FINAL
PROJECT REPORT
for
PC 242

To:

Horticultural Development Council
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Bedding Plants: An investigation into the potential growth promoting and disease suppressive effects of different substrate mixes and commercially available bio-stimulants under different nutrient regimes

August 2006

Grower Summary

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Project Title: Bedding Plants: An investigation into the potential growth promoting and disease suppressive effects of different substrate mixes and commercially available bio-stimulants under different nutrient regimes

Project Number: PC 242

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Project Co-ordinator: Miss Fay Richardson

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Key Words: Bedding plants, bio-stimulants, nutrient, feed, regimes, substrates, pansy, black root rot, *Thielaviopsis basicola*, efficacy.

The results and conclusions in this report are based on a single fully replicated trial at one period during the year. The conditions under which the experiment was carried out and the results generated have been reported with detail and 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 to be used as the basis for commercial product recommendations.

AUTHENTICATION

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

Signature.....

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Date.....

Report authorised by.....

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Grower summary

Headline

- None of the ten commercial biostimulants tested resulted in a significant difference in final commercial evaluation of crop quality.
- Further work is necessary to determine whether such bio-stimulants substrate mixes do help reduce susceptibility to infection either directly or indirectly.
- Investigation of disease suppression in different substrate/biostimulant mixes was inconclusive as inoculation with the fungus *Thielaviopsis basicola*, surprisingly, had little impact on crop vigour and classic symptoms of black root rot did not develop. Hence, further work.

Figure 1. Bio-stimulant trial in January 2006 at crop maturity

Background and expected deliverables

Growers are under constant pressure from retailers to maintain consistently high levels of plant quality whilst concomitantly lowering production costs. However, recent changes in EU legislation have removed many effective pesticides that could previously be used to prevent damage and losses in ornamental crops. Growers therefore face the problem of meeting the retailers' specifications with an increasingly smaller range of pesticides in their armoury.

As a result growers are turning to various 'natural' methods including bio-stimulants and compost teas to improve plant growth and minimise the risk from plant pathogens. Compost teas are dilute extractions of composted plant material, which are subsequently used as drenches or sprays. They allegedly contain a range of micro-flora, such as bacteria and fungi, that are claimed to benefit plant growth, in addition to a number of plant breakdown products such as hormones, humates and nutrients that may influence plant quality. However, the composting process is inherently difficult to control, and this can result in a large variation in the 'quality' of the compost teas with potentially erratic results. In addition, extensive work at SAC as part of an HDC project (HNS 125) on compost teas indicated that the application of compost teas to HONS, in that study at least, had negligible commercial benefits in improving plant quality or controlling disease.

Other work has focused on the development of 'bio-suppressive' substrates, which can reduce the level of soil-borne disease. As with compost teas, this trait has been linked to a range of suppressive micro-flora, which attacks pathogenic organisms by a variety of means, such as direct predation, or through competition for a particular food source. For these bio-suppressive substrates to work the substrate must be carefully chosen, and must contain a relatively high proportion of undecomposed plant material, such as can be found in pine bark or composted green waste (CGW). However, if this material is too well composted it will lack many nutrients essential to sustain a healthy range of micro-flora, and bio-suppression may not occur.

To solve the inherent variability found in the use of compost teas and bio-suppressive substrates, a substantial amount of work has been carried out to identify, isolate and culture the organisms involved in bio-suppression. Many companies have now released 'bio-stimulants' based on specific strains of these organisms, which can be used to artificially boost the levels of beneficials in the substrate, to achieve a positive impact on plant growth and disease. In addition to the bio-stimulants based on microbes, a number of other bio-stimulants are based on inorganic or organic compounds. These can vary from seaweed extract, humates (organic compounds arising from decomposed plant material) and fertiliser products that claim to enhance availability of certain nutrients and perhaps stimulate development of some of the beneficial micro-organisms that occur naturally in composts.

In many cases, the data supporting such products is based on 'in-house' trials and there has been little independent verification of the benefits of their use. Where independent research has been carried out suggests some positive effects have been noted, though further independently verified research is required to ensure that these products do work on a consistent basis under UK conditions. The primary purpose of the trial was to provide information to indicate the potential of these products to improve plant vigour, suppress disease and enhance overall plant

quality. Based on the results it is hoped that growers will, in time, be able to make a more accurate judgement on the economic benefits of applying these products to their crops.

Summary of the project and main conclusions

The project used pansy as a model crop to evaluate the potential impact of various applied bio-stimulants to improve plant vigour, minimise disease risk and enhance overall plant quality under different nutrient and substrate regimes from September 2005 - January 2006.

(i) Growing media

This was the most dominant single factor that influenced crop vigour. Four different substrates were compared including 100% 'Irish' and 'Baltic' peat and two 50:50 pine bark/peat mixes made with both the Irish and Baltic peat. In both assessments the plants grown in 100% peat substrates were more vigorous that those grown in the peat/pine bark mixes. At the first assessment the plants grown in the 100% peat compost were on average 10% more vigorous than those grown in the peat/pine bark mixes, and this difference between the substrates was maintained at the second assessment. However, when fresh weight was analysed the substrates did not directly affect fresh weight and the differences were due to an interaction between substrate types and the feeding regime.

ii) Feed regimes

Where plants were irrigated with either plain water or liquid feed at 100ppm nitrogen there was little visible difference between the plants at maturity. However, when their fresh weight was analysed, plants that were fertilised were significantly heavier when grown in both of the100% peat substrates increasing on average by 15%, but no such increase in fresh weight with feeding was recorded when plants were grown in either of the 50:50 bark/peat mixes.

iii) Bio-stimulants

Half the plants in the trial were inoculated with a spore suspension of the fungus *Thielaviopsis basicola*, cause of black root rot in Pansy, immediately after transplanting. Root infection established successfully in the inoculated control plants 3-4 weeks post-inoculation and this should have formed an effective base infection level for later evaluation of bio-stimulant performance in the trial.

In total 10 different commercial bio-stimulants were compared in the trial. Following application according to manufacturers label recommendations none of the products selected resulted in a visible difference in crop quality during an independent commercial assessment at the termination of the trial, irrespective of whether the plants were inoculated with *T. basicola* or not but the pathogen had not caused severe black root rot symptoms. Hence although some bio-stimulants affected crop development, unfortunately they could not be sufficiently tested in the presence of

disease. Whilst the number of bio-stimulants providing a positive response was relatively small, some also appeared to have a negative impact on both plant vigour and fresh weight.

Bio-stimulant treatments 10 (Mroots) and 12 (Trianum G) reduced plant vigour at both assessments, though only the former reduced the fresh weight to a significant degree. In contrast, bio-stimulant treatment 5 (Biomex Green Cross) increased plant vigour at the first assessment and increased fresh weight to a statistically significant degree.

Whilst some of these bio-stimulants influenced both plant vigour and fresh weight the effects were not noticeable visually when the commercial assessment of the plants was carried out. Nor did any of the applied bio-stimulants affect flowering time to any commercially significant degree and all the treatments reached the point of 30% of pack flowering within 2 – 3 days of each other. When the disease assessments were carried out the results were generally inconclusive and this was considered to be due primarily to the fact that the introduced pathogen had not succeeded in establishing sufficiently to cause characteristic black root rot symptoms in inoculated plants. As a result, none of the applied bio-stimulant treatments had an effect on the level of disease and this aspect of the project requires further investigation. It is pertinent in this respect a *Pythium* sp. developed naturally in this trial and caused a significant degree of root decay. Whilst the infection was not uniform across the trial none of the superimposed treatments appeared to have any appreciable effect on its development.

iv) Interactions

The trial was designed to identify if there was any synergistic or antagonistic interaction between the three major treatments, namely bio-stimulants, substrate type and feeding regime. In the cases where there was some statistically significant interaction, such as between substrates and bio-stimulants the effects were much smaller than the main effects of substrate or bio-stimulant on their own. The only interaction to have a substantial effect was the interaction between substrates and feeding regime on the fresh weight of the plants. When these were recorded it was evident that plants that were fertilised and grown in 100% peat substrates were 15% heavier than those irrigated with plain water when grown in same substrate. In contrast, plants grown in the peat/bark mixes did not produce heavier plants when fed when compared to plants irrigated with plain water.

There were no other significant interactions in the study.

Financial Benefits

Many of the bio-stimulant products evaluated in this study are sold based on claims that they enhance plant vigour, flowering or disease resistance, thus allowing growers to obtain a commercial benefit from their use through maximising quality or reducing waste. However, under the conditions that we tested the products their influence on any of these factors was minimal. It is important however, that the results from this single trial conducted in one season should not

be seen as evidence that these products will not work at all. Rather they perhaps indicate that their effects may not be consistent across all crops, all pathogens or all year round and that further robust studies will be required to improve our understanding of their reported activity as there is considerable anecdotal evidence from growers that they can influence plant growth. However, because many of them are based on living organisms that can be affected by the environment, they cannot be utilised in a similar manner to chemicals that are generally less influenced by environmental conditions. It is also important to consider the cost of application of certain products, especially those that require repeated, often frequent, applications and this may restrict their commercial use due to the high labour costs associated with spraying crops.

Action Points for Growers

- In this trial, agronomic factors such as the choice of substrate had a greater impact on plant growth than any bio-stimulant treatment.
- Until further evidence can be gained to demonstrate positive efficacy from applied bio-stimulants, consider treating a small crop area in the first instance and ensure an untreated control area is retained alongside for comparative purposes.
- Do not rely on bio-stimulants as the sole mechanism to enhance plant growth or control disease
- The application of bio-stimulants should not be seen as a straightforward replacement for pesticides, but as part of a more 'holistic' approach to disease control
- Bio-stimulants cannot act as an eradicant like some chemical treatments, but instead can only potentially prevent the risk of disease through a claimed array of protective mechanisms, and should not therefore be used for the control of established infections.
- As many bio-stimulants are based on living organisms, the growing environment may influence their efficacy.
- The numbers of treatment applications suggested by some products (every two weeks) allied to limited benefits for plant growth and health seen in this trial make their use questionable when labour costs are considered.

Science section

Introduction

In the USA in the 1980's it was noted by HONS growers that plants grown in substrates with a high proportion of pine bark exhibited a lower incidence of soil borne diseases and this phenomenon was termed 'disease suppression' (Hoitink *et al* 2000, DeCuister 1999, Hoitink 1985). The discovery stimulated a considerable amount of work in an attempt to discover the mechanisms behind this effect as it was thought it could offer growers the opportunity to control disease without recourse to aggressive and expensive pesticides. Dr. Harry Hoitink of Ohio State University has demonstrated that an indigenous micro-flora evolves in these 'suppressive' substrates that inhibit the development of pathogenic organisms through a number of different mechanisms. These may involve direct predation of the pathogen, direct competition for food source or habitat, improving nutrient absorption by plant roots or other more tenuous mechanisms. As the work progressed a number of micro-organisms were identified as playing a major role in the effectiveness of suppressive substrates (Litterick *et al* 2004). Fungi such as *Trichoderma* and *Streptomyces* spp. and bacteria, most notably *Bacillus subtilis*, *Pseudomonas* spp. and *Agrobacterium* spp. appeared to be most significant in this regard.

However, research by Hoitink indicated that the composting process that generated these suppressive composts could adversely affect the degree of suppression. This is due to the fact that these suppressive organisms require a certain level of nutrients (such as complex and simple sugars), which are rapidly reduced as the compost matures – thus if the material is composted for too long, it will be devoid of any useful nutrients. As a result, if the complex composting process could not be accurately controlled, then growers could not rely on the substrates alone to suppress disease during commercial production on a consistent basis.

