	18	50	18	20	16	30	28	125	17	70	24	0	18	0	16	10
24	20	40	17	40	19	30	22	20	22	30	15	35	18	30	23	0	21	0	19	40
25	16	120	26	40	16	70	21	20	21	40	19	10	16	40	21	0	20	0	21	20
Total	477	1060	480	1260	452	1185	479	795	471	1075	476	895	451	1080	472	90	466	90	460	1080
Average	19	42	19	50	18	47	19	32	19	43	19	36	18	43	19	4	19	4	18	43

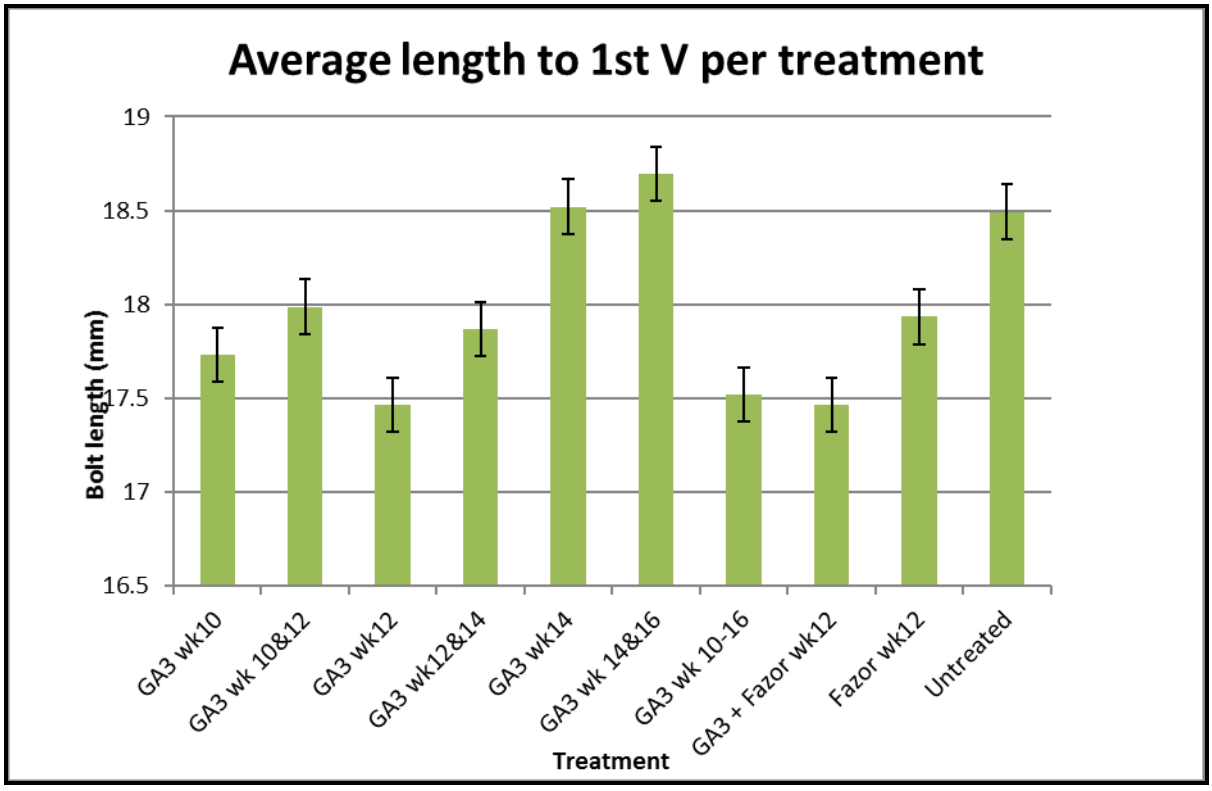


Figure 4b. Average length to first V. Site 2 year 2

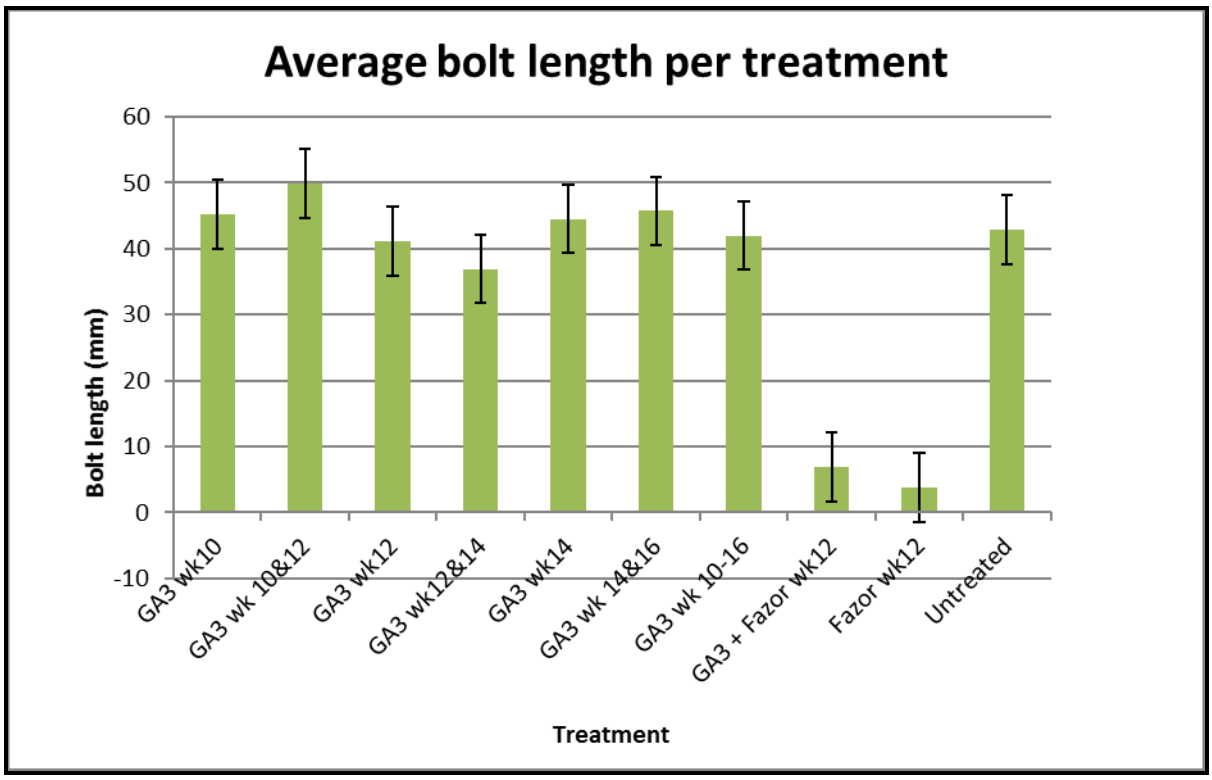


Figure 5b. Average bolt length. Site 2 year 2

Table 10b. Plot weights and mean plant weights per treatment. Site 2 Year 2

Rep 1		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	62	61	67	61	64	72	60	64	61	63
	Weight	28.49	24.62	24.26	24.39	24.98	28.48	26.56	26.53	22.69	24.23
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		27.66	23.79	23.43	23.56	24.15	27.65	25.73	25.7	21.86	23.4
Average		0.45	0.39	0.35	0.39	0.38	0.38	0.43	0.40	0.36	0.37
Rep 2		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	76	72	63	70	83	76	67	80	65	76
	Weight	28.88	28.81	25.58	26.43	26.14	28.36	25.34	30.58	26.49	27.62
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		28.05	27.98	24.75	25.6	25.31	27.53	24.51	29.75	25.66	26.79
Average		0.37	0.39	0.39	0.37	0.30	0.36	0.37	0.37	0.39	0.35
Rep 3		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	64	73	73	59	81	60	70	61	70	75
	Weight	26.79	26.93	26.15	24.68	28.53	23.12	27.09	24.38	27.77	27.17
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		25.96	26.1	25.32	23.85	27.7	22.29	26.26	23.55	26.94	26.34
Average		0.41	0.36	0.35	0.40	0.34	0.37	0.38	0.39	0.38	0.35

