DEPARTMENT for ENVIRONMENT, FOOD and RURAL AFFAIRS

CSG 15

Research and Development

Final Project Report

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Project title	Alternative, non-animal based nutrient sources, for organic plant raising.
DEFRA project code	**OF0308**
Contractor organisation and location	IOR-Elm Farm Research Centre Hamstead Marshall Newbury Berks RG20 0HR
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Executive summary (maximum 2 sides A4)

Organic plant raising has been investigated under two previous government funded projects (OF0109 & OF0144) (1, 2) and it was shown in this research that organic ‘transplants’ could be produced for a range of crop species (3, 4, 6, 7). However, some species were easier to produce than others and one of the limiting factors was the availability of suitable nutrient sources, especially for supplementary feeding. The use of animal based nutrient sources in organic plant raising has always been considered far from ideal and there are now moves within the EU to ban all animal bi-products in organic plant raising. This work aimed to identify suitable non-animal based nutrient sources to be used as base nutrients for growing media and as supplementary feeds.

The objectives of the project are;

1. To identify suitable alternative, non-animal based nutrient sources for organic plant raising.
2. To assess these non-animal based nutrient sources under UK organic plant raising conditions.

To identify suitable alternative, non-animal based nutrient sources for organic plant raising.
A UK, European and international search (literature, web, phone/personal contacts) was undertaken in early 2002 to establish what suitable, non-animal based, nutrient sources were available. Information on the products was sourced from the producer, supplier or manufacture and collated. Products that were obviously not suitable for organic production were excluded. This search identified a wide range of different types of non-animal based nutrient sources. A range of these products were used in the assessments in objective 2.

To assess these non-animal based nutrient sources under UK organic plant raising conditions.
Media trials
Three commercially available growing media which utilise a non-animal based nutrient source were identified; Sinclair, Vapogro and Melcourt and a fourth was made for the purposes of these trials in consultation with the manufacturer; Vapogro with double the added base nutrients. Two species with contrasting requirements (leek and cabbage) were used to assess the efficacy of these media.

Cabbage
- The Sinclair, Vapogro and Melcourt media all produced cabbage transplants considered to be of an acceptable quality, when supplied with supplementary feed.
- The Vapogro media with double the normal strength of base feed was able to produce cabbage transplants of acceptable quality without the need for supplementary nutrients.
- The Vapogro media with double the normal strength of base feed was able to produce cabbage transplants that were as large as those produced in the Sinclair and Melcourt growing media with supplementary feed. Though they were at an earlier growth stage.
- When supplied with supplementary feed, the Vapogro medium with double the normal strength of base feed produced significantly larger cabbage transplants than the other three media, though they were not more advanced in terms of growth stage.
- The Sinclair, Vapogro and Melcourt media, when supplied with supplementary feed, produced cabbage transplants that were not significantly different from one another in most respects.
- Adding supplementary feed to all the media resulted in more severe aphid infestation.

Leek
- All of the growing media used were only able to produce leek transplants of acceptable quality when supplementary nutrients were added.
- The largest most vigorous leek transplants were produced in the Melcourt media, this is particularly significant as this is a peat free medium.
- The Vapogro media with double the added base nutrients was able to produce acceptable leek transplants, but they were severely attacked by sciarid fly, which caused large numbers to die.

Supplementary feed trials

Four commercially available non-animal derived, organic supplementary feeds were identified (AmegA BIOFEED 5.0-0-2.5; Westland Organic Tomato and Vegetable liquid feed (WTV); Bioplasma NATURAL GROW and Gem Fruit ‘n’ Veg Fertilizer). These were tested against a standard animal derived organic feed and conventional mineral fertiliser feed. Two species with contrasting requirements (leek and cabbage) were used to assess the efficacy of these feeds in a single growing media (Vapogro).
- Two of the feeds, WTV and AmegaA (with added phosphorus) produced cabbage and leek transplants of acceptable quality, broadly equivalent to those fed Nu-Gro, the standard organic supplementary feed.
- AmegaA without added phosphorus produced lower quality transplants.
- Bioplasma NATURAL GROW and Gem Fruit ‘n’ Veg Fertilizer produced poor quality transplants, not significantly different from zero feed in most respects.
- The exception to this was the degree of rooting, which was lower in the feeds with largest shoots, AmegaA with added phosphorus, and WTV and highest with the Bioplasma NATURAL GROW feed.
- Leeks grown with AmegaA with added phosphorus suffered severe sciarid fly attack
- The use of AmegaA and WTV merit further investigation, particularly regards their field performance.