In addition to the potential use of suppressive composts, there are alternative means of boosting the levels of beneficials in the substrates rather than relying on the natural development of micro-flora in the substrates. One approach is the use of 'compost teas', which are derived from a dilute extraction of decomposed plant material. It has been suggested that these preparations contain a complex mix of beneficial organisms, together with other useful products arising from plant breakdown such as hormones and minor nutrients, which may boost the health of the plant. However, these products suffer from the same difficulty in controlling the exact nature of the composting process, potentially resulting in a large variation in the number and type of the micro-flora in the solution, therefore reducing their efficacy on some occasions. This concern has been borne out in a recent HDC trial on these products at SAC (HNS 125), which indicated that the applications of these compost teas have negligible effect on plant quality and health.

To reduce the problem in the potential variation in the type and range of micro-flora generated by suppressive substrates and compost teas, researchers started to identify and culture specific strains of fungi and bacteria implicated in disease suppression or enhanced plant growth; the aim being to generate a more consistent response.

As a result of such research several companies have brought a number of fungal and bacterial products to market as 'bio-stimulants', claiming that their use will accelerate the development of specific beneficial micro-flora within the substrate thus enhancing plant growth and reducing the incidence and severity of disease. Work in America (McSpadden 2002, Arena and Jeffers 2001) has indicated that they may work, but there has been little independent verification of these products within the UK. A small amount of 'commercial' work has been carried out to date e.g. W J Findons and Son, and whilst this generated some useful information, no work has been undertaken on disease suppression.

One potential problem with the use of the formulated commercial preparations or products is that early work by Hoitink and Kuter in 1985 indicated there was a link between POC (particulate organic matter) and disease suppression. In this work they discovered that as the level of the least decomposed fraction of organic material fell, the degree of suppression was reduced. Hoitink proposed that these products would only work effectively in substrates using a relatively young peat that has undergone relatively little decomposition, such as a 'blonde' peat from the Baltic regions, as opposed to a dark, highly decomposed peat that can be readily found in Irish peat bogs. The efficacy of these products could be boosted further by incorporating a portion of green waste or pine bark to provide a wider range of food sources for the microbes, hence maintaining a higher level of microbial activity.

In addition to the bio-stimulants based on biologically active preparations, other products are also being marketed which claim similar responses. These are either fertiliser preparations claimed to boost plant growth by enhancing availability of levels of certain nutrients, or plant extracts from seaweed or decomposed plant material such as humates. These bio-stimulants can be applied to the plants as a drench or pre-mixed into the compost. Over the past 5 years they have intensively marketed in the USA and European countries, and several products are now well established in the marketplace.

Within the UK a number of such bio-stimulant products are currently being marketed though, at the present time depending on the label claim's they fall outside the scope of the Control of Pesticides Regulations (COPR) or the Plants Protection Products Regulations (PPPR). Instead, in general they tend to fall within a 'grey area' that is less well regulated. It is possible that they will ultimately be regulated as a result of the EU harmonisation directive (Directive 91/414/EC) though this is likely to still depend on the actual manufacturers label claims for specific products.

It is highly significant however, that with the marked reduction in the number of plant protection products available to growers to assist in maintaining plant quality and control disease there has been a significant upsurge in both interest and use of these alternative products. In spite of the interest in these products and considerable use by some growers, there has been little independent verification of their actual benefits, with the majority of information available coming

direct from individual companies marketing literature. It is also pertinent here that those growers who use such products rarely leave an untreated area of the crop for comparison purposes, and therefore such anecdotal information is of limited value from a scientific perspective.

The primary objective of this trial therefore was to compare a range of different substrates in conjunction with a series of commercially available biostimulant products marketed in the UK, the aim being to determine whether the various label claims and hypotheses proposed elsewhere are robust. A pansy crop was selected as an appropriate host due to its general susceptibility to root disease. Rather than relying on a natural infection of disease, the black root rot pathogen (*Thielaviopsis basicola*) was introduced artificially. Finally in addition, a further parameter was included to examine different feed regimes and their potential impact on the crop and biostimulant performance.

Materials & Methods

(i) Trial site location and cropping details

A modern glasshouse (Multi-Factorial Unit compartment) at STC Ltd, comprising some 200 sq m floor space was allocated for the study. Seed of pansy 'Blue Blotch' were sown into '360' trays then germinated under controlled conditions courtesy of W J Findons and Son. When the cotyledons had fully developed the trays of plants were collected and transported to STC where they were grown-on until ready for transplanting in polystyrene 'double-six' packs. When the plugs were ready, they were transplanted and placed on a Mypex covered floor in the glasshouse at STC for trial purposes.

(ii) Trial Design

The trial site comprised of a fully randomised split plot design with 3 replicate blocks. Each replicate contained 4 different inoculation/fertiliser treatment combination blocks (12 in total) as demonstrated below in Figure 2. Each treatment block contained the randomised individual substrate/biostimulant combinations composed of 4 substrates and 12 different bio-stimulants treatments (Figure 3). Each bio-stimulant treatment was comprised of 2 x 'double six' packs of plants giving a complex array of 576 individual plots in the trial.

Figure 2. Overall layout of biostimulant trial

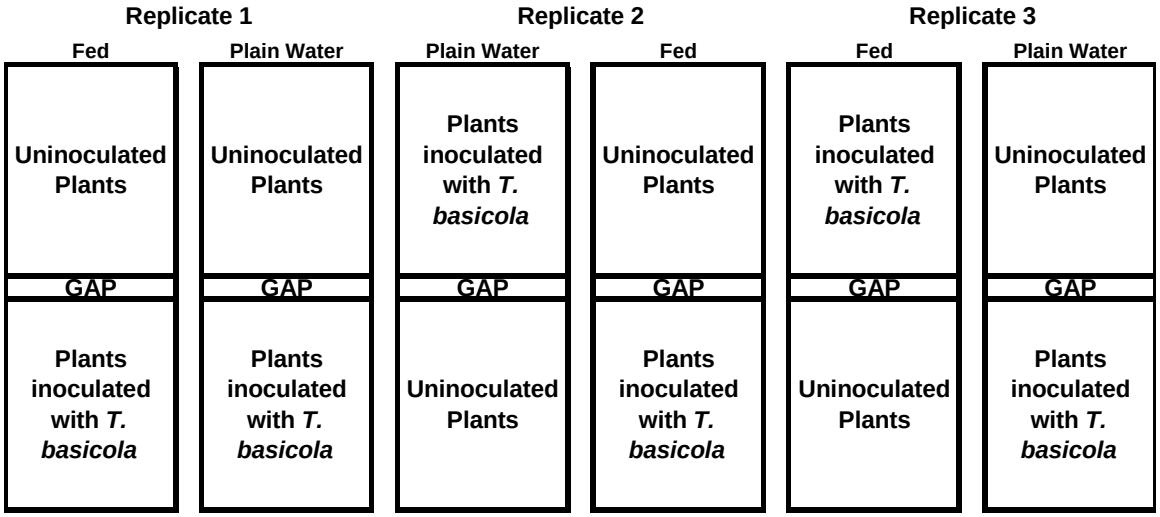


Figure 3. Detailed breakdown of an individual treatment block

1 - 12 = different bio-stimulant treatment (BS) described in Table 1

BS 1	BS 2	BS 3	Substrate 1
BS 4	BS 5	BS 6	
BS 7	BS 8	BS 9	
BS 10	BS 11	BS 12	
etc.			Substrate 2
			Substrate 3
			Substrate 4

(iii) Compost products and mixes

The substrates were supplied courtesy of Bulrush horticulture and were composed of the following:-

1. A young 'blonde' Baltic peat
2. A mature Irish peat
3. A 50:50 mix of Baltic peat and pine bark
4. A 50:50 mix of Irish peat and pine bark

(iv) Nutrient feed regimes

For two weeks after transplanting all plants were irrigated with plain water, and then the trial was split. One batch of plants continued to be irrigated with plain water for the remainder of

trial whereas the other half was irrigated with a liquid feed at every watering providing 100 ppm N based on 'Sangral' 1:1:1 fertiliser injected through a Dosatron at 1:100 dilution

(v) Bio-stimulant product selection and application

Following extensive industry consultation, through discussion with various colleagues and the HDC project co-ordinator, a range of available UK bio-stimulant products were chosen for further study. A full list of the short-listed products is shown in Table 1. Eight of the bio-stimulants were based on bacterial/fungal preparations; the remaining two being based on humates or fertiliser preparations. The fungicide carbendazim (Bavistin DF) was used as a standard control treatment.

Table 1: Selected bio-stimulants and related treatments used in the trial

Product	Application	Active Substance	Mixing rate	No. & timing of applications *
1. Untreated control	–	–	–	–
2. Chemical control – Bavistin DF	Drench	Carbendazim	1g/litre	**Once at transplanting**
3. Bactolife	Drench	Bacteria and fungi with	500g in 100 litres water	**Every two months after**

		fertiliser		**initial application**
4. Biohumate	Drench	Humate plus fulvate salts with plant saponins	0.5 litres in 100 litres water	**Every month after initial application**
5. Biomex Green Cross	Foliar Spray	Foliar fertiliser with highly available phosphorous	2 litres in 100 litres water	**Every two weeks after initial application**
6. Gliomix	Drench	*Gliocladium*	160g in 100 litres water	**Once at transplanting**
7. Revive	Drench	Bacteria	320 ml in 100 litres water	**Once at transplanting**
8. Stimagro	Foliar Spray	Soil microbes	40g in 100 litres water	**Every month after initial application**
9. Biofungus	Compost Incorporation	6 species of *Trichoderma*	200g in 100 litres compost	**Once - pre-mixed in substrate**
10. MRoots	Compost Incorporation	Fertiliser + 17 species of endo- and ecto- mycorrhiza	60g in 100 litres water, mix well into substrate	**Once - pre-mixed in substrate**
11. Mycortex	Compost Incorporation	Bacteria, fungi, mycorrhiza, humates and plant extracts	250g in 100 litres water mix well into substrate	**Once - pre-mixed in substrate**
12. Trianum-G	Compost Incorporation	*Trichoderma harzianum*		**Once - pre-mixed in substrate**

* Treatments were started at transplanting and continued (where necessary) until marketing stage (~30% pack flowering) according to manufacturers recommendations

(vi) <u>Diary</u>

Action	Date
Collection of plants from Findons	08/09/05
CCC spray (0.5ml/litre)	16/09/05
Incorporation into compost of Biofungus, MRoots, Mycocortex and Trianum-G products	04/10/05
Plugs transplanted	05/10/05
Application of Bactolife, Biohumate, Biomex Green Cross, Gliomix, Revive and Stimagro products	06/10/05
Plants inoculated with *T. basicola*	14/10/2005
1st vigour assessment	26 /10/05
Application of Biomex Green Cross	19/10/2005
Application of Biohumate, Biomex Green Cross and Stimagro	04/11/2005
Application of Biomex Green Cross and initial sampling of plants to determine presence of *T. basicola*	18/11/2005
2nd vigour assessment	25/11/05
Application of Bactolife, Biohumate, Biomex Green Cross, Stimagro	02/12/2005
Application of SL567A to control downy mildew	12/12/2005
Flowering assessment	6/10 – 15/12/2005
Commercial assessment and 'shelf-life' storage trial	13 - 20/12/2005
Application of Biohumate	16/12/2005
Destructive disease assessment	13 – 19/01/2006

(vii) Fungicide applications

To prevent the potential risk of applied fungicides adversely affecting the establishment and performance of the bio-stimulants, it was agreed that (apart from standard fungicide treatment T2) fungicides would only be applied in situations where the presence of disease potentially compromised the trial objectives. The utmost care was taken to ensure that where they were used they were likely to have minimal impact on both the introduced pathogen and the applied bio-stimulant products.

