Project title:	Improving Quality and Extending the Season for Late UK Leeks
Project number:	FV 387a
Project leader:	David Norman, Precision Agronomy Ltd
Report:	Final Report, October 2013
Previous report:	FV 387
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Date project commenced:	01 December, 2011
Date project completed (or expected completion date):	30 November, 2013

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.

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CONTENTS

Leek Bolting in the Field Trial

GROWER SUMMARY

Headline

Maleic hydrazide applied as the product Fazor, gave a highly significant reduction of bolting in late leeks produced under UK conditions, giving the potential for the leak season to be extended by 3-4 weeks.

Background

The season for UK leeks starts with harvest at the end of June using transplant plants produced under glass and then transplanted outside under crop covers, the season then runs through until late April/early May in the following year. The crops for the latest part of the season are direct field drilled in the previous May for harvest up until late April/early May the following year. The season finishes usually because the old season crop runs to seed (bolts) making it unacceptable for the market. In many similar biennial crops such as onions, carrots and parsnips the use of a sprout suppressant reduces bolting and re-growth to allow a longer marketing season. The use of these sprout suppressants also offers improvements in quality and shelf life for late season produce. The use of such materials has not been investigated in leeks previously and hence this study was proposed by the British Leek Growers Association. Maleic hydrazide is currently not approved for use in leeks in the UK.

Summary

Fazor (maleic hydrazide) show excellent promise for extending the season of UK leeks. This can be achieved from a by reduction in bolting, the main cause of the loss of quality at the end of the UK leek season. In addition to reducing bolting Fazor has other beneficial effects on leek quality by reducing softness and telescoping, both of which are important quality defects at the end of the UK season. There does, however, need to be caution in the use of this product, should it become approved, as application too early can cause leeks to become too short and fat, application too late, after bolting has occurred does not have any beneficial effects. The effects of gibberellins on the increase of shank length were inconclusive, with some variable results with interesting trends but no significant increase proven from the one year of trial.

Financial benefits

Using this technique could extend the leek season by up to four weeks, potentially allowing year long 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 £3,000,000 worth of production value to this figure.

Action Points

- This study has confirmed that the application window for maleic hydrazide on leeks is during March, as spring re-growth resumes after the winter dormant period. The effects have been proven on two different varieties and over three seasons of work.

- The use of maleic hydrazide is likely to result in an exceedance of the current maximum residue level (MRL) for leeks as the use is not an approved use and the MRL is set at a low rate to reflect this. Once the timing and rates have been confirmed therefore, residue studies data will be required to submit data to allow an increase of the MRL, to comparable levels with other crops where the active is in approved use. Following this increase in MRL an application for an off-label approval could be submitted.

SCIENCE SECTION

Introduction

Currently the UK supplies home grown leeks from early July until the end of April 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.

The total value of UK leek production is around £35,000,000 (source Defra hort. Stats 2009). Extending domestic production by 4 weeks could add £2-2.5 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 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.

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. This follow-on project was therefore designed to refine the timing of the spring application, test the rate of application and investigate whether the technique could be integrated with storage and different varieties to provide the maximum benefit. Due to uncertainty regarding whether maleic hydrazide will 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, 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 types and therefore could meet the project objective of season extension for UK leeks.

Materials and methods – Year One

Experimental design

The trial was carried out at field Hub 70, Hubbersteads farm, Upware, Cambridgeshire (OS grid reference: TL 546681). The soil in this field is an organic clay loam. The crop was direct drilled using natural seed and a precision commercial air drill on the 7th May 2011.

The experiment comprised of two treatments applied at eight different timings, 16 treatments in total. This gave seventeen plots per replicate, including an untreated control. There were three replicates to the experiment, giving a total of fifty one plots. Each plot measured 2m by 6m.The variety used was Harston, known for its bolting susceptibility.

Treatments

The treatments were two rates of maleic hydrazide (60%w/w) as the product Fazor at 8.0kg/ha or 4.0kg/ha product respectively (see table 1). Treatments were due to be applied at eight timings, two in February, four in March, and two in April (see tables below). The treatments were applied with a precision 2M Azo plot sprayer.

Table 1: The treatments used in the trial

Treatments		Product/ha		Water
	Product	Rate	unit	l/ha
1	Fazor 8.0 - T1	8000	gm	400
2	Fazor 4.0 – T1	4000	gm	400
3	Fazor 8.0 – T2	8000	gm	400
4	Fazor 4.0 – T2	4000	gm	400
5	Fazor 8.0 – T3	8000	gm	400
6	Fazor 4.0 – T3	4000	gm	400
7	Fazor 8.0 – T4	8000	gm	400
8	Fazor 4.0 – T4	4000	gm	400
9	Fazor 8.0 – T5	8000	gm	400
10	Fazor 4.0 – T5	4000	gm	400
11	Fazor 8.0 – T6	8000	gm	400
12	Fazor 4.0 – T6	4000	gm	400
13	Fazor 8.0 – T7	8000	gm	400
14	Fazor 4.0 – T7	4000	gm	400
15	Fazor 8.0 – T8	8000	gm	400
16	Fazor 4.0 – T8	4000	gm	400
17	Untreated	0		400

Table 2 – Treatment application details

Treatment	Date & Time	Operator	Temp °C	Wind speed (mph) & direction	Cloud cover
T1-T2	07/02/2012 1400 - 1420	P Hammond	2	6, NW	40%
T3-T4	21/02/2012 1130 – 1145	P Hammond	11	14, NE	20%
T5-T6	06/03/2012 1345 – 1400	P Hammond	8	3, N	100%
T7-T8	12/03/2012 1445 – 1500	P Hammond	9	5, S	100%
T9-T10	21/03/2012 1245 – 1300	P Hammond	16	3, NE	10%
T11-T12	28/03/2012 0945 – 1000	P Hammond	10	1, NE	0%
T13-T14	05/04/2012 0945 – 1000	P Hammond	6	10, SW	80%
T15-T16	16/04/2012 0955 – 1010	P Hammond	6	4, S	90%

Assessments

The crop was harvested on the 4th May 2012; at the same time the surrounding field crop was being harvested. Assessments on yield and bolting were carried out. Before harvest the mean plant height for each plot was measured. For the yield assessments three meter

lengths of each of the two centre rows of each plot were hand lifted and loose leek specification trimmed to 30cm length by professional leek harvesters provided by Allpress Farms Ltd. The leeks were weighed and counted by Precision Agronomy staff, to obtain the gross yield and average leek plant weight. Further to this bolt lengths were measured for each plant at harvest. Samples from each plot of 25 leeks from each replicate so a total of 75 leek plants per treatment, were sent to NIAB, Cambridge for shelf-life testing where they were put into the shelf life room at 4^{o}C. The samples were kept in plastic bags and then put in crates which were wrapped and covered in plastic to keep the humidity up around the leeks. Bolt lengths were also measured from 10 new plants from each plot 14 days after the harvest date.

Samples were assessed by NIAB staff after 7 days. The following measures were recorded: count of leeks which had telescoped (converted to a percentage), sum of telescoping length in cm (converted to per plant), count of leeks with re-growth of roots, 1-9 score of overall sample for softness (1=soft, 9 =firm), and count of leeks obviously bolted (converted to a percentage).

Samples were re-bagged and covered to maintain humidity levels and returned to cold storage for a further 7 days. The following measures were recorded 14 days after harvest: sum of telescoping length in cm (converted to per plant), a 1-9 score of overall sample for softness (1=soft, 9 =firm) and the mean bolt length per leek. The bolt length was assessed by cutting leeks in half along their length and the bolt length measured.

Residue Testing

A sub-sample of six treated leeks from a selection of treatments were taken at the point of harvest in the field, in final trimmed form, and sent to Eclipse at Chatteris for maleic hydrazide residue testing.

Statistical Analysis

An analysis of variance test was carried out for each character using GenStat software. All data was treated in the same way irrespective of the type of data which follows the standard analyses used by NIAB. There was only a single analysis for each character i.e. we haven't taken out 'anomalous' plots thrown up by analyses.