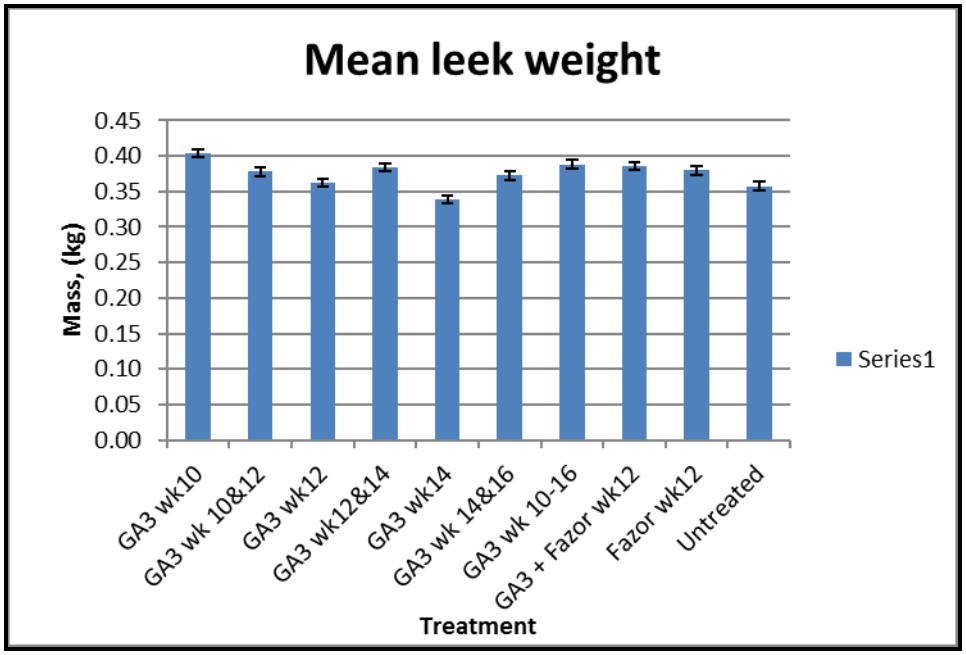


Figure 5b. Mean Leek weight. Site 2 year 2

Year two Data, Site Three – Hubbersteds 65

Table 1c. Measured length to first V and bolt length (mm) Rep 1. Site 3 year 2

Rep 1	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	29	50	28	350	32	350	29	255	35	90	40	110	32	80	36	110	25	90	32	55
2	24	95	27	120	25	110	27	225	30	280	37	280	23	350	27	85	39	190	21	20
3	28	80	26	145	28	270	32	80	25	90	29	210	28	60	26	140	31	140	27	350
4	24	100	27	135	28	0	32	350	24	70	28	95	31	260	28	60	23	40	31	340
5	22	85	22	35	26	60	21	55	20	70	32	200	25	40	27	55	26	120	26	125
6	18	65	29	70	24	70	33	300	28	75	30	210	39	140	26	145	28	240	35	230
7	29	350	25	180	18	0	34	160	24	140	30	85	25	100	28	45	24	120	29	155
8	30	290	25	70	25	45	26	260	24	130	23	35	23	60	23	70	25	180	29	195
9	26	110	26	175	22	35	34	100	33	220	26	170	29	120	27	95	27	35	30	40
10	20	170	25	40	26	65	23	120	31	120	28	260	25	90	31	350	29	225	29	205
11	31	225	27	110	31	50	34	290	23	120	27	160	27	223	35	90	29	50	23	180
12	33	220	22	60	22	135	31	350	27	155	30	130	27	130	28	45	31	150	22	210
13	21	110	25	20	29	150	26	70	23	100	20	100	25	100	32	350	29	105	29	220
14	26	45	26	70	25	150	27	35	29	190	32	350	25	350	29	75	25	55	38	70
15	21	0	30	310	21	20	27	160	22	20	30	260	19	160	29	145	28	180	32	160
16	30	190	33	55	25	165	27	350	24	165	29	80	20	20	35	250	35	230	26	60
17	31	210	28	245	23	40	30	80	28	145	22	25	29	65	29	200	37	350	26	140
18	21	95	31	320	27	30	30	270	21	35	26	350	34	290	29	165	30	190	29	40
19	29	145	25	140	20	110	36	350	32	230	39	280	22	100	23	45	30	90	24	85
20	28	185	18	80	24	55	29	30	29	190	24	70	24	35	31	110	24	270	28	140
21	24	180	27	285	20	60	32	350	35	155	31	210	31	255	33	175	27	115	32	150
22	25	275	24	100	19	60	27	80	29	155	34	170	20	120	25	90	23	25	26	30
23	30	30	26	275	22	185	29	190	30	85	29	50	33	145	29	220	23	210	27	85
24	23	145	30	80	32	250	26	70	25	90	25	220	31	100	29	10	19	30	26	40
25	23	50	27	0	29	125	28	190	30	140	30	330	18	250	21	95	23	30	30	110
Total	646	3500	659	3470	623	2590	730	4770	681	3260	731	4440	665	3643	716	3220	690	3460	707	3435
Average	26	140	26	139	25	104	29	191	27	130	29	178	27	146	29	129	28	138	28	137