(viii) Assessment Parameters

a) Time to rooting out

The time for the roots to penetrate to side and bottom of the pack was scheduled to be recorded. However, the removal of the plants from the trays proved impossible to accomplish without causing damage to the plant, which could have affected later measurements on vigour. As such, further attempts to measure this aspect ceased.

b) Plant vigour indices

The plants were assessed for vigour twice during the project, once when the plants had established and the tray cover was incomplete allowing individual plants to be readily assessed, and again when tray cover was almost complete. A subjective 0 – 5 scale was used where 0 was dead, 1 was smallest and 5 the largest.

For the first assessment the standards used were individual plants, but by the second assessment it was not possible to judge each plant separately, and a ½ tray (six plants) was used as the assessment standard.

c) Flowering

The date each individual flower opened was recorded until ~50% flowering had occurred.

d) Quality and shelf life assessment

The HDC Project Co-ordinator was asked to carry out this component of the work and the assessments benefited from prior involvement in the development of the bedding plant quality assessment trials conducted at Wellesbourne. The bedding plants were assessed using the scoring system developed in PC200 when the plants reached marketing stage (~30% of pack flowering). After the assessment a portion of the plants were subsequently placed on a Danish trolley for 4 days to assess whether their shelf life was improved by any treatment.

e) Fresh weight

After the quality assessment was complete, 3 plants were sampled at random from each replicated treatment and fresh weight recorded on a digital scale to 2 decimal places.

f) Appearance of foliar deficiencies

Throughout the trial a record was taken of the development of any foliar deficiencies that could affect overall quality of plants.

g) Pathogen inoculation

An isolate of *Thielaviopsis basicola* collected from infected pansy roots was bulked up on potato dextrose agar (PDA, Oxoid) and grown for one month until conidia and

chlamydospores had been produced. The agar-based cultures were macerated with de-ionised water (90 plates/25litres water) using a hand blender to give a smooth homogenous mix. On the 14th October, approximately 1 week after transplanting, 10ml aliquots of the suspension were applied using a syringe directly around the stem base of the treated plants.

The trial was subsequently inspected regularly to monitor the crop for signs of disease development e.g. poor growth and vigour, purpling of leaves, plant death.

In mid-November a more detailed examination of plants was undertaken of a small number of plants in the inoculated control plots were also examined following removal from the trays using low and high power microscopy to check the roots for black root rot and other infections. A significant proportion of the roots on each plant examined showed characteristic discolouration and the presence of chlamydospores of *T. basicola* indicating that the inoculation with *T. basicola* had been successful. It was not possible to carry out a full disease assessment across the trial at this stage as this would have required destruction of a significant proportion of the trial crop. However, the infection process was judged to be entirely satisfactory at this stage and it was considered just a matter of time before foliar symptoms were expressed.

At the end of the trial period in mid-January 2006 a full, destructive disease assessment was carried out. During this assessment 6 plants from each 12 pack (12 plants/treatment from 4 replicates) were removed from their modules and inverted so that the level of discolouration on the roots could be assessed. The amount and severity of the root discolouration was scored using the following 0-3 severity score. A visual example of each severity score is presented at Figure 4.

0-3 Severity score for root discolouration

0 - roots white and healthy in appearance
1 - slight discolouration on a small amount of root
2 – more extensive discolouration affecting approximately 50% of visible root tissue.
3 – severe discolouration affecting > 75% of visible root tissue

Figure 4 - Roots showing 0-3 discolouration scale

Where root discoloration was evident sub-samples of affected plants were returned to the laboratory to determine the presence of black root rot caused by *T. basicola* via high power (x 400) microscopy. Checks for the presence of other root pathogens were conducted at the same time.

Results

Bio-stimulant manufacturers claim that the products can enhance the growth the growth and development of plants in number of different ways, such as increased growth, disease resistance and higher overall quality. As a result we series of parameters were chosen that could be used to ascertain whether the products were capable of influencing growth as had been claimed.

i) Time to rooting out
ii) Plant vigour (two assessments)
ii) Flowering
iii) Quality and shelf –life assessments
iv) Fresh weight

v) Foliar deficiencies
vi) Resistance to disease

(i) Time to rooting out

Due to excessive damage caused to the plants when checking for degree of root development, this parameter was no longer assesed as damage may have influenced later results.

(ii) Plant Vigour

a) First vigour assessment (26/10/05)

The statistical interpretation of this data indicated that there were significant differences with the following factors

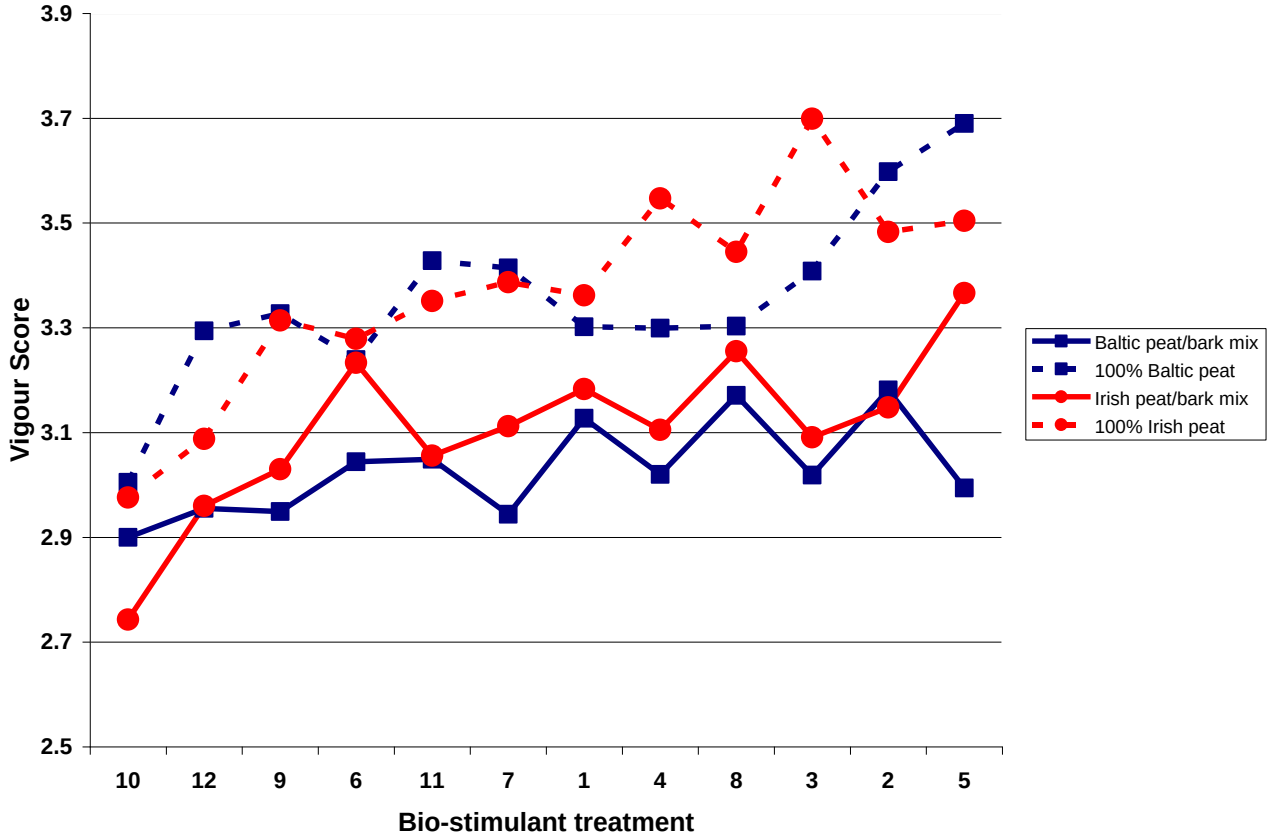
a.i) Substrate and bio-stimulants
a.ii) Substrate
a.iii) Bio-stimulants

a.i) Substrate and bio-stimulant interaction

Of the three factors influencing vigour, the interaction between the bio-stimulants and substrate was the least significant, and was mainly due to the interaction between bio-stimulants 3 and 5, as can be seen in Figure 5 which shows the increasing bio-stimulant means for each substrate, with a least significant difference of 0.26.

The interaction appeared to be due to bio-stimulants 3 (Bactolife) and 5 (Biomex Green Cross)
When bio-stimulant 3 was used plants grown in the Irish peat were significantly more vigorous (by 0.3 units) compared to those grown in the Baltic peat. With biostimulant 5, plants grown in Baltic peat/bark substrate were less vigorous (by 0.4 units) than those grown in Irish peat/bark mix. However, these interactions were statistically less significant than the main effects seen with either the substrate or bio-stimulants.

Figure 5. Impact of bio-stimulant/substrate interaction on vigour at first assessment



a.ii) Substrate

When these results were analysed, it was clear that the substrate had a significant impact on plant vigour, with plant grown in both the 100% peat substrates were significantly more vigorous, averaging about 0.3 units more than plants grown in peat/bark mixes (Table 2)

Table 2. Compost mean vigour scores

Substrate	Vigour Score
Baltic bark	3.03
Baltic peat	3.36
Irish bark	3.11
Irish peat	3.37
SED (24 df)	0.063

This could potentially be a result of slightly increased water stress in the peat/bark mixes, or perhaps the plants were slower to get established in the more open mix.

a.iii) Bio-stimulants

Although the majority of bio-stimulants had no significant impact on plant vigour (Table 3), three did. When compared to the untreated control, plants treated with bio-stimulant 5 (Biomex Green Cross) were more vigorous, but those treated with bio-stimulants 10 (Mroots) and 12 (Trianum G) were less vigorous than the control.

Table 3. Bio-stimulant mean vigour scores at first vigour assessment.

Bio-stimulant	Vigour	Significance level (Compared with control)
1. Control	3.24	
2. Bavistan WF	3.35	NS
3. Bactolife	3.30	NS
4. Biohumate	3.24	NS
5. Biomex Green Cross	3.39	5%
6. Gliomix	3.20	NS
7. Revive	3.23	NS
8. Stimagro	3.29	NS
9. Biofungus	3.16	NS
10. MRoots	2.91	1%
11. Mycortex	3.22	NS
12. Trianum-G	3.07	1%
SED (352 df)	0.061	

b) Second vigour assessment (25/11/05)

With over 25% of the plots scoring 5 in this assessment the results were heavily skewed, which made statistical analysis using a standard analysis of variance (ANOVA) difficult. Instead, a further statistical test (Mann-Whitney U test) was used to validate the results for direct effects of the bio-stimulants.