Plant height data were log transformed to ensure it was normally distributed then treatments were compared using an ANOVA. Average plant weight was normally distributed and effects of treatment were compared using an ANOVA with post-hoc sequential Bonferroni

tests carried out to adjust for multiple testing. All model diagnostic plots showed normal behavior of residuals.

Results

All treatments, except T15 and 16, both Fazor 4kg/ha and Fazor 8kg/ha at the last application date, showed significantly smaller bolt lengths compared to the untreated control (P<0.001) (Fig. 1).

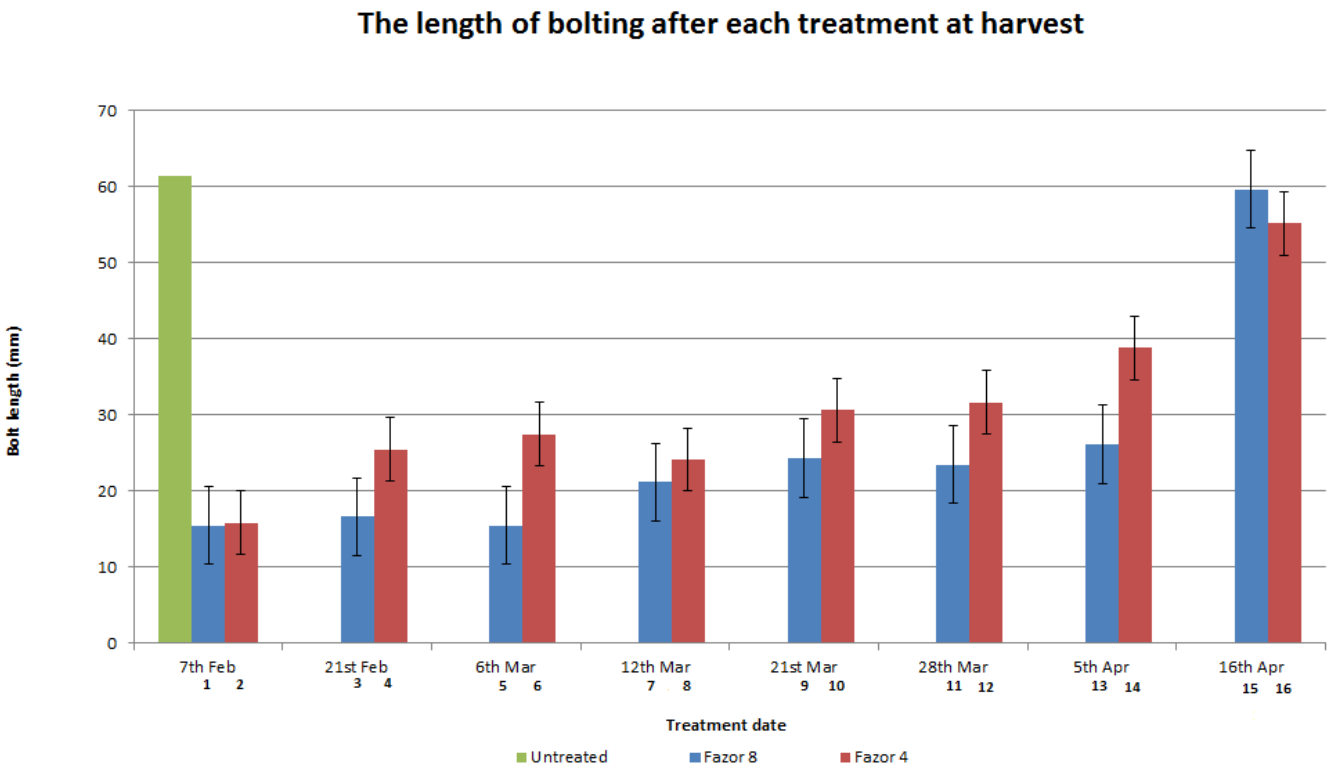


Fig 1: The length of bolting after each treatment.

Fig1 shows that treatments 10, 11, 12 and 13 were also significantly shorter than treatments 15 and 16 (P<0.001). Treatments 1 to 9 were also significantly lower than treatments 14, 15 and 16 (P<0.001). Treatment 14 also gave a significantly shorter average bolt length than treatment 15 although at a lower confidence level (P<0.01).

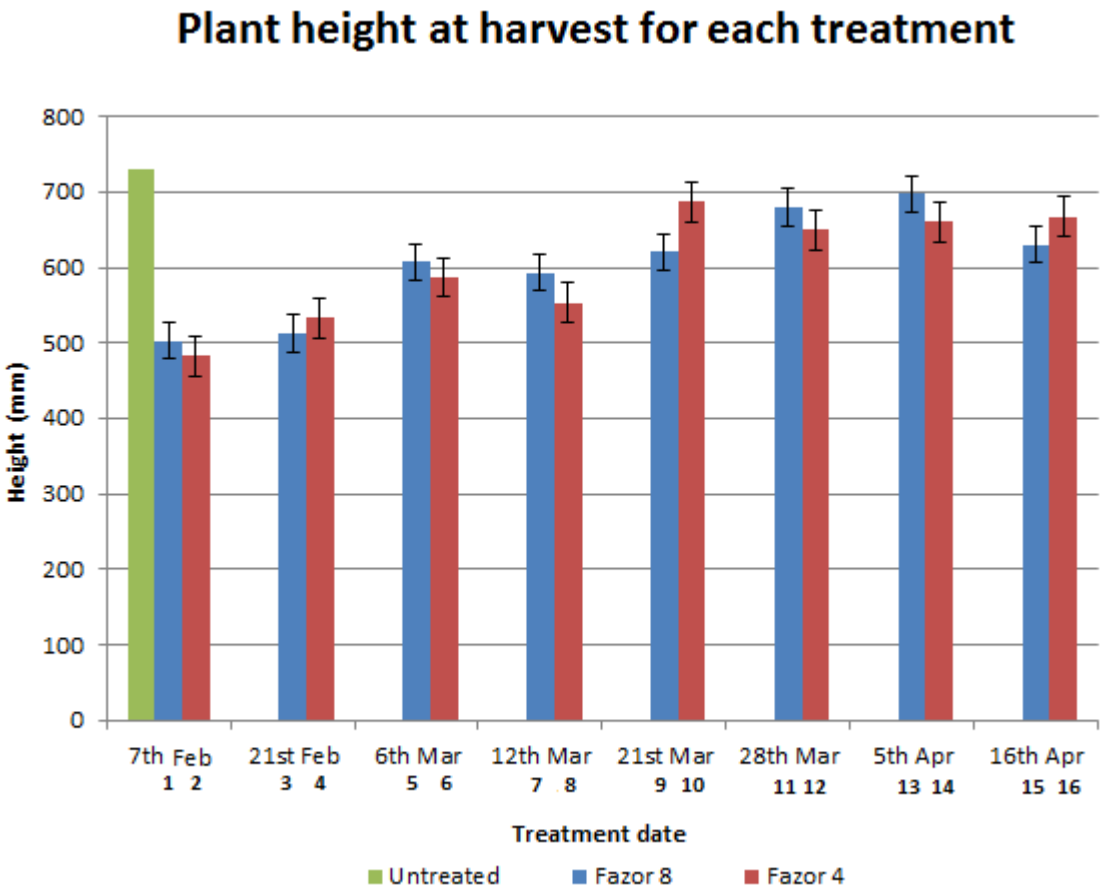


Fig. 2: The plant height at harvest for each of the treatments.

The results shown in Figure 2 indicate a general trend for increased plant height with later application dates of both doses of Fazor. Treatments 1, 2, 3, 4 and 8 all produced plants significantly shorter than the untreated control ($P<001$). Treatment 10, 11 and 13 also have significantly taller plants than treatments 1, 2 and 3 ($P<0.01$). Treatments 14 and 16 also gave significantly taller plants than treatment 2 ($P<0.01$).