Table 2c. Measured length to first V and bolt length (mm) Rep 2. Site 3 year 2

Rep 2	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	26	55	35	350	24	100	40	210	27	350	23	20	24	45	30	170	32	350	24	55
2	23	85	28	150	32	320	29	260	32	210	33	350	24	230	30	45	23	240	29	240
3	28	300	26	65	30	350	26	90	25	120	30	350	24	120	29	190	25	35	24	280
4	28	215	33	350	21	140	23	90	38	140	21	310	27	140	29	100	28	80	28	40
5	27	55	25	230	42	350	21	130	31	135	30	90	24	35	33	25	27	240	28	60
6	32	85	23	60	26	45	25	140	19	180	22	90	22	70	29	245	24	60	20	60
7	25	55	31	265	25	15	26	0	27	230	28	110	27	280	24	230	30	160	23	130
8	23	45	26	220	37	130	31	170	27	120	30	130	26	140	29	100	26	50	26	50
9	25	175	28	19	22	280	29	170	27	155	26	210	28	200	30	245	34	230	31	155
10	31	230	24	35	29	350	26	130	26	130	29	60	23	130	32	350	27	170	29	35
11	26	275	26	80	24	130	25	40	21	140	24	20	27	150	31	110	25	90	26	280
12	24	40	26	135	27	50	43	350	27	130	26	40	23	110	24	350	29	160	22	120
13	26	170	25	90	26	280	26	270	20	260	24	300	25	225	27	110	24	95	30	150
14	27	60	27	170	35	310	26	290	26	125	32	150	29	55	32	300	28	45	23	160
15	26	40	27	190	24	15	20	145	34	75	27	130	24	135	25	200	22	60	27	170
16	33	210	23	35	24	140	27	350	20	45	22	60	26	110	26	120	26	260	25	170
17	32	225	22	240	21	75	26	80	18	40	28	20	26	50	24	20	37	350	32	35
18	35	350	27	35	20	50	35	350	19	350	26	180	20	50	31	230	29	150	31	150
19	25	60	24	220	26	25	29	98	33	290	32	40	20	200	30	290	29	290	31	100
20	25	140	29	80	23	205	21	115	23	35	30	190	23	45	28	55	30	60	24	210
21	25	160	30	65	27	205	26	245	27	280	28	70	29	350	28	120	29	100	27	260
22	28	350	22	130	27	255	23	30	27	190	26	350	21	60	30	350	30	280	25	80
23	26	160	27	280	21	50	25	240	3	260	28	70	30	210	30	185	22	30	32	200
24	28	120	24	80	29	110	24	295	28	265	28	350	26	350	22	210	21	20	27	280
25	29	350	32	30	28	0	30	240	25	20	30	50	21	120	30	180	27	110	28	170
Total	683	4010	670	3604	670	3980	682	4528	630	4275	683	3740	619	3610	713	4530	684	3715	672	3640
Average	27	160	27	144	27	159	27	181	25	171	27	150	25	144	29	181	27	149	27	146