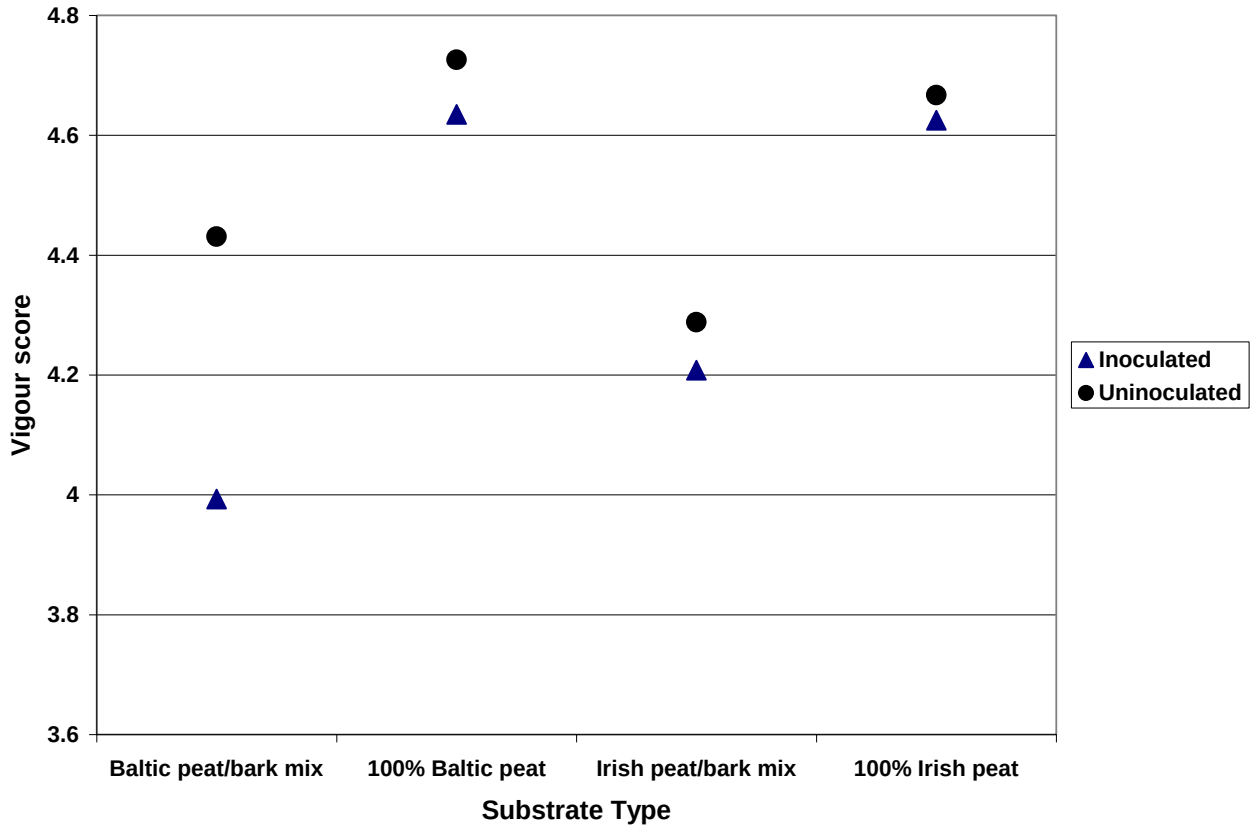
The main effects seen in this vigour assessment were:

b.i) Substrate and inoculation interaction
b.ii) Substrate and feed
b.iii) Substrate
b.iv) Bio-stimulants

b.i) Substrate and inoculation interaction

As with the first vigour assessment, the interaction between two factors was less significant than the main effects seen in either the substrate or bio-stimulants. In this interaction, the vigour of inoculated plants grown in the Baltic peat/bark mix was significantly reduced (0.45 units) compared to uninoculated plants in the same substrate. Inoculation in the other substrates had little effect.

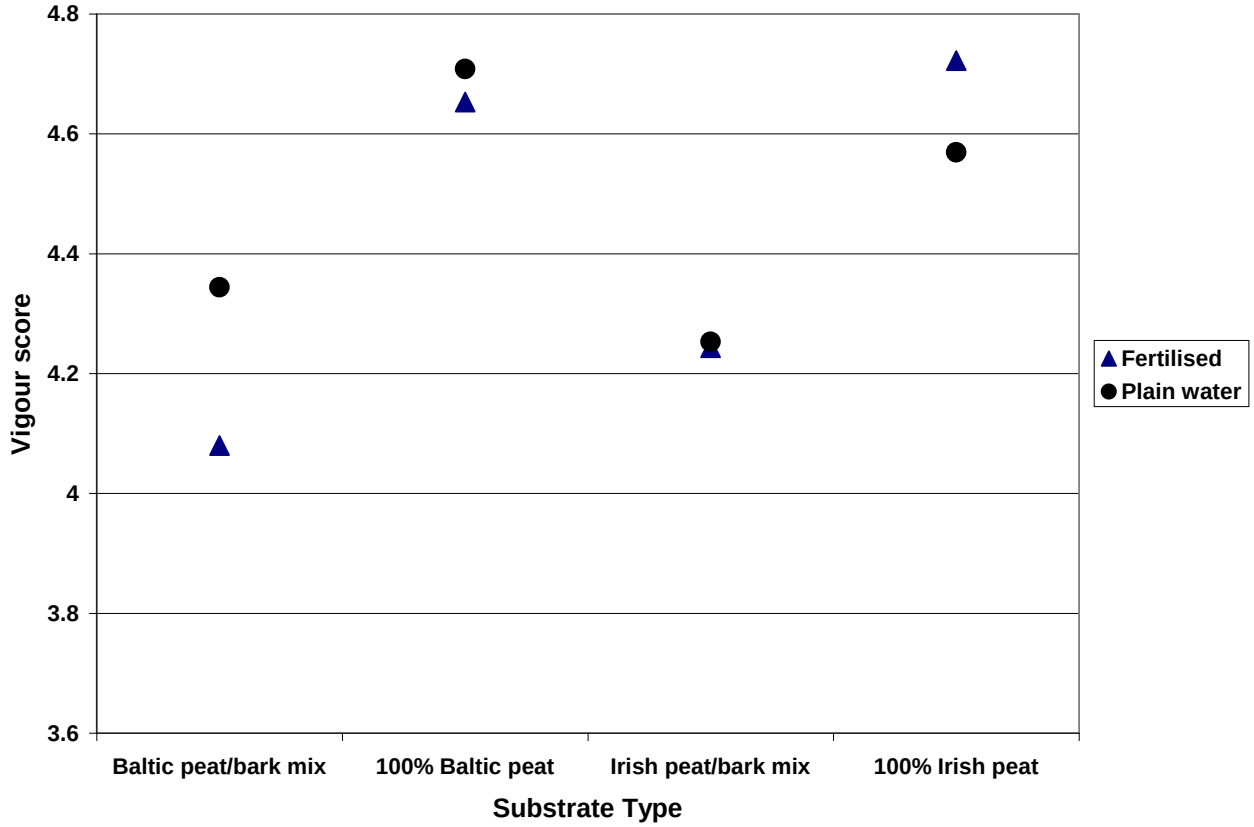
Figure 6. Impact of inoculation/substrate interaction on vigour score at second assessment



b.ii) Substrate and feed interaction

The other, smaller interaction was between the substrate and feeding regime, where unfed plants in Baltic peat/bark mix were more vigorous than the fed plants. However, the differences are not much greater than the standard error of the means and this result may be an anomaly.

Figure 7. Impact of fertiliser/substrate interaction on vigour at second assessment



b.iii) Substrate

The distinct differences seen between substrates in the first vigour assessment (i.e. better performance in 100% peat) were even more pronounced at the second vigour assessment, with the difference increasing to 0.4 units (Table 4).

Table 4. Compost mean vigour scores

Substrate	Vigour
Baltic bark	4.21
Baltic peat	4.68
Irish bark	4.25
Irish peat	4.65
SED (24 df)	0.058

b.iv) Bio-stimulants

In contrast with the first vigour assessment, plants treated with biostimulant 5 (Biomex Green Cross) no longer exhibited increased vigour when compared to the control. However, plants treated with bio-stimulants 10 (Mroots) and 12 (Trianum G) continued to exhibit the reduced vigour noted in the first vigour assessment.

Table 5. Bio-stimulant mean vigour scores at the second vigour assessment.

Bio-stimulant	Mean (Vigour)	Mann -Whitney Significance level (Compared with control)
1. Control	4.56	
2. Bavistan WF	4.62	NS
3. Bactolife	4.73	NS
4. Biohumate	4.50	NS
5. Biomex Green Cross	4.67	NS
6. Gliomix	4.48	NS
7. Revive	4.45	NS
8. Stimagro	4.67	NS
9. Biofungus	4.35	NS
10. MRoots	3.83	<0.1%
11. Mycortex	4.47	NS
12. Trianum-G	4.19	<0.1%

(iii) Flowering times

From the data generated from the trial it is evident that the different biostimulant treatments had little impact on time to flower (see Appendix 1), a factor that is more clearly controlled by temperature and light. 64 days after transplanting no treatment combination had reached 30% pack flowering, after 67 days 92% had reached that point, and all treatments had reached 30% pack flowering at 70 days. One trend, although it was not consistent across all the treatments, was that plants grown in 50:50 peat/bark mixes tended to be slower to flower than plants grown in other substrates.

(iv) Quality and shelf-life assessment

When the quality assessment was carried out it proved impossible to detect any differences between the treatments in relation to this parameter. There was no substantial difference in any

factor that could affect plant quality, such as foliage colour/development, flowering or growth habit.

After the plants were assessed following storage on a Danish trolley, apart from a small degree of stretching across all treatments, there were no substantial differences detected, with no obvious impact on plant quality.

(v) Fresh weight

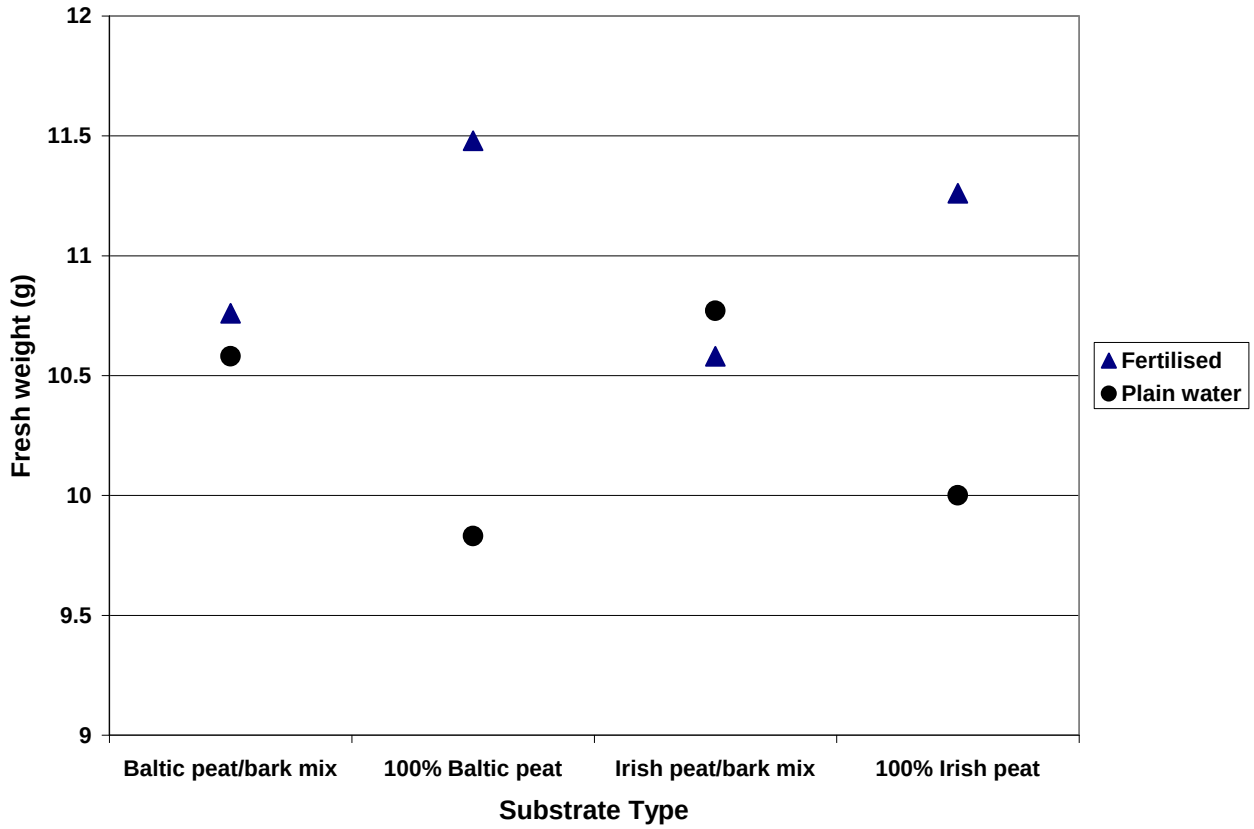
The main effects of fresh weight analysis were:-

1. Feed and compost interaction
2. Main effects of bio-stimulant

c.i) Feed and substrate interaction

Although there were minor differences seen in vigour with substrate/feed interactions, when the fresh weight of plants was analysed it was evident that there was a greater impact on plant growth than could be picked up by visual inspection alone. Feeding had a positive impact on plant growth when plants were grown in 100% peat based substrateswith an average increase of 15% fresh weight when plants were fed, but this enhanced growth was not evident in plants grown in peat/bark mixes.