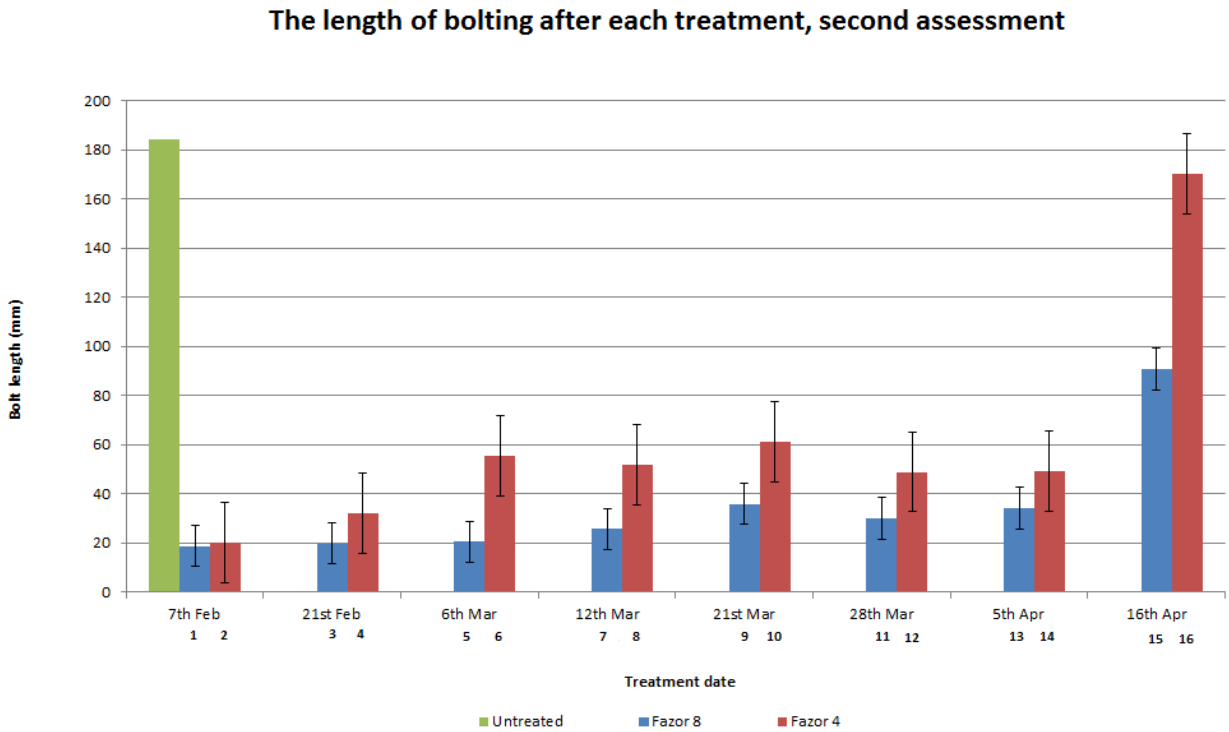


Fig 3: The bolt lengths at the second field assessment 14 days after normal harvest.

Fig 3 shows that all treatments except T16 had significantly shorter bolt lengths than the untreated (P<0.001). T15 showed significantly longer bolt lengths than all other Fazor 8 treatments and the two early February Fazor 4 treatments (P<0.001). T16 showed significantly longer bolt lengths than all other treatments (P<0.001) and was not significantly different from the control.

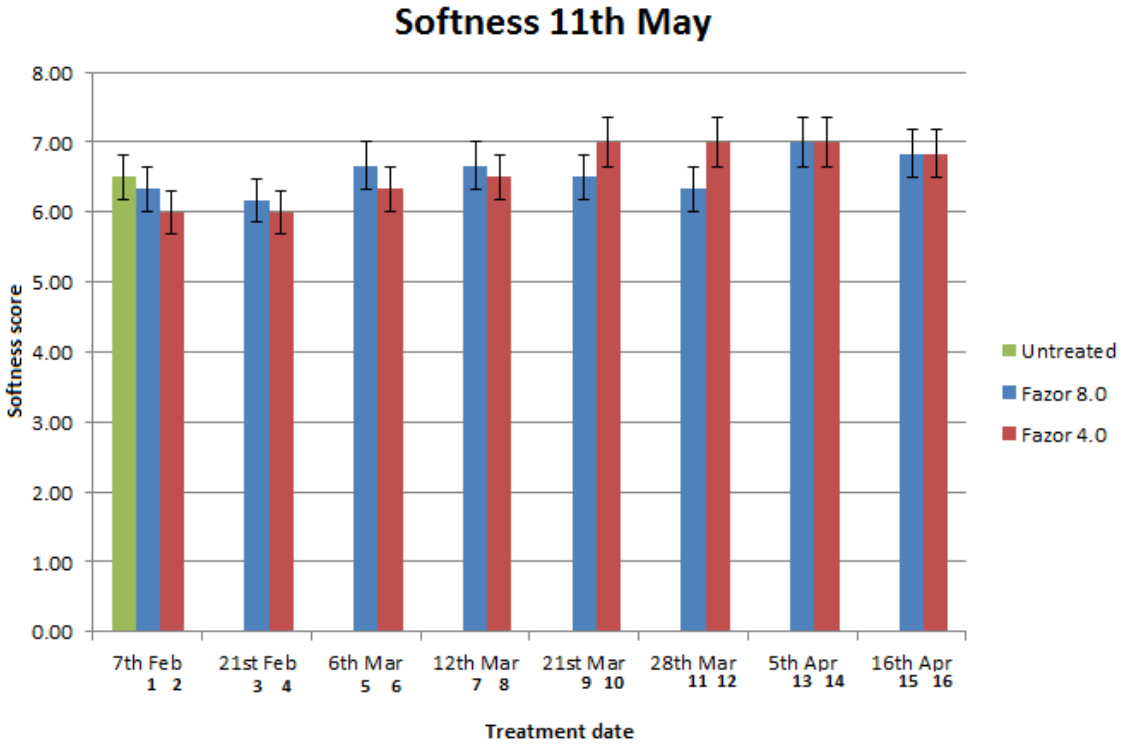
Date	Timing	Rep 1	Rep 2	Rep 3	Average
7th feb	T1	480	500	530	503
	T2	490	480	480	483
21stfeb	T3	500	500	540	513
	T4	480	540	580	533
6th mar	T5	590	590	640	607
	T6	550	620	590	587
12th mar	T7	500	700	580	593
	T8	570	520	570	553
21st mar	T9	590	650	620	620
	T10	630	750	680	687
28th mar	T11	620	660	760	680
	T12	670	620	660	650
5th apr	T13	640	690	760	697
	T14	700	650	630	660
16th apr	T15	620	600	670	630
	T16	690	640	670	667
Untreated	T17	740	650	800	730

Table 5: The plant heights in mm for each of the treatments

Table 6: The results of the first shelf life assessments on the 11th May 2012.

Dose	Date of application	Treatment No.	telescoping /plant cm	softness 1-9 (1=soft)	% bolters
Fazor 8.0	07-Feb	T1	0.00	6.33	0.00
Fazor 4.0	07-Feb	T2	0.04	6.00	0.00
Fazor 8.0	21-Feb	T3	0.00	6.17	0.00
Fazor 4.0	21-Feb	T4	0.03	6.00	0.00
Fazor 8.0	06-Mar	T5	0.00	6.67	0.00
Fazor 4.0	06-Mar	T6	0.00	6.33	0.00
Fazor 8.0	12-Mar	T7	0.01	6.67	0.00
Fazor 4.0	12-Mar	T8	0.01	6.50	0.00
Fazor 8.0	21-Mar	T9	0.03	6.50	0.00
Fazor 4.0	21-Mar	T10	0.01	7.00	0.00
Fazor 8.0	28-Mar	T11	0.01	6.33	0.00
Fazor 4.0	28-Mar	T12	0.00	7.00	0.00
Fazor 8.0	05-Apr	T13	0.05	7.00	0.00
Fazor 4.0	05-Apr	T14	0.01	7.00	0.00
Fazor 8.0	16-Apr	T15	0.05	6.83	0.00
Fazor 4.0	16-Apr	T16	0.01	6.83	0.00
Untreated	-	T17	0.05	6.50	0.00