Table 3c. Measured length to first V and bolt length (mm) Rep 3. Site 3 year 2

Rep 3	Height (mm)																			
	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10	
Stick	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt	V	Bolt
1	23	190	31	70	29	220	26	190	25	70	32	100	28	180	25	30	22	90	26	110
2	33	240	27	190	25	140	32	260	23	130	29	120	22	350	32	65	35	150	44	320
3	30	30	22	190	20	60	38	280	28	240	29	160	26	250	37	110	30	215	33	350
4	34	230	22	160	19	350	30	150	21	200	26	90	32	350	30	210	33	320	26	95
5	29	140	31	70	28	350	27	140	23	80	21	50	28	280	29	350	25	160	29	350
6	34	50	27	280	33	350	28	230	20	40	28	30	28	10	29	100	29	70	29	65
7	30	340	25	180	32	140	21	40	31	170	24	160	30	150	32	300	25	170	24	290
8	29	80	21	220	30	220	29	190	31	290	30	100	31	90	29	50	26	195	24	55
9	18	20	30	350	24	50	30	190	25	300	28	230	26	100	26	90	25	230	32	190
10	30	200	27	70	31	100	26	40	30	110	24	220	33	180	27	20	23	40	36	210
11	31	350	25	120	26	180	29	250	29	280	28	95	23	40	41	100	28	260	32	175
12	20	30	34	280	33	350	30	230	22	15	23	100	28	50	24	40	27	350	24	120
13	25	170	24	20	27	50	26	100	20	30	35	250	26	140	22	100	34	55	28	160
14	33	290	29	30	31	140	24	30	25	140	26	60	25	220	26	130	22	190	29	350
15	21	40	25	70	26	150	30	120	23	20	21	75	27	190	34	250	26	55	26	20
16	20	60	32	100	29	120	23	140	30	50	24	60	26	250	30	120	23	245	30	165
17	25	100	30	240	41	320	29	30	25	300	28	40	19	40	36	220	30	80	31	350
18	25	120	19	220	24	90	32	350	25	200	27	200	29	60	27	30	26	60	32	30
19	32	350	26	230	21	25	28	70	27	150	23	30	27	280	32	350	24	80	32	175
20	23	130	27	150	34	310	32	290	27	200	36	250	24	15	32	260	33	290	31	80
21	24	50	34	90	34	225	31	200	25	40	32	350	30	170	27	3350	32	170	23	140
22	28	70	20	55	25	115	34	100	40	130	24	170	35	70	23	275	23	220	29	350
23	24	220	31	60	19	0	31	25	39	350	29	210	28	160	30	45	27	290	29	160
24	35	340	24	70	31	220	30	180	28	70	27	140	21	310	28	450	32	185	26	350
25	27	140	26	80	28	210	23	130	29	140	26	100	31	250	34	180	33	180	26	350
Total	683	3980	669	3595	700	4485	719	3955	671	3745	680	3390	683	4185	742	7225	693	4350	731	5010
Average	27	159	27	144	28	179	29	158	27	150	27	136	27	167	30	289	28	174	29	200