Figure 8. Impact of substrate/fertiliser regime interaction on plant fresh weight



c.ii) Main effects of bio-stimulants

The fresh weights of the biostimulant treatments varied from 10.2g to 11.17g, with three bio-stimulants exhibiting significant differences (Table 6). Treatments 2 (Fungicide control) and 5 (Biomex Green Cross) were significantly heavier than the control, and treatment 10 (Mroots) was significantly lighter. However, the maximum % weight gain or loss in comparison with the control was ~ 6%, a difference that would not be immediately noticeable when visually assessed.

Table 6. Mean fresh weights of plants with different bio-stimulants

Bio-stimulant	Mean fresh weight (g)	Significance level (Compared with control)
1. Control	10.58	
2. Bavistan WF	11.17	5%
3. Bactolife	10.52	NS
4. Biohumate	10.73	NS
5. Biomex Green Cross	11.16	5%
6. Gliomix	10.74	NS

7. Revive	10.41	NS
8. Stimagro	10.63	NS
9. Biofungus	10.68	NS
10. MRoots	10.20	5%
11. Mycortex	10.60	NS
12. Trianum-G	10.49	NS
SED (352 df)	0.274	

(vi) Foliage quality

Throughout the trial it was not possible to detect any variation in the colour of the foliage. The only aspect that was noted was that the Biohumate product, which was a dark viscous material, stained the leaves and this remained evident for a number of days after treatment. This may have been more visible at this time of year (compared to Spring-Summer) as the plants were only irrigated occasionally and the product was not washed off.

With the lack of a prophylactic fungicide spray regime in place (to minimise impact on bio-stimulants) the pansy crop did suffer from sporadic outbreaks of downy mildew in the later stages of trial. Applications of SL567A (metalaxyl-M) did retard disease progress though did not eradicate the problem completely. Where the disease developed it appeared to be entirely random and was not associated with any specific substrate, feed or specific bio-stimulant treatment.

(vii) Pathogen inoculation

Unfortunately the introduced pathogen, whilst establishing successfully, did not develop on the roots sufficiently to cause classic black root rot symptoms on the above-ground portion of the plants e.g. leaf yellowing/purpling and stunting. This made it difficult to conduct an evaluation of the efficacy of the applied bio-stimulants with respect to disease suppression.

During the detailed root assessments discolouration of root tissues was evident, including in the uninoculated control plants. Microscopic examination of the discoloured roots showed no evidence of infection by *T. basicola* and chlamydospores, conidia or mycelium were not found on either the uninoculated or inoculated roots. However, low numbers of fungal resting spores (oospores) consistent with those of a *Pythium* sp. were observed. Sub-samples of roots from both inoculated and uninoculated plants were collected and cultured onto selective and non-selective agar in the laboratory. A *Pythium* sp. was consistently isolated from all root samples yet surprisingly *T. basicola* was not detected.
The data in Table 7 compares the effect of the bio-stimulants within each compost type.

- Within composts A and B (Irish peat and 50:50 mix Irish peat and pine bark respectively), no significant differences in the severity and incidence of root discolouration were seen.

- With compost C (Baltic peat) the inoculated treatments 4 (Biohumate), 9 (Biofungus) and 10 (Mroots) all showed significantly higher severity of root discolouration than the untreated control (Treatment 1).

- With compost D (50:50 mix of Baltic Peat and Pine Bark) the uninoculated 2 (fungicide), 3 (Bactolife) and 11 (Mycortex) all resulted in significantly lower levels of root discolouration than the inoculated 5 (Biomex Green Cross) and 8 (Stimagro).

Table 7. Comparison of severity and incidence of root discolouration within each compost type.

Treatment	Mean Severity of Root Discolouration (0-3 scale)	Treatment	Mean Severity of Root Discolouration (0-3 scale)	Treatment	Mean Severity of Root Discolouration (0-3 scale)	Treatment	Mean Severity of Root Discolouration (0-3 scale)
A1 U	0.21^{ab}	B1 U	0.17^{a}	C1 U	0.15^{cd}	D1 U	0.17^{bc}
A2 U	0.31^{ab}	B2 U	0.0^{a}	C2 U	0.04^{d}	D2 U	**0.02^{c}**
A3 U	0.21^{ab}	B3 U	0.25^{a}	C3 U	0.23^{cd}	D3 U	**0.02^{c}**
A4 U	0.04^{b}	B4 U	0.04^{a}	C4 U	0.15^{cd}	D4 U	0.38^{abc}
A5 U	0.19^{ab}	B5 U	0.33^{a}	C5 U	0.29^{cd}	D5 U	0.33^{abc}
A6 U	0.31^{ab}	B6 U	0.31^{a}	C6 U	0.29^{cd}	D6 U	0.08^{bc}
A7 U	0.31^{ab}	B7 U	0.13^{a}	C7 U	0.10^{cd}	D7 U	0.04^{bc}
A8 U	0.31^{ab}	B8 U	0.04^{a}	C8 U	0.29^{cd}	D8 U	0.21^{bc}
A9 U	0.69^{ab}	B9 U	0.67^{a}	C9 U	0.23^{cd}	D9 U	0.08^{bc}
A10 U	0.25^{ab}	B10 U	0.27^{a}	C10 U	0.60^{a-d}	D10 U	0.27^{abc}
A11 U	0.33^{ab}	B11 U	0.27^{a}	C11 U	0.27^{cd}	D11 U	**0.02^{c}**
A12 U	0.31^{ab}	B12 U	0.23^{a}	C12 U	0.25^{cd}	D12 U	0.31^{abc}
A1 I	0.47^{ab}	B1 I	0.23^{a}	C1 I	0.20^{cd}	D1 I	0.24^{bc}
A2 I	0.52^{ab}	B2 I	0.60^{a}	C2 I	0.44^{a-d}	D2 I	0.44^{abc}
A3 I	0.46^{ab}	B3 I	0.71^{a}	C3 I	0.71^{a-d}	D3 I	0.48^{abc}
A4 I	0.77^{ab}	B4 I	0.35^{a}	C4 I	**1.27^{ab}**	D4 I	0.65^{abc}
A5 I	0.42^{ab}	B5 I	0.58^{a}	C5 I	0.81^{a-d}	D5 I	**1.17^{a}**
A6 I	0.42^{ab}	B6 I	0.17^{a}	C6 I	0.71^{a-d}	D6 I	0.60^{abc}
A7 I	0.33^{ab}	B7 I	0.83^{a}	C7 I	1.06^{abc}	D7 I	0.35^{abc}
A8 I	0.65^{ab}	B8 I	0.38^{a}	C8 I	0.98^{a-d}	D8 I	**0.98^{ab}**
A9 I	0.90^{a}	B9 I	0.54^{a}	C9 I	**1.25^{ab}**	D9 I	0.83^{abc}
A10 I	0.81^{ab}	B10 I	0.65^{a}	C10 I	**1.35^{a}**	D10 I	0.77^{abc}
A11 I	0.46^{ab}	B11 I	0.38^{a}	C11 I	0.71^{a-d}	D11 I	0.60^{abc}

A12 I	0.79[ab]
LSD P=0.05	0.43
SD	0.30
CV	69.44

B12 I	0.77[a]
LSD P=0.05	0.48
SD	0.34
CV	92.23

C12 I	0.63[a-d]
LSD P=0.05	0.55
SD	0.39
CV	72.24

D12 I	0.48[abc]
LSD P=0.05	0.51
SD	0.36
CV	91.14

Means followed by the same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

U = Uninoculated I = Inoculated SD = standard deviation CV = coefficient of variance

Table 8. Comparison of severity and incidence of root discolouration - all compared to A1 uninoculated.

Treatment	Mean Severity of Root Discolouration (0-3 scale)
A1 U	0.21^{e-h}
A2 U	0.31^{d-h}
A3 U	0.21^{e-h}
A4 U	**0.04^{gh}**
A5 U	0.19^{e-h}
A6 U	0.31^{d-h}
A7 U	0.31^{d-h}
A8 U	0.31^{d-h}
A9 U	0.69^{a-h}
A10 U	0.25^{e-h}
A11 U	0.33^{d-h}
A12 U	0.31^{d-h}
A1 I	0.47^{a-h}
A2 I	0.52^{a-h}
A3 I	0.46^{b-h}
A4 I	0.77^{a-h}
A5 I	0.42^{b-h}
A6 I	0.42^{b-h}
A7 I	0.33^{d-h}
A8 I	0.65^{a-h}
A9 I	0.90^{a-g}
A10 I	0.81^{a-h}
A11 I	0.46^{b-h}

Treatment	Mean Severity of Root Discolouration (0-3 scale)
B1 U	**0.17^{fgh}**
B2 U	**0.0^{h}**
B3 U	0.25^{e-h}
B4 U	**0.04^{gh}**
B5 U	0.33^{d-h}
B6 U	0.31^{d-h}
B7 U	**0.13^{fgh}**
B8 U	**0.04^{gh}**
B9 U	0.67^{a-h}
B10 U	0.27^{e-h}
B11 U	0.27^{e-h}
B12 U	0.23^{e-h}
B1 I	0.23^{e-h}
B2 I	0.60^{a-h}
B3 I	0.71^{a-h}
B4 I	0.35^{d-h}
B5 I	0.58^{a-h}
B6 I	0.17^{fgh}
B7 I	0.83^{a-h}
B8 I	0.38^{c-h}
B9 I	0.54^{a-h}
B10 I	0.65^{a-h}
B11 I	0.38^{c-h}

Treatment	Mean Severity of Root Discolouration (0-3 scale)
C1 U	**0.15^{fgh}**
C2 U	**0.04^{gh}**
C3 U	**0.23^{e-h}**
C4 U	**0.15^{fgh}**
C5 U	0.29^{d-h}
C6 U	0.29^{d-h}
C7 U	**0.10^{gfh}**
C8 U	0.29^{d-h}
C9 U	0.23^{e-h}
C10 U	0.60^{a-h}
C11 U	0.27^{e-h}
C12 U	0.25^{e-h}
C1 I	0.20^{e-h}
C2 I	0.44^{b-h}
C3 I	0.71^{a-h}
C4 I	**1.27^{ab}**
C5 I	0.81^{a-h}
C6 I	0.71^{a-h}
C7 I	1.06^{a-e}
C8 I	0.98^{a-f}
C9 I	**1.25^{abc}**
C10 I	**1.35^{a}**
C11 I	0.71^{a-h}

Treatment	Mean Severity of Root Discolouration (0-3 scale)
D1 U	0.17^{fgh}
D2 U	**0.02^{gh}**
D3 U	**0.02^{gh}**
D4 U	0.38^{c-h}
D5 U	0.33^{d-h}
D6 U	**0.08^{gh}**
D7 U	**0.04^{gh}**
D8 U	0.21^{e-h}
D9 U	0.08^{gh}
D10 U	0.27^{e-h}
D11 U	**0.02^{gh}**
D12 U	0.31^{d-h}
D1 I	0.24^{e-h}
D2 I	0.44^{b-h}
D3 I	0.48^{a-h}
D4 I	0.65^{a-h}
D5 I	**1.17^{a-d}**
D6 I	0.60^{a-h}
D7 I	0.35^{d-h}
D8 I	0.98^{a-f}
D9 I	0.83^{a-h}
D10 I	0.77^{a-h}
D11 I	0.60^{a-h}

A12 I	0.79^{a-h}	B12 I	0.77^{a-h}	C12 I	0.63^{a-h}	D12 I	0.48^{a-h}
						LSD P=0.05	0.48
						SD	0.35
						CV	79.67

Means followed by the same letter do not significantly differ (P=0.05, Student-Newman-Keuls)

U = Uninoculated I = Inoculated SD = standard deviation CV = coefficient of variance

In Table 8 the data compares all of the treatments back to A1 (uninoculated, untreated, standard compost).