(A)



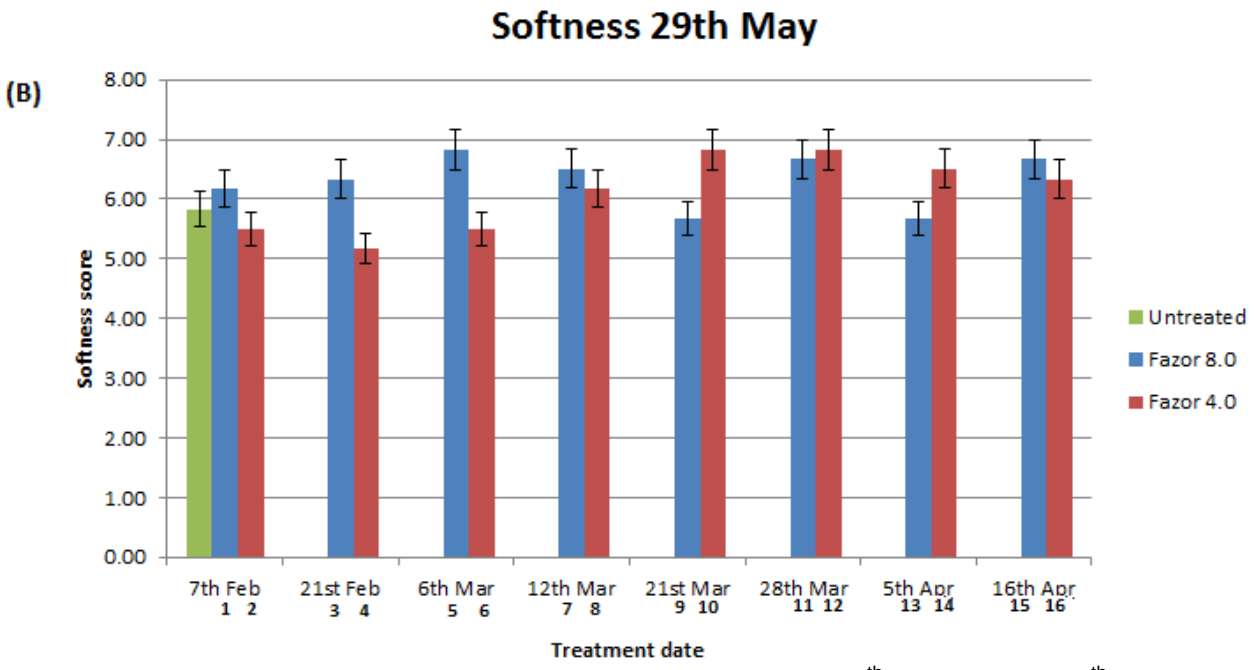


Fig 4: The softness assessment results taken at two dates: 11th May (A) and 29th May (B).

The softness scores taken during shelf-life testing (Fig 4) showed the trend that later application dates resulted in firmer leeks (lower score equals firmer leeks). The earlier treatments 2 and 4 produced the softest leeks and these were significantly softer than treatments 5, 7, 10, 12, 13, 14, 15 and 16. Treatments 1, 6 and 11 were significantly softer than 10, 12, 13 and 14

The second softness assessment showed a slightly different pattern to the first. Here Fazor 8 produced slightly firmer leeks at earlier assessment dates whereas Fazor 4 still resulted in softer leeks at earlier application date. Treatment 4 gave the softest leeks, which were significantly softer than treatments 1, 3, 5, 7, 8, 10, 11, 12, 14, 15 and 16. Treatments 2 and 6 produced leeks significantly softer than treatments 5, 7, 10, 11, 12, 14 and 15. Treatments 9 and 13 resulted in leeks significantly softer than 5, 10, 11, 12 and 15. Treatments 5 and T10 also gave significantly firmer leeks than the untreated control.

Table 7: The results of the second shelf life assessment on the 29th May 2012.

Dose	Date of application	Treatment No.	telescoping /plant cm	softness 1-9 (1=soft)	% bolters
Fazor 8.0	07-Feb	T1	0.20	6.17	0.09
Fazor 4.0	07-Feb	T2	0.25	5.50	0.43
Fazor 8.0	21-Feb	T3	0.03	6.33	0.15
Fazor 4.0	21-Feb	T4	0.52	5.17	1.40
Fazor 8.0	06-Mar	T5	0.16	6.83	0.51
Fazor 4.0	06-Mar	T6	0.71	5.50	1.76
Fazor 8.0	12-Mar	T7	0.27	6.50	0.55
Fazor 4.0	12-Mar	T8	0.43	6.17	1.27

Fazor 8.0	21-Mar	T9	0.79	5.67	1.27
Fazor 4.0	21-Mar	T10	0.45	6.83	1.57
Fazor 8.0	28-Mar	T11	0.49	6.67	1.63
Fazor 4.0	28-Mar	T12	0.45	6.83	2.65
Fazor 8.0	05-Apr	T13	0.92	5.67	2.64
Fazor 4.0	05-Apr	T14	0.71	6.50	2.80
Fazor 8.0	16-Apr	T15	0.69	6.67	4.51
Fazor 4.0	16-Apr	T16	1.00	6.33	4.41
Untreated	-	T17	0.92	5.83	6.07

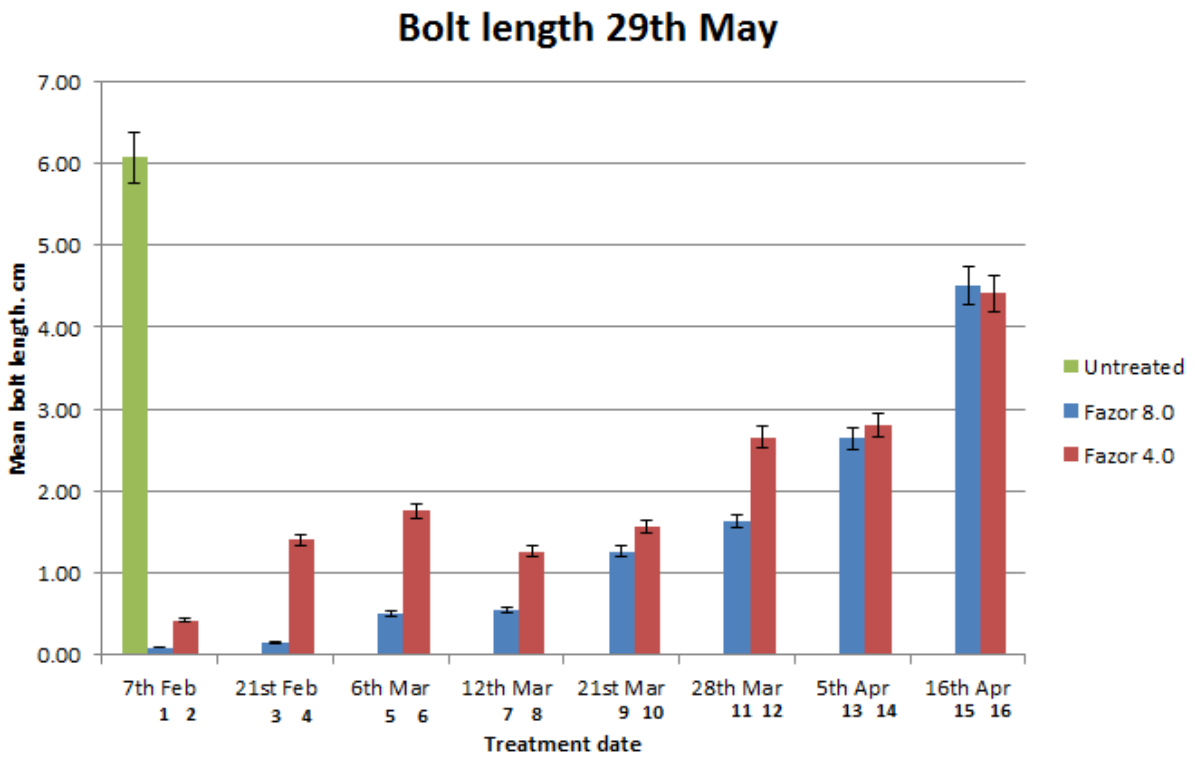


Fig 5: The results of the bolting assessment made at the second shelf life assessment.