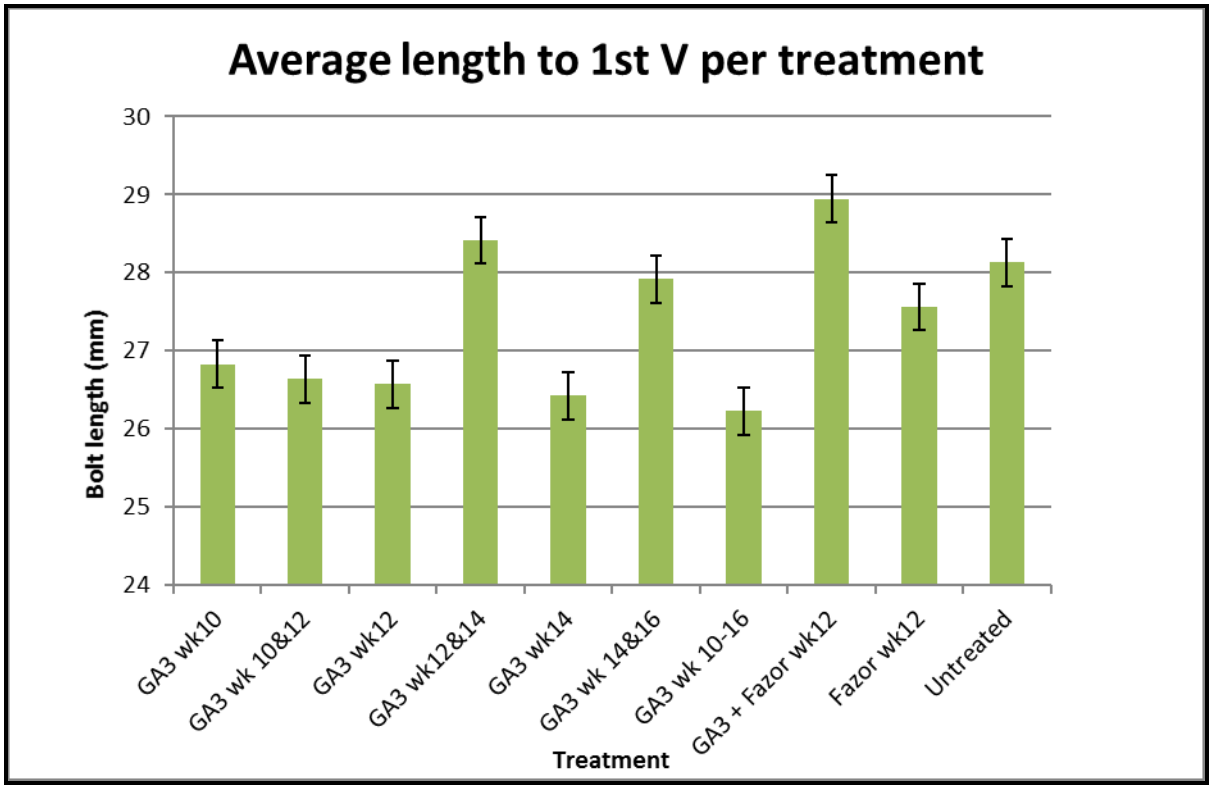


Figure 1c. Average length to first V. Site 3 year 2

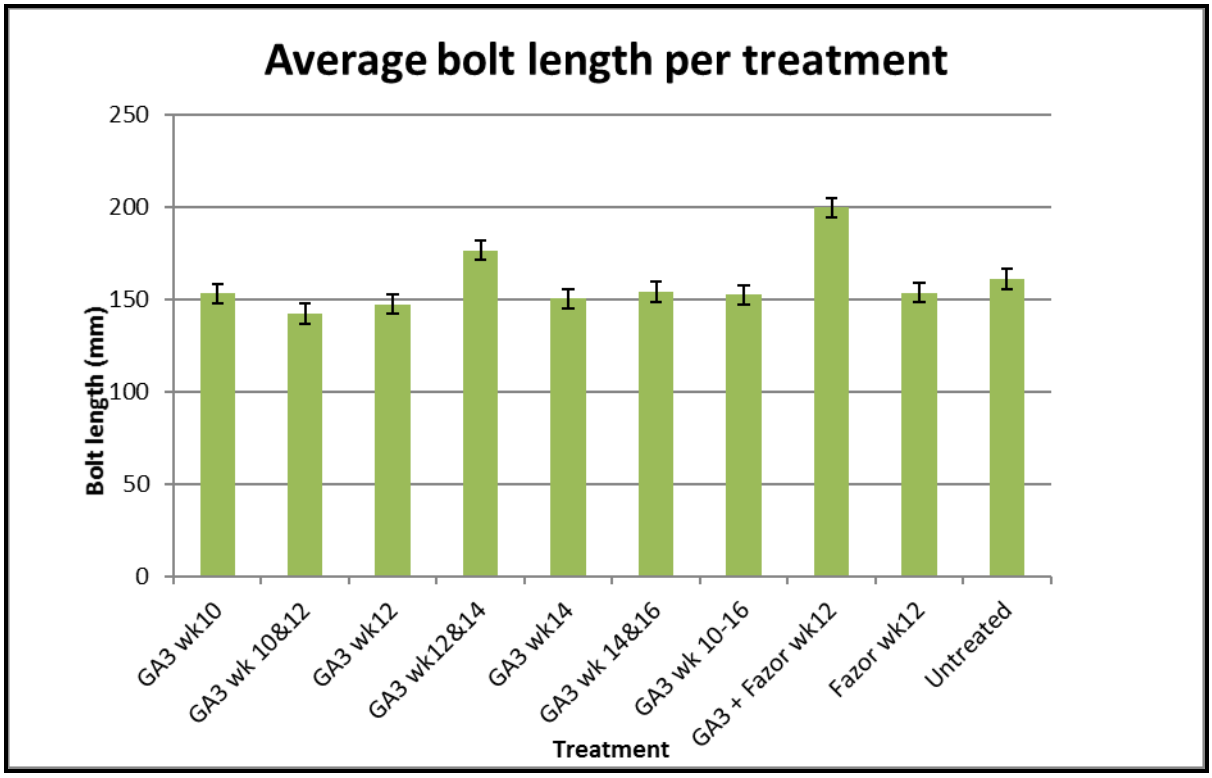


Figure 2 c. Average bolt length. Site 3 year 2

Table 4c. Plot weights and mean plant weights per treatment. Site 3 year 2

Rep 1		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	78	86	77	78	81	87	73	81	81	80
	Weight	26.39	31.33	26.58	32.77	27.54	28.7	26.76	27.77	26.03	29.16
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		25.56	30.5	25.75	31.94	26.71	27.87	25.93	26.94	25.2	28.33
Average		0.33	0.35	0.33	0.41	0.33	0.32	0.36	0.33	0.31	0.35
Rep 2		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	80	88	90	80	83	65	78	84	84	76