- Several of the uninoculated treatments (shown in bold) resulted in a significantly lower severity of root discolouration than 3 of the inoculated treatments in compost C.

- The level of discolouration recorded in the uninoculated treatments in all composts appeared to be slightly lower than that recorded in the inoculated samples, but in the majority of cases the differences were not significant (P=0.05), largely due to variability between replicates.

It was not possible to determine whether any of the discolouration seen was caused by *T. basicola* or whether it was all caused by infection with *Pythium* sp., though the absence of characteristic spores of *T. basicola* on the roots and the general presence of oospores suggested it was primarily caused by the isolated *Pythium* sp. which occurred naturally in the trial area.

Discussion

The removal of many highly effective fungicides from the marketplace due to recent EU legislation has resulted in growers facing increasing difficulties in producing the high quality plants demanded by retailers. This has led to increasing interest in the use of bio-stimulants that claim to enhance growth and disease control through maximising levels of 'beneficials' in the substrates.

During this trial detailed assessments were made of parameters that bio-stimulants were alleged to influence e.g. agronomically important parameters such as growth (vigour, fresh weight) flowering times, and foliage quality. Although some statistically significant effects with a small number of bio-stimulants were seen, when vigour and fresh weight were analysed, these were not large enough to have any real impact on a commercial crop. The largest influence on plant growth was with factors such as substrate type or feeding regime rather than the direct effects of the bio-stimulants. When a commercial assessment was made of the different treatments there was no discernable difference seen between the different bio-stimulants.

However, it is important to note that their performance in the presence of disease could not be fully evaluated as, for some unaccounted reason, the introduced pathogen failed to establish to cause characteristic black root rot symptoms. It is possible, of course, that one or other of the introduced biological biostimulant products could have colonised the trial area and hence prevented the pathogen from establishing. Alternatively, the climate or other conditions at the time of the year the trial was conducted may not have been favourable for infection or establishment of the fungus. Unfortunately there was no means of determining this in the trial conducted. It is of course also possible that some other micro-organisms including the *Pythium* sp. identified out-competed the *T. basicola* and halted its establishment.

The one consistent effect that was seen was with 'Mroots', which reduced both plant vigour and fresh weight. This apparent negative impact may reflect the use of the specific organisms used in this biostimulant – mycorrhizal fungi. These fungi are well known to improve the ability of plants to absorb nutrients in a symbiotic relationship, and can enable plants to scavenge phosphate more effectively. However, these plants also draw nutrients directly from the roots of the host plant until they establish themselves in the environment. In addition, under conditions where the plant is adequately or excessively fertilised, the fungi may switch from a symbiotic to parasitic relationship, again drawing nutrition from the plant rather than the surrounding soil (Marschener, H 1995). It may have been the case that in this trial either or both of these conditions existed, with the resulting negative effect on plant vigour and weight.

However, when an independent commercial assessment was conducted by the HDC grower co-ordinator, there were no important differences in relation to the visual quality of the plants between the treatments. This fact is important to growers as unless there is a distinct and visible effect to be gained from the use of bio-stimulants their use may be not be cost-effective. With some bio-stimulants, such as Biohumate, they left stains on the surface of the leaf that affected the appearance of the crop.

However, bio-stimulants are also claimed to affect the level of disease present in a crop, and the purpose of the disease aspect of this trial was to provide a measure of the efficacy of the various bio-stimulants used to a) enhance root and plant vigour and make the plants more able to withstand infection from pathogens and b) to directly protect the roots from the chosen pathogen by competition or direct antagonistic behaviour. It is fairly clear that none of the biostimulant treatments used in this trial were particularly effective in reducing the *Pythium* spp. infection which occurred naturally, though randomly, in the trial area. It is also relevant here that the standard fungicide (carbendazim) applied in treatment 2 would not have had any activity against oomycete fungi such as *Pythium* spp..

It is possible that the timing of the trial may not have been particularly conducive to the development of black root rot infection. In an ideal scenario putting plants under stress whilst they are putting a lot of energy into a growth spurt leads to plants that are more prone to infection from pathogens, and also faster development of disease symptoms. A trial carried out during the spring or early summer may provide a more suitable environment for development of good root rot symptoms. Either way, it is evident that further work is required in this regard.

Conclusions

- The use of some bio-stimulants may influence plant vigour and size, but in this trial the differences were not commercially significant

- In the absence of a successful infection with black root rot it was not possible to whether the bio-stimulants had any positive or negative effects. However, they appeared to have had minimal influence on the *Pythium* that occurred naturally, but sporadically in the trial

- Agronomic factors such as the type of the substrate and nature of the feeding regime had a greater influence on plant vigour and fresh weight, compared to the impact of the bio-stimulants.

- The use of the evaluated bio-stimulant products as a straight replacement for fungicides could potentially present a high-risk scenario at the present time. It is imperative therefore that further work is carried out, preferably in conjunction with the manufacturers to further validate their efficacy, especially in response to high disease pressures from a range of different root and foliar pathogens.

- Improvements in general plant health are likely to be as readily and more consistently achieved through improved crop husbandry, and attention to crop hygiene.

- The timing of the use of these bio-stimulants may affect their efficacy – this trial took place during a period of low temperatures (October 2005 - January 2006). Successful bio-suppression may be more robust at certain minimal substrate temperatures i.e. above 10°C, and in this respect further validation is required under different environmental regimes.

- In conclusion therefore more independent work needs to be carried out to ascertain if the efficacy of such bio-products can be improved by temperature, substrate type and other such agronomic factors in the presence of aggressive pathogens.

Technology Transfer

The trial site was visited by a number of horticultural technical managers, and information was passed on to interested parties at BBPA/HDC meetings, but no formal presentation of work has been made to date.

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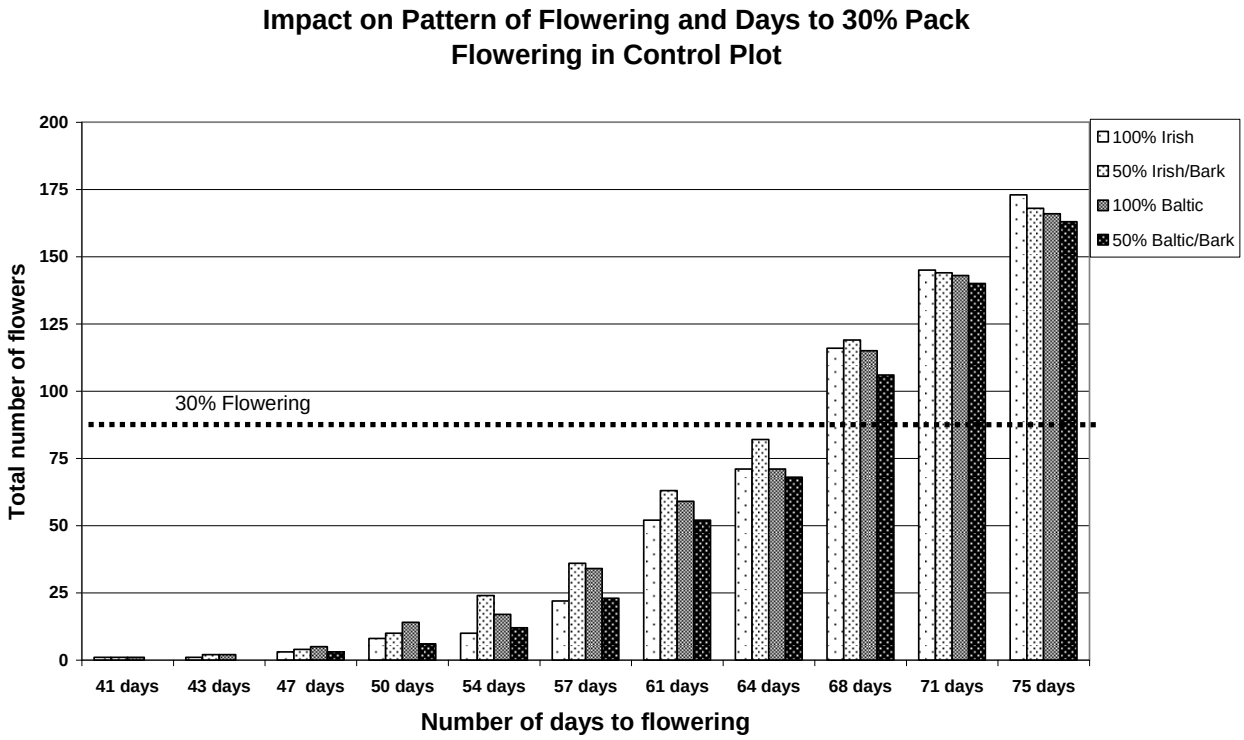
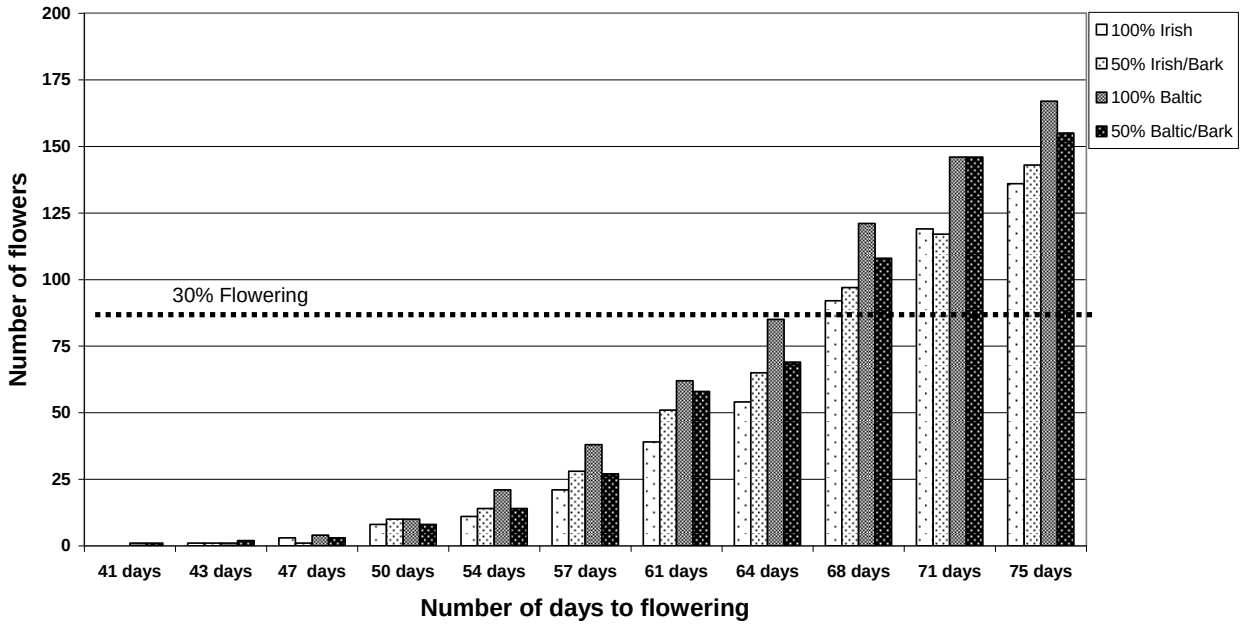
Appendices

Appendix 1.