Bolting shelf-life results: Fig 5 shows that all treatments resulted in significantly less bolting than the untreated control (Fig 4, Table 3). Treatments 1-14 showed significantly smaller bolt lengths than treatments 15 and 16. Fazor 8 resulted in lower bolt lengths than Fazor 4 at all application dates except the last. There is a clear trend showing that the earlier these treatments are applied the lower the bolting length. Fazor 8 showed significant improvements in bolt length reduction over Fazor 4 at applications on 21st Feb, 6th Mar and 28th Mar/3.

The first shelf-life assessment for telescoping showed the earlier the treatment was applied the lower the levels of telescoping. Treatments 13 and 15 resulted in the same amount of telescoping as untreated control. This was significantly more than treatments 1, 3, 5, 6, 7, 8,

10, 11, 12, 14 and 16. Treatment 2 also showed significantly more telescoping than treatments 1, 3, 5, 6 and 12

At the second assessment the same pattern appeared as the first shelf life assessment - the earlier the treatment was applied the lower the levels of telescoping. Treatment 13 showed the longest telescoping which was significantly higher than treatments 1, 2, 3, 5, 7 and 8. Treatments 6 and 14 also showed significantly more telescoping than treatments 3 and 5. T9 also showed high levels of telescoping - significantly higher than treatments 1, 2, 3, 5 and 7.

Residue Testing

A sub-sample of six treated leeks from a selection of treatments were taken at the point of harvest in the field, in final trimmed form, and sent to Eclipse at Chatteris for maleic hydrazide residue testing.

Table 3: Residue results

Treatment Number	Treatment Date	Treatment Rate	Result (mg/kg)
T3	21/02/12	8	4.8
T4	21/02/12	4	1.2
T7	12/03/12	8	7.4
T8	12/03/12	4	4.9
T11	28/03/12	8	14.0
T12	28/03/12	4	5.8
T15	16/04/12	8	7.0
T16	16/04/12	4	1.8

The current Maximum Residue Level (MRL) for maleic hydrazide on leeks is 0.2. The level is set so low as maleic hydrazide has no approval on this crop. In related crops where approvals exist, MRLs are set at much higher levels (see Table 4).

Table 4: MRL's for Maleic Hydrazide in some Vegetable Crops

Crop	Use Approved	MRL Set
Leeks	No	0.2
Onions	Yes, label	15
Garlic	Yes, SOLA	15
Shallots	Yes, SOLA	15
Carrots	Yes, SOLA	30
Parsnips	Yes, SOLA	30
Potatoes	Yes, label	50

All of the treatments would have resulted in an MRL above the current level for leeks of 0.2. The 0.2 is set as a default level for most crops where there is no approval. If the level was raised to the same level as in approved crops such as onion, shallot or garlic then all applications would have resulted in residues below the MRL. If the application rate were

the same as in onions with the same 7 day PHI then the residue level is likely to be under 10, however an MRL of 15 would cover all likely situations.

Discussion

The two bolting assessments made in the field showed that earlier treatment dates resulted in lower levels of bolting. Further to this the higher application rate of Fazor gave a smaller bolt length compared to the lower application rate at almost all application timings. At the second in-field assessment the applications of Fazor 4kg/ha from the 6th March onwards were not significantly different to the last application of Fazor 8kg/ha. This suggests that Fazor 8kg/ha gave better bolting reduction at any date up until the start of April compared to Fazor 4kg/ha.

The plant heights at harvest, however, showed that the earliest applications gave slightly shorter plants. This trade off was also apparent after shelf-life tests. The bolting assessment made showed that the later applications resulted in significantly longer bolt lengths than those made at the beginning of the season and, again, at all treatments dates bar the last, Fazor 8kg/ha showed smaller bolt lengths than Fazor 4kg/ha. The applications made on the 21st March appear to mark the tipping point. After this date applications, particularly of Fazor 4kg/ha, did not appear to control bolting as well as earlier applications did.

There was a stronger pattern in the first softness assessment than the second, where earlier applications gave softer leeks with the two February applications of Fazor 4kg/ha giving the softest leeks. At the second softness assessment the earlier applications of Fazor 4kg/ha also gave the softest leeks. Earlier applications of Fazor 8kg/ha showed slightly firmer leeks than at the earlier softness assessment.

It appears, therefore, that there is a still a trade-off between bolting control and leek quality. The earlier timings give the best control of bolting but also softer, shorter plants. Fazor 8kg/ha also appears to perform better than Fazor 4kg/ha at both bolting control and shelf life assessments at this application timing. The timings of the Fazor 8 applications on the 6th March and the 12th of March seem to provide the best compromise.

Materials and methods – Year Two

Experimental design

The trial was carried out at field HH27, Hollyhouse Farm, Chatteris, Cambridgeshire (OS grid reference: TL 435872). The soil in this field is an organic loam. The crop was direct

drilled using natural seed and a precision commercial air drill on the 7th May 2012. Two varieties were used drilled side by side in the field, these were Harston, the test variety from 2011-12, known to be bolt susceptible and fairly long and the variety Triton which is shorter and most frost hardy.

Two identical experiments were laid out in each variety plot side by side in the field, there were seven treatments looking at different timings of gibberellins, gibberellins plus Fazor and one treatment of Fazor alone applied at the best timing from the 2011-12 trial. Each plot measured 2m by 6m with 3 replicate plots/treatment.

Treatments

All applied to both varieties on the same days

	Treatments	**Hectare rates**	
	Product	**Product (g)**	**Water l/ha**
1	GA3 wk 18	350	400
2	GA3 wk18 + wk16	350	400
3	GA3 wk 16	350	400
4	GA3 wk 14	350	400
5	GA3 wk 16 & Fazor	350 4000	400
6	GA3 wk 18 + wk 16 & Fazor wk 12	350 4000	400
7	Fazor only wk 12	4000	400
8	Untreated		

Application Details

	Timing 1 Wk12	**Timing 2 Wk14**	**Timing 3 Wk16**	**Timing 4 Wk18**
Operator	P Hammond	P Hammond	P Hammond	P Hammond
Date	18/03/2013	02/04/2013	15/04/2013	29/04/2013
Time	1600 - 1615	0935 - 0938	0950 - 1010	1040 - 1055
Temp	6	5	13	9
Wind Speed	6	14	9	16
Wind direction	NE	NE	E	E
Cloud cover	50%	5%	40%	60%

Fazor contains 60% maleic hydrazide

GA3 applied as product Smartgrass which contains 40% gibberellic acid

Neither of these products carries a current approval for leeks.

Assessments

The trials were harvested on the 8th May at the same time as the surrounding field crop. Both varieties were harvested on the same day and assessments made of bolting length, plant height and yield. For the yield assessments three meter lengths of each of the two centre rows of each plot were hand lifted and loose leek specification trimmed to 30cm length by professional leek harvesters provided by Allpress Farms Ltd. The leeks were weighed and counted by Precision Agronomy staff, to obtain the gross yield and mean stick mass. Further to this bolt lengths were measured by splitting open 10 leeks per plot (30 leeks per treatment) and measuring internal flower stalk development. A further 10 leeks per plot (30 per treatment) were hand measured from the base plate to the first V or leaf split.

Statistics

Results for both Harston and Triton varieties were analysed identically. Bolt length was not normally distributed and negative binomial generalized linear models with log-link functions were used to analyse the effects of treatment on bolt length. Post-hoc testing was carried out using a sequential bonferroni test to adjust for multiple testing. Plant height data were log transformed to ensure it was normally distributed then treatments were compared using an ANOVA. Average plant weight was normally distributed and effects of treatment were compared using an ANOVA with post-hoc sequential bonferroni tests carried out to adjust for multiple testing. All model diagnostic plots showed normal behavior of residuals.