Conclusion.

This study has shown that there area range of non-animal based organic base and supplementary feeds available to the UK organic plant raiser. Although only a limited range of feeds were trialled on a limited number of species (cabbage and leeks) it is likely that the products available will produce suitable quality organic transplants.

Scientific report (maximum 20 sides A4)

BACKGROUND & OBJECTIVES.

Organic plant raising has been investigated under two previous government funded projects (OF0109 & OF0144) (1, 2) and it was shown in this research that organic 'transplants' could be produced for a range of crop species (3, 4, 6, 7). However, some species were easier to produce than others and one of the limiting factors was the availability of suitable nutrient sources, especially for supplementary feeding. Alliums were more difficult to produce due to the production period being longer than for other species which resulted in nutrients in the growing media being exhausted before the transplant was ready for planting out.

The use of non-animal based and on-farm produced fertilisers is more common amongst other European countries. Little of the research into these nutrient sources has been published and where it is it is often published as foreign language technical notes (7,8,9). However, by drawing on this information and through personal communications with European partners, the University of Kassel, Germany (10) and the Research Institute for Organic Agriculture (FiBL) Switzerland (11), and Sweden (12) it is clear that there may be suitable non-animal based nutrient sources for plant raising in the UK.

FiBL have undertaken some work using ricinus cake (Maltaflor), protein from potato, a product called Hexabio and faba bean meal (11). None were as successful as animal based products. In Sweden a by-product from the paper industry (Biobact) is currently used by organic plant raisers (12) and a granular form of alfalfa meal is also available as a nutrient source. Braun (9) and Fragstein (10) suggests that crushed pulse seeds and ricinus cake could be substitutes for animal based nutrient sources. There are advantages of the crushed pulse seed feed as it can be produced on farm (or associated farms) and milled to the required particle size. However, with both crushed pulses and ricinus cake there can be a risk of phytotoxicity if the seed is sown too soon after incorporation of the feed into the media. Most of this work has also been carried out using the nutrient as a fertiliser for field crops as apposed to a supplementary feed for plant raising. Some plant based nutrient sources have been studied previously and included in the previous government funded project. Comfrey was investigated during project OF0109 (1) but was found to be too low in nitrogen to be of any real benefit. Some work has been reported using nettles (13) and a further investigation of this readily available nutrient source could be worthwhile.

There was a clear need to identify suitable nutrient sources for two different uses within plant raising. 1; to replace the base fertiliser that is added to the growing media formulation prior to sowing and 2; to provide a source that can be used for supplementary feed during the growth of the transplant. These nutrient sources are likely to be different due to the differing requirements of base and supplementary feeds. Base feeds should be slow release and become available to the plant throughout its development. The supplementary feed needs to provide more readily available nutrients, especially N. The supplementary feed should ideally be in a liquid form (solution and/or suspension of nutrients) suitable to be delivered through the irrigation system. Alternatively it could be in a granular or powder (solid) form.

The purpose of this study was to draw together information on the availability of the feeds and their organic acceptability and to run (limited) trials to assess the usefulness of the available products for use by UK organic plant raisers.

The objectives of the project are;

3. To identify suitable alternative, non-animal based nutrient sources for organic plant raising.
4. To assess these non-animal based nutrient sources under UK organic plant raising conditions.

Objective 1. To identify suitable alternative, non-animal based nutrient sources for organic plant raising.

A UK, European and international search (literature, web, phone/personal contacts) was undertaken in early 2002 to establish what suitable, non-animal based, nutrient sources were available. Information on the products was sourced from the producer, supplier or manufacturer and collated. This search identified a wide range of different types of non-animal based nutrient sources suitable for organic production; these were collated (Annex 1). However, not all were available or suitable for UK systems, those that were are presented in Table 1.1.

Table 1.1: Identified non-animal based nutrient sources for organic plant raising