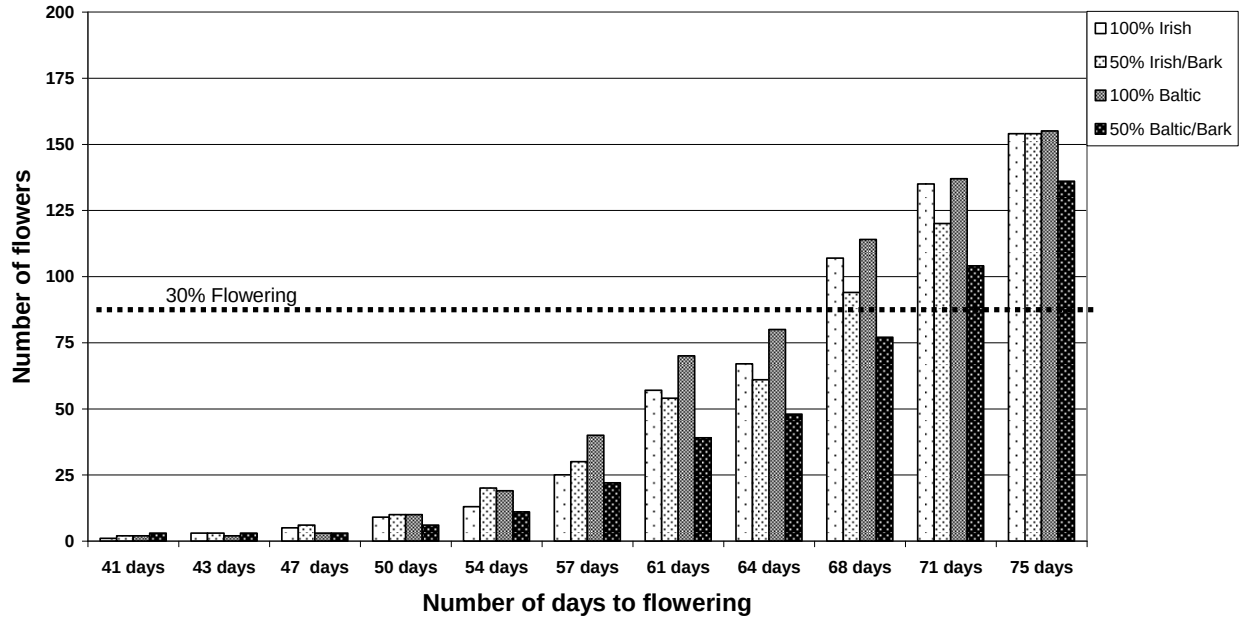
1. Pattern of flowering



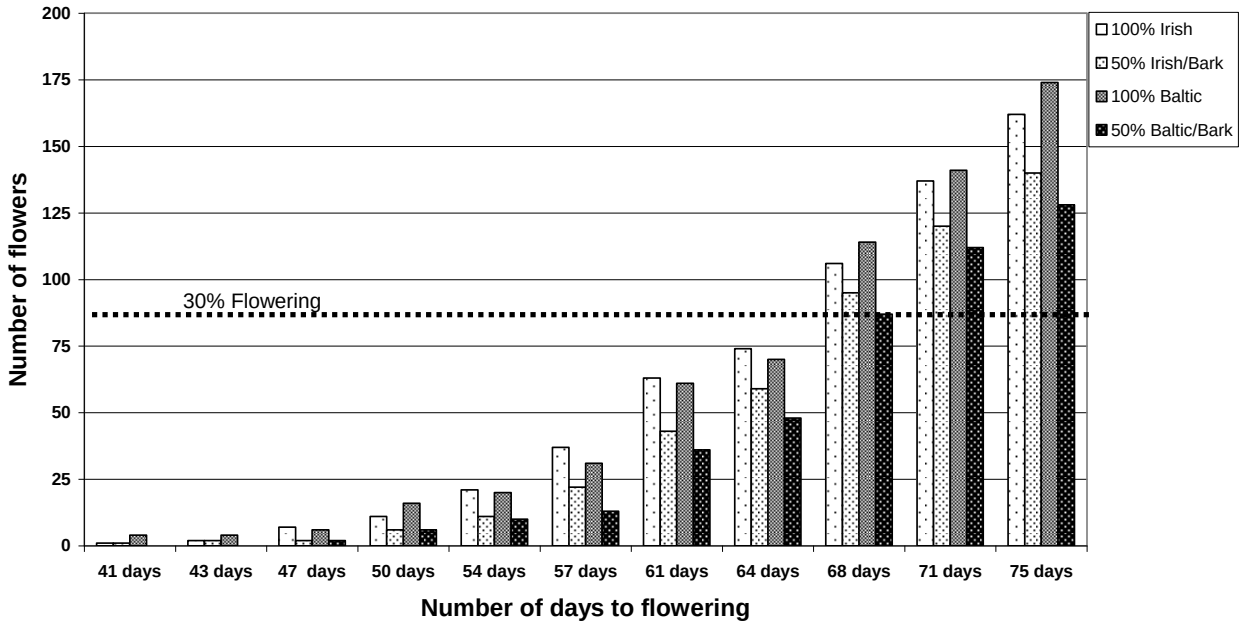
Impact of Bavistin DF on Pattern of Flowering and Days to 30% Pack Flowering



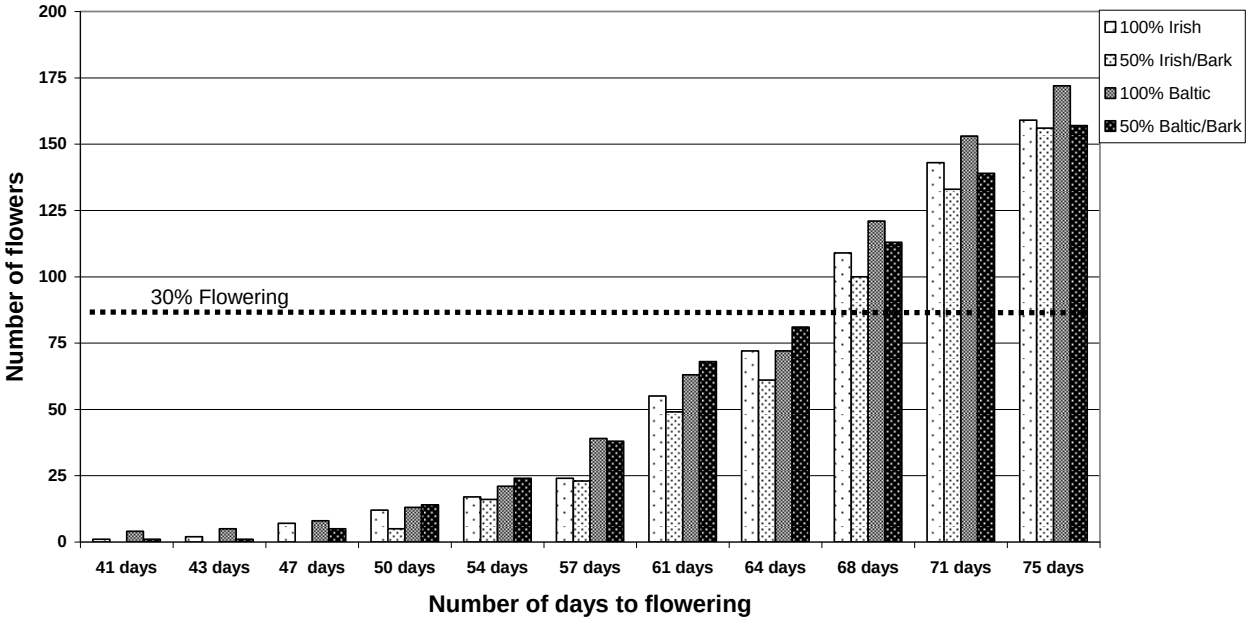
Impact of Bactolife on Pattern of Flowering and Days to 30% Pack Flowering



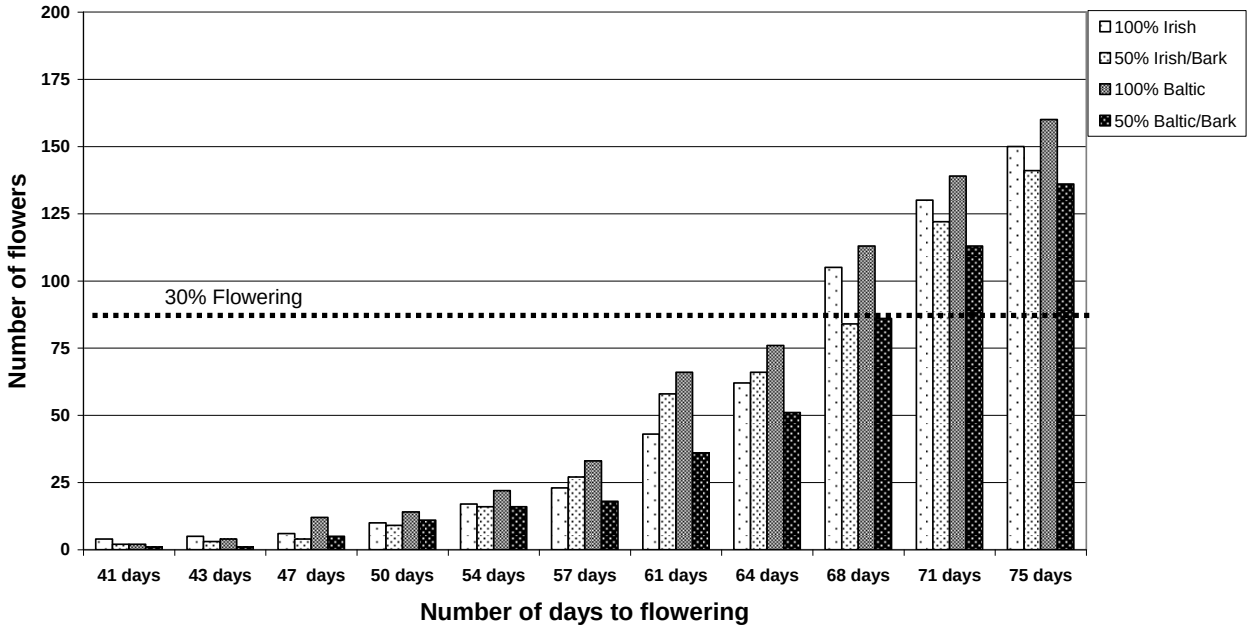
Impact of Biohumate on Pattern of Flowering and Days to 30% Pack Flowering



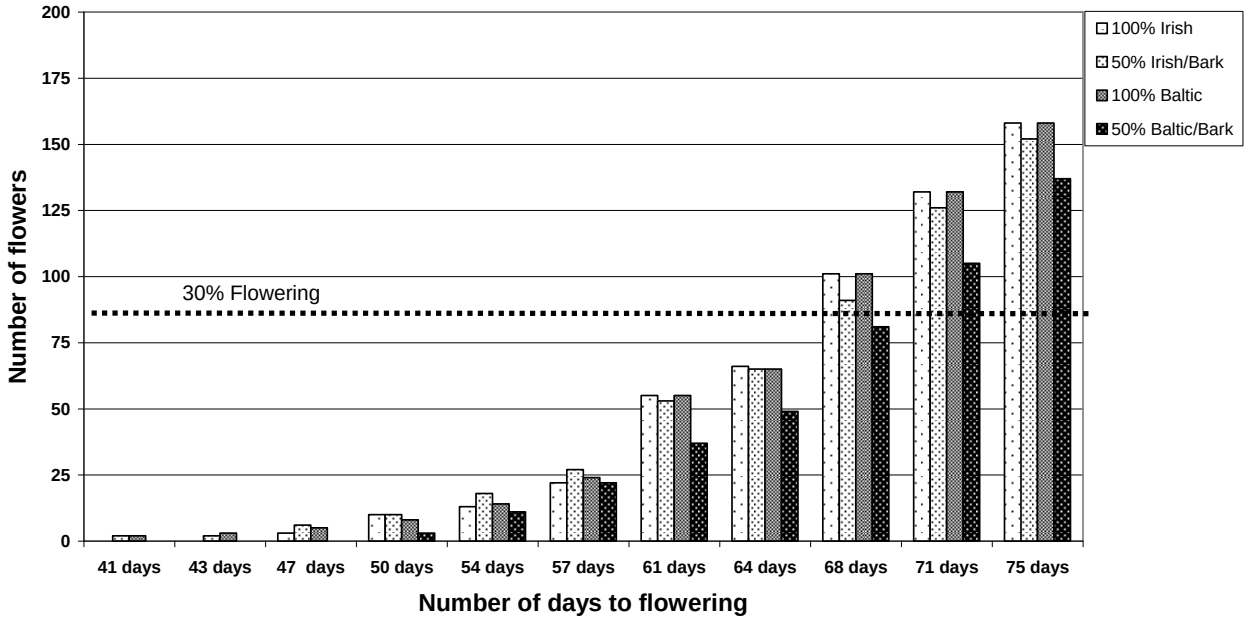
Impact of Biomex Green Cross on Pattern of Flowering and Days to 30% Pack Flowering