Results for Variety Triton

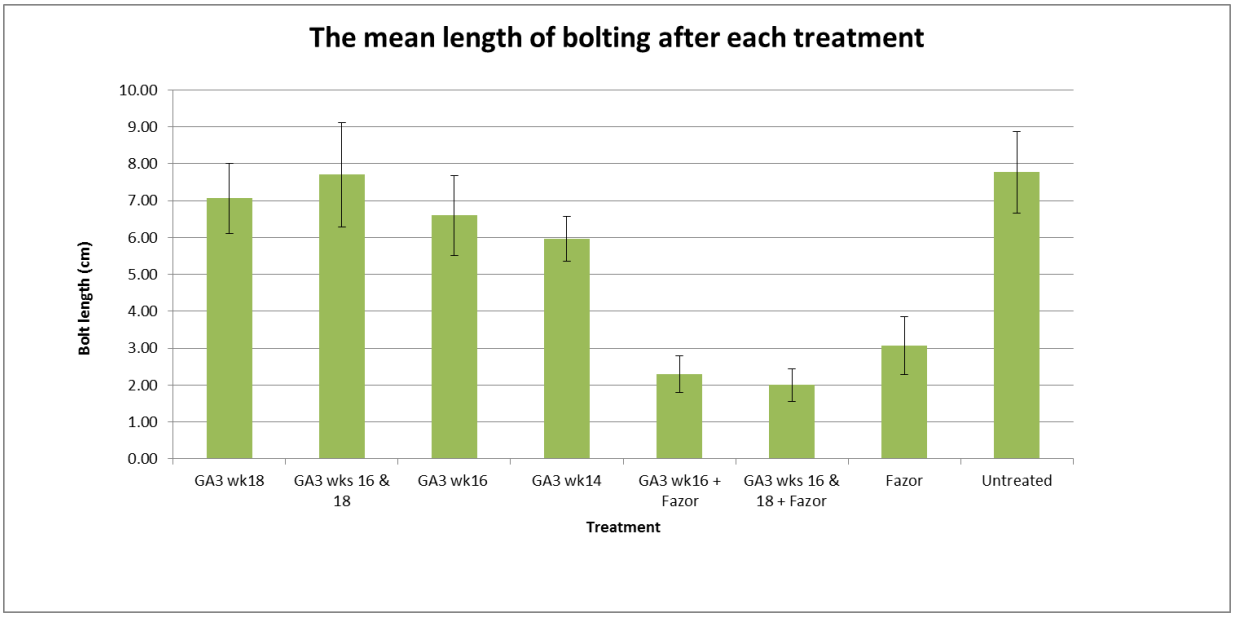


Fig 6. Mean length of bolt var. Triton

The results (Fig 6) indicate that none of the GA3 treatments had any significant effect on bolt reduction, the Fazor treatments however did significantly reduce bolting. Treatments containing Fazor were therefore highly significant in reducing the length of bolting in variety Triton.

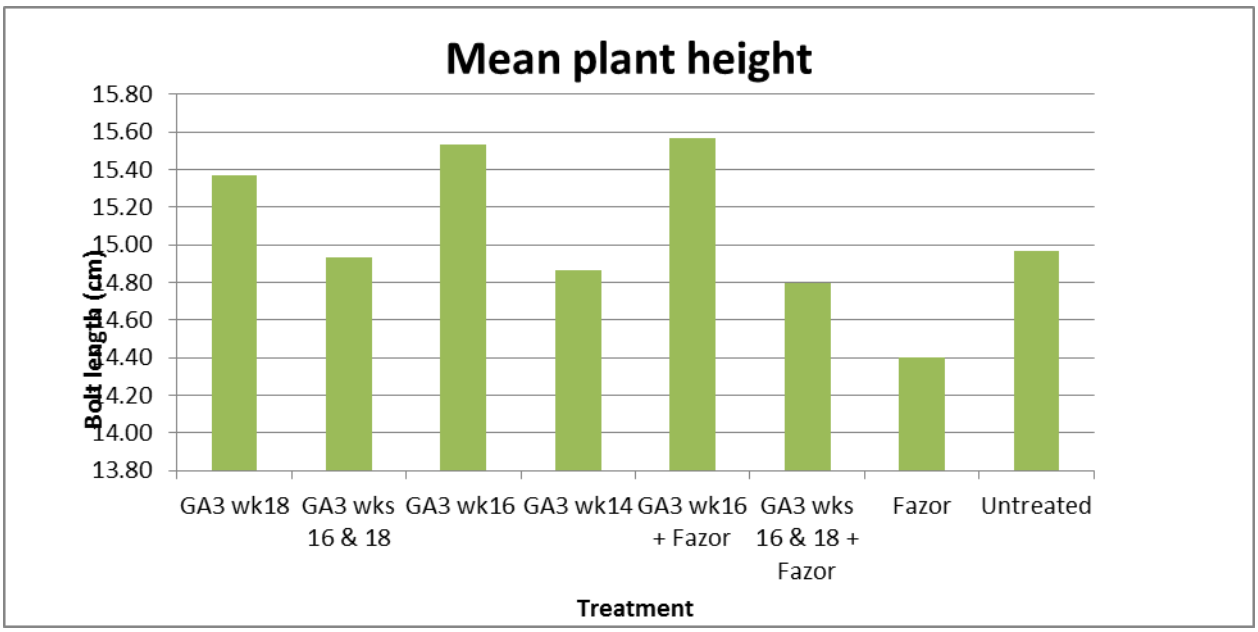


Fig 7. Plant height to first V variety Triton

Although there appears to be a trend from these results in Fig 7 for GA3 wk16 treatments to be taller than the untreated and the Fazor plots analysis showed the differences not to be significant.

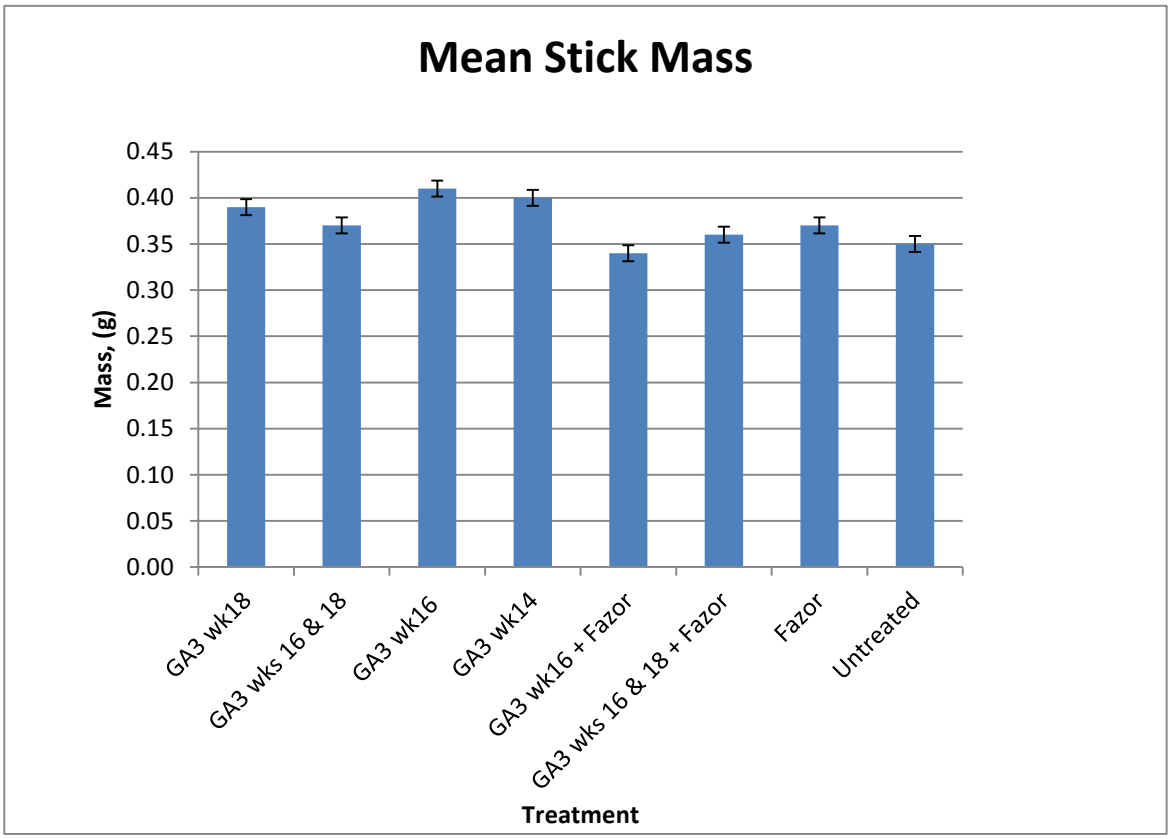


Fig 8 Mean leek weight Variety Triton

Fig 8 shows there were no significant differences in yield measured as mean individual stick weight between any of the treatments and the untreated control, or between the replicates, yields were very consistent across the trial.