	Weight	28.79	28.39	29.68	28.93	28.68	22.41	28.32	28.41	28.73	26.17
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		27.96	27.56	28.85	28.1	27.85	21.58	27.49	27.58	27.9	25.34
Average		0.35	0.31	0.32	0.35	0.34	0.33	0.35	0.33	0.33	0.33
Rep 3		Weight (g)									
		Trt1	Trt2	Trt3	Trt4	Trt5	Trt6	Trt7	Trt8	Trt9	Trt10
	Number	72	76	75	73	65	82	87	79	82	80
	Weight	29.74	25.99	27.47	26.93	22.97	30.61	29.61	28.78	30.28	29.28
	Sling	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total (g)		28.91	25.16	26.64	26.1	22.14	29.78	28.78	27.95	29.45	28.45
Average		0.40	0.33	0.36	0.36	0.34	0.36	0.33	0.35	0.36	0.36

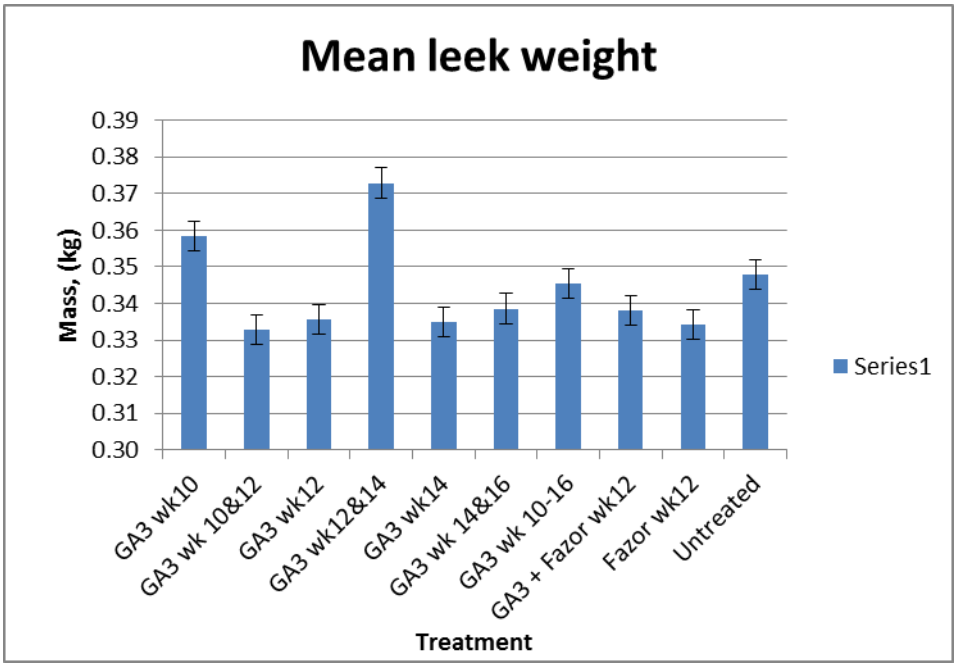


Figure 3c. Mean leek weight. Site 3 year 2