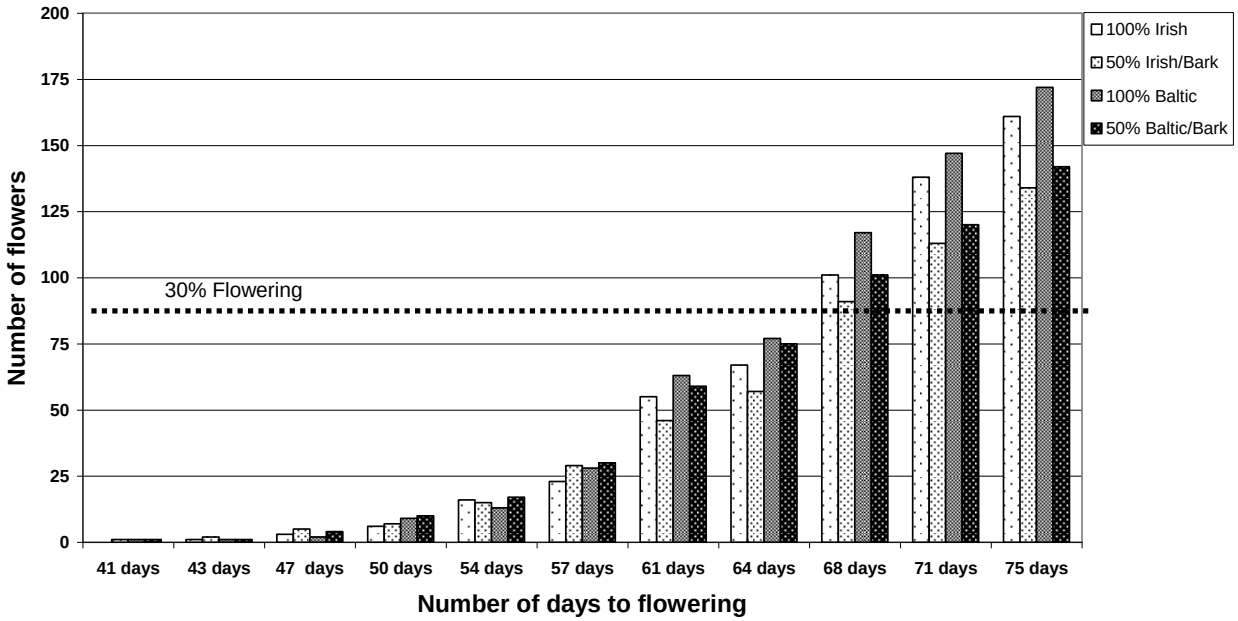
Impact of Gliomix on Pattern of Flowering and Days to 30% Pack Flowering



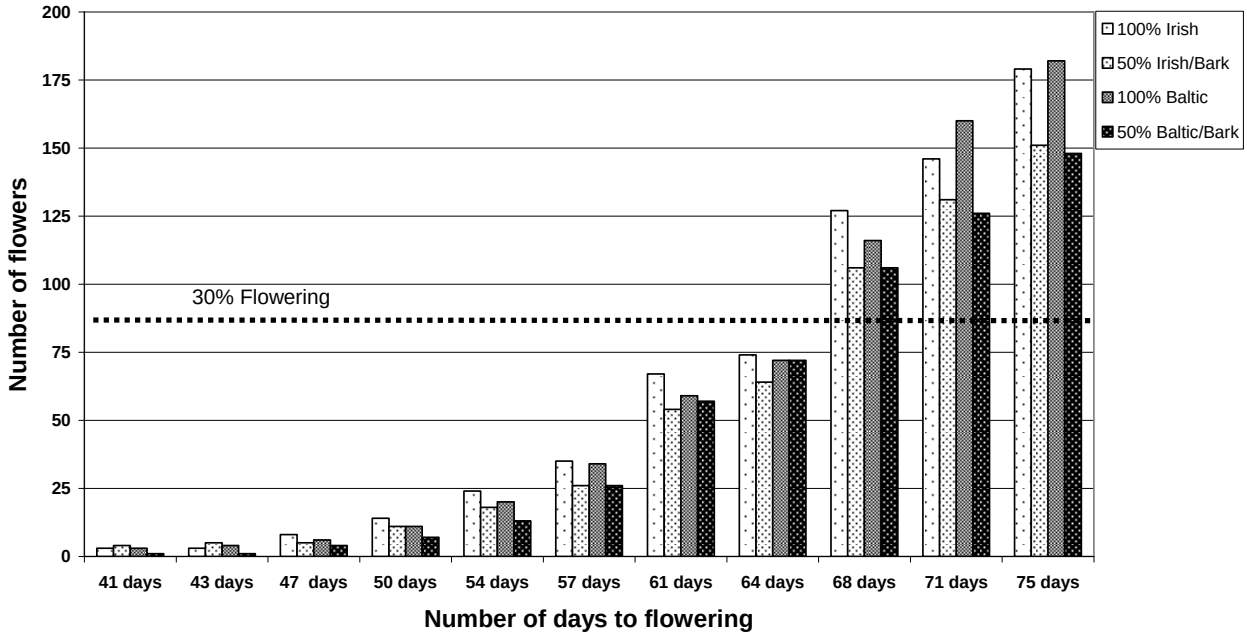
Impact of Revive on Pattern of Flowering and Days to 30% Pack Flowering



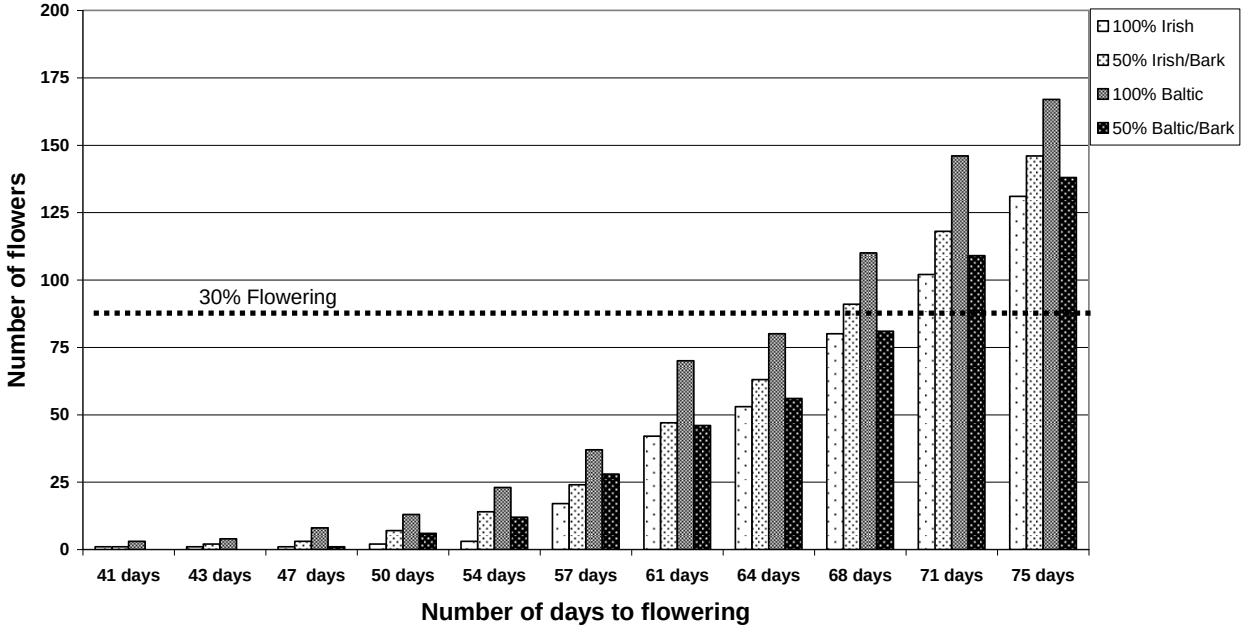
Impact of Stimagro on Pattern of Flowering and Days to 30% Pack Flowering



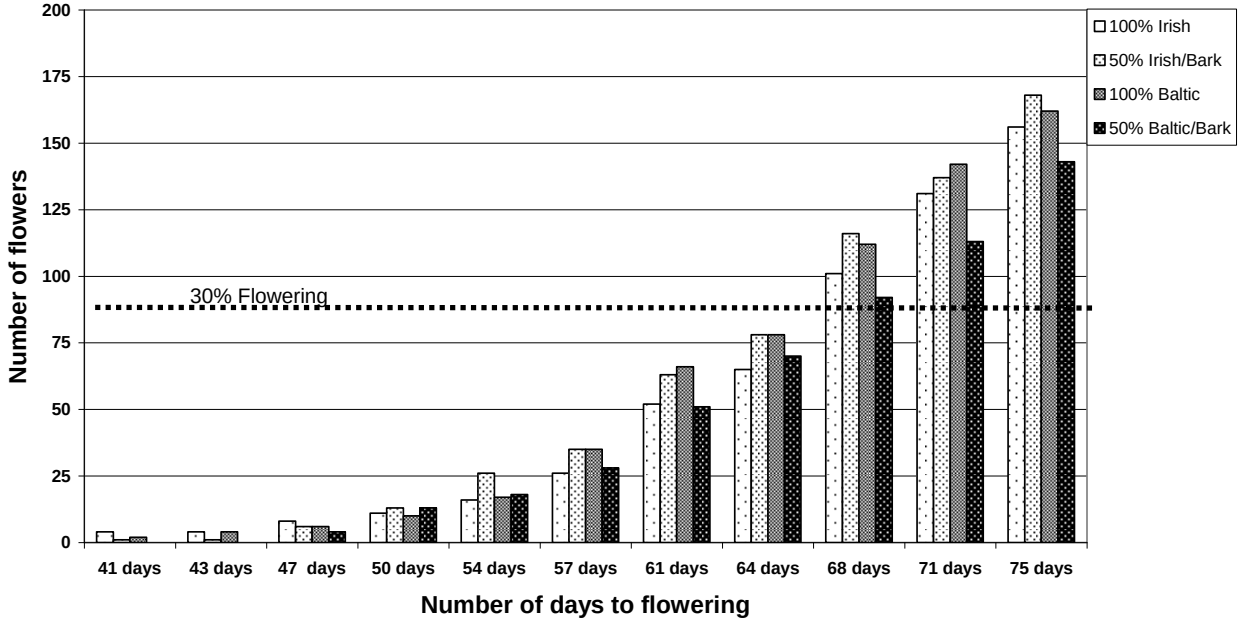
Impact of Biofungus on Pattern of Flowering and Days to 30% Pack Flowering



Impact of MRoots on Pattern of Flowering and Days to 30% Pack Flowering



Impact of Mycortex on Pattern of Flowering and Days to 30% Pack Flowering



Impact of Trianum-G on Pattern of Flowering and Days to 30% Pack Flowering