Results for Variety Harston

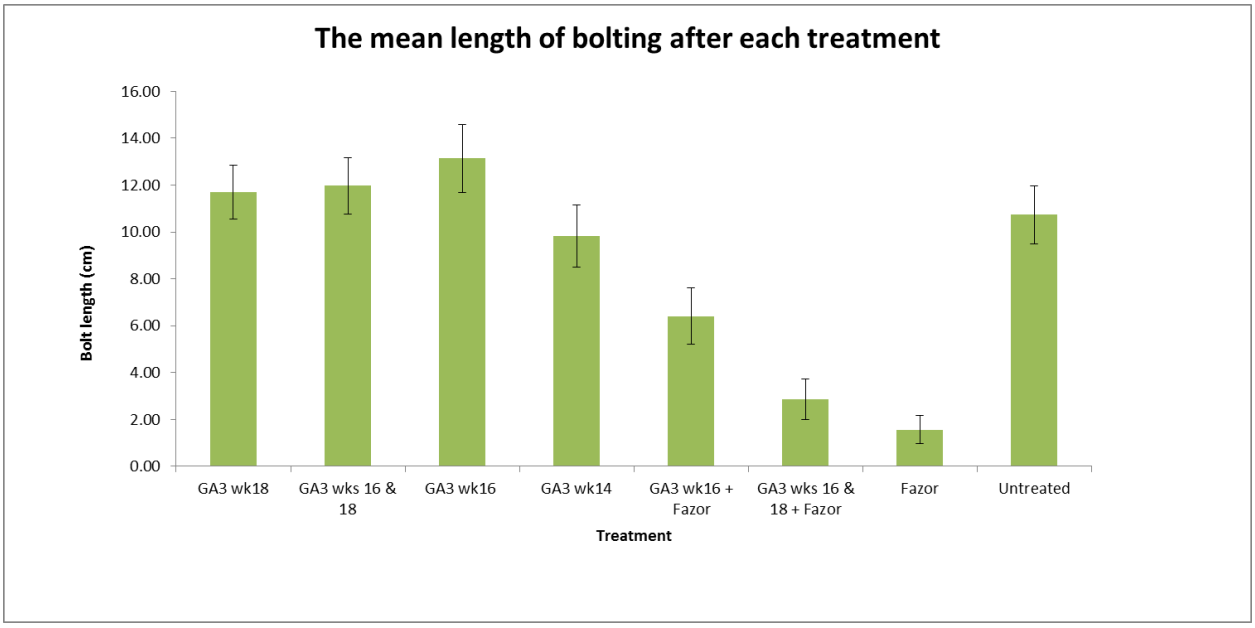


Fig 9. Mean length of bolt variety Harston

Fig 9 shows that there were much greater differences in the bolt height with Harston than with Triton, as would be expected. Again, the treatments containing Fazor gave a highly significant reduction in the length of bolting. Although there appeared to be a trend with some of the GA3 treatments producing a slightly longer length of bolt than the untreated none of these differences were significant.

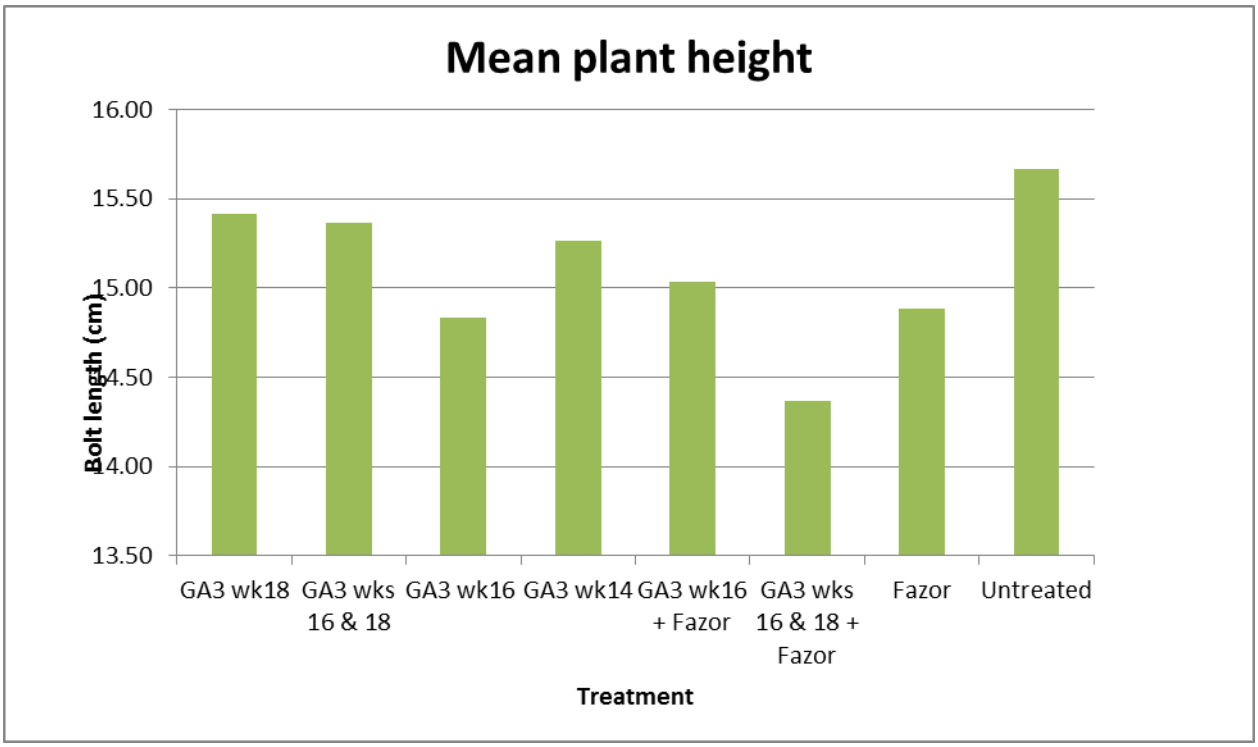


Fig 10. Mean plant height variety Harston

Although Fig 10 appears to show a trend for the untreated leeks to be slightly taller than the treated leeks, none of these differences were significant.

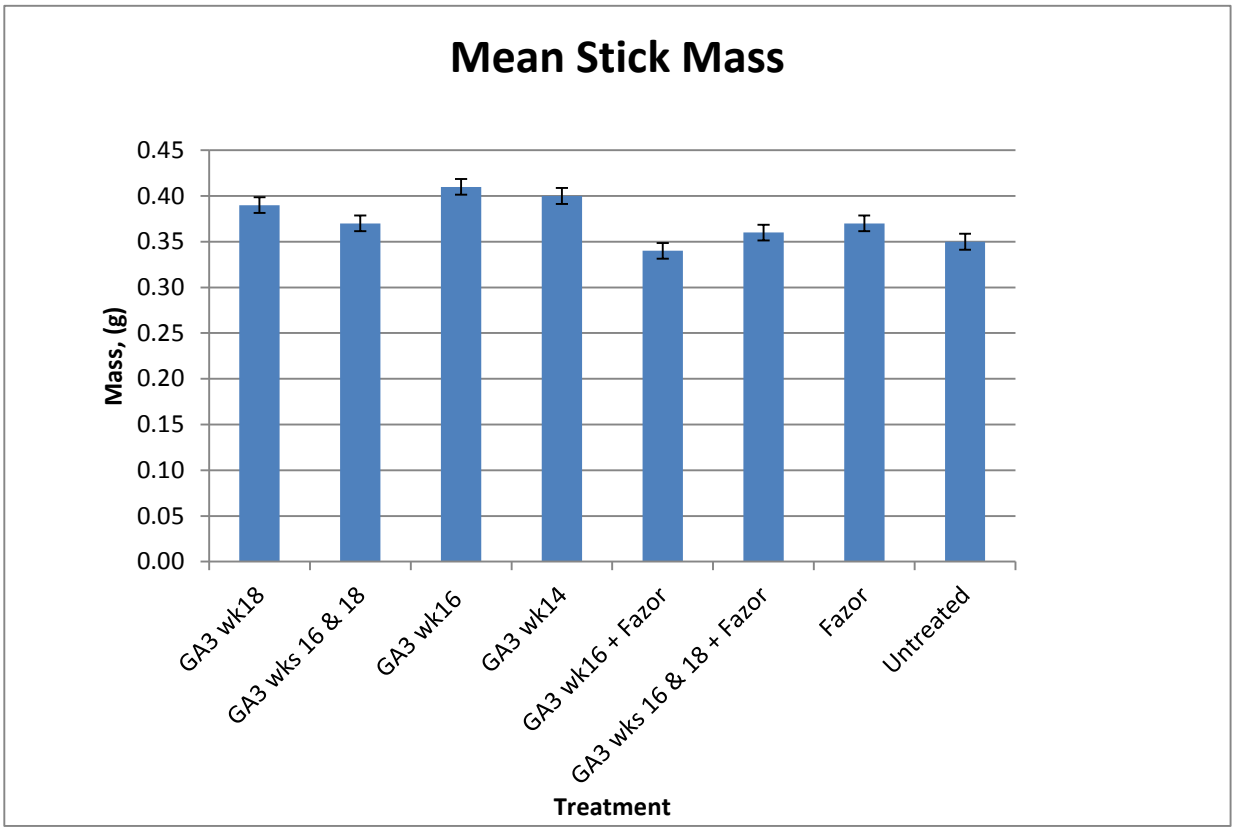


Fig 11. Yield of Harston expressed as mean stick weight.

Fig 11 shows that the yield of leeks was very consistent over the trial with no significant differences between treatments or between the three replicates.

Conclusions

Fazor (maleic hydrazide) showed excellent promise for extending the season of UK leeks. This can be achieved through a reduction in bolting, the main cause of the loss of quality at the end of the UK leek season. In addition to reducing bolting, Fazor has other beneficial effects on leek quality in that it reduced softness and telescoping, both of which are important quality defects at the end of the UK season. There does, however, need to be caution in the use of this product, should it become approved, as application too early can cause leeks to become too short and fat, application too late, after bolting has occurred does not have any beneficial effects. Both a bolt susceptible variety (Harston) and bolt resistant variety (Triton) showed significant benefits from the Fazor treatment by reducing bolting at harvest. Applied at the correct time there appears to be no significant reduction in crop yield.

The use of gibberellins has not been proven to give a statistically significant increase in leek shank length.

If the use of Fazor is combined with a bolt resistant variety and cold storage, the UK could potentially have all year round UK leek production. The potential value of this to the industry would be in the order of £3,000,000 per annum. It is recommended that an approval for the use of Fazor be sought.

Knowledge and Technology Transfer

In this two year project; year one results were presented to the UK Leek Growers Association at their 2012 winter meeting. Results from the year 2 work and the final summary have yet to be presented to the industry, but the project leader would propose these are disseminated at the UK Leek Growers Association Winter 2013 meeting. It would also be proposed to discuss any future work and development of these products following the presentation of the results to the UK Leek Growers Association.

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.

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.

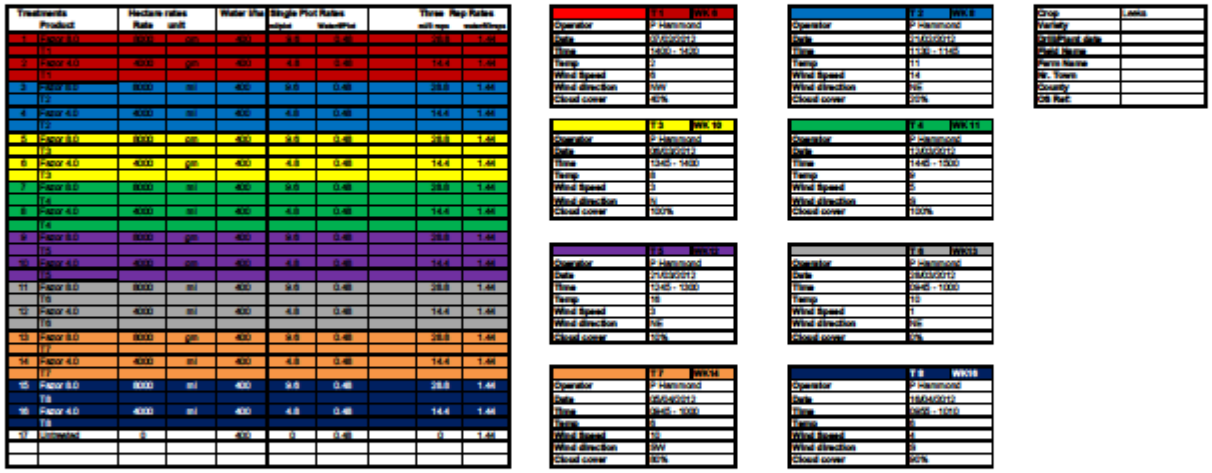
DEFRA Basic Hort Stats
https://www.gov.uk/government/publications/basic-horticultural-statistics

Appendix 1

Year one Treatment Plan Layout

PA -HDC FV387a Leek PGR's Allpress Farms

11	2	7	1	16	8	4	14	17	6	9	3	15	5	10	12	13
9	7	5	11	17	13	15	12	3	14	16	2	6	1	4	8	10
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17



Appendix Two
Year Two Treatment Plan Layout

HDC Leek Season Extension 2013 - FV387a

7	2	1	6	8	4	5	3
4	7	6	8	2	5	3	1
1	2	3	4	5	6	7	8

2M

6M

Treatments		Hectare rates			Single Plot Rates			Three Rep Rates	
	Product	Rate	Water l/ha		g/ml/plot	Water/l/Plot		ml/3 reps	water/l/3reps
1	GA3 wk 18	87.5	400		0.105	0.48		0.315	1.44
2	GA3 wk18+16	87.5	400		0.105	0.48		0.315	1.44
3	GA3 wk 16	87.5	400		0.105	0.48		0.315	1.44
4	GA3 wk 14	87.5	400		0.105	0.48		0.315	1.44
5	GA3 wk 16	87.5	400		0.105	0.48		0.315	1.44
	& Fazor	4000			4.8			14.4	
6	GA3 wk 18, 16	87.5	400		0.105	0.48		0.315	1.44
	& Fazor	4000			4.8			14.4	
7	Fazor	4000	400		4.8	0.48		14.4	1.44
8	Untreated				0	0		0	0

	Timing 1	Timing 2
Operator	P Hammond	P Hammond
Date	18/03/2013	02/04/2013
Time	1600 - 1615	0935 - 0938
Temp	6	5
Wind Speed	6	14
Wind direction	NE	NE
Cloud cover	50%	5%

	Timing 3	Timing 4
Operator	P Hammond	P Hammond
Date	15/04/2013	29/04/2013
Time	0950 - 1010	1040 - 1055
Temp	13	9
Wind Speed	9 (24 gust)	16
Wind direction	E	E
Cloud cover	40%	60%

Crop	Leeks
Variety	Triton
Drill/Plant date	
Field Name	HH27
Farm Name	Hollyhouse
Nr. Town	Mepal
County	Cambs
OS Ref:	435872