Product Name	**Contents / NPK**	**Supplier**	**Other Info**
Supplementary feeds.			
AmegA BIOFEED 5.0-0-2.5	Organic Sugar beet extract N 5%, P 0% & K 2.5%	AmegA Sciences	100% organic raw materials, 100% non-animal origin, based entirely on plant extracts
AmegA BIOFEED 2.5-0-5.0	Organic Sugar beet extract N 2.5%, P 0% & K 5.0%	AmegA Sciences	100% organic raw materials, 100% non-animal origin, based entirely on plant extracts
AmegA BIOFEED 4.0-0-4.0	Organic Sugar beet extract N 4%, P 0% & K 4%	AmegA Sciences	100% organic raw materials, 100% non-animal origin, based entirely on plant extracts
Bio-system	Microbial based powder	Humate International and John McLauchlan Horticulture	Use with Humate – plants flower better and crops yield improves
Bioplasma NATURAL GROW	Suspension of algae N 0.07%, P 0.018% & K 0.07%	Bioplasma Australia Pty Ltd	Foliar or root feed.
Comfrey Plant Fertiliser	Comfrey crop cut 3 times a year, placed in barrels to disintegrate leaving black liquor – after a month is drained and pasteurised.	HDRA, Chase Organics or Ragman's Farm	Ideal for vegetables, flowers, lawns & young tree's. Highly commended for tomatoes & peppers
Gem Fruit 'n' Veg Fertilizer.	Suspension Nitrogen fixing bacteria and organic nutrients (no data on major nutrients)	Joseph Metcalf Ltd	All fruit, vegetable and salad crops
Humate Granular	Composition is approx 70% (Humic & Fulvic acids) and 30% inorganic	Humate International and John McLauchlan Horticulture	Granular –spread onto soil where breaks down slowly
Humate As (soluble)	Humic and Fulvic acid content is between 64 – 74%	Humate International and John McLauchlan Horticulture	Dissolved in water, ideal for root and foliar application
Humate Iron Chelate	Total Nitrogen 6%, soluble potash 2%, chelated iron 10%	Humate International and John McLauchlan Horticulture	Dissolved in water, ideal for root and foliar application to correct deficiencies of Iron in soil and composts
Maxicrop liquid seaweed – professional strength	Made from Norwegian seaweed	Maxicrop International Ltd	Liquid –improves soil conditions, enhances natural development & resistance to stresses.
Maxicrop liquid seaweed – soluble seaweed and kelp meal	Made from Norwegian seaweed	Maxicrop International Ltd	Liquid –improves soil conditions, enhances natural development & resistance to stresses.
Maxicrop liquid seaweed (plus Iron)	Made from Norwegian seaweed	Maxicrop International Ltd	Liquid –improves soil conditions, enhances natural development & resistance to stresses.
Organic Liquid Fertilisers & composts	Free of animal input	West Riding Organics, HDRA, Chase Organics,	Liquid and compost
Perform TOG 8% Calcium Premium liquid nutrient	Total nitrogen 4%, soluble calcium 8%	Aqua-aid and John McLauchlan Horticulture	Ensures calcium and other nutrients are available to plant
Vitagrow 5+1+10 100% organic pure vegetable	Total nitrogen 5%, P_2O_5 1%, K_2O 10% and 43% organic matter from vegetables	Avoncrop Ltd and Vapo Gro Ltd	For soil grown crops under glass & outside, where animal sourced fertilisers are prohibited.
Westland Tomato and Vegetable feed	Lucerne meal, yaka, kali panasse, rock sulphate, molasses, sugars (N 4%, P 2%, K 6% & trace elements)	Westland Horticulture	For all fruit and Vegetables
Media			
Organic Standard Modular Compost	Fine grade, well decomposed Sphagnum peat (N 474 g/m3, P2 0 5 318 g/m3, K2O 288 g/m3)	William Sinclair Horticulture.	Suitable for: modular transplants, seed sowing, and rooting cuttings. 1st choice for onions, leeks & celery
Organic Low Nutrient Modular Compost	Fine grade, moderately decomposed Sphagnum pea t(N 218 g/m3 , P205 146 g/m3, K2O 132 g/m3)	William Sinclair Horticulture.	Suitable for: modular transplants, seed sowing, and rooting cuttings. Preferred choice for non-vigorous brassica transplants
Organic Standard Modular Compost	Fine grade, moderately decomposed Sphagnum peat ((N 435 g/m3, P2 0 5 292 g/m3, K2O 264 g/m3)	William Sinclair Horticulture.	Suitable for: vegetables, salad crops & AYR chrysanthemums
Organic Potting & Bedding compost	Medium grade, moderately decomposed Sphagnum peat (N 514 g/m3 , P2 0 5 345 g/m3, K2O 312 g/m3)	William Sinclair Horticulture.	Suitable for: all year round raising of salad, veg, bedding & potting plants
VapoGro	Fine grade sphagnum peat (N 326 g/m3, P2O5 166 g/m3, K2O 175 g/m3	VapoGro Ltd	Suitable for all plant raising
Melcourt	Composted coniferous tree bark and wood fibre (N 110 g/m3, P 32 g/m3, K 750 g/m3,	Melcourt Industries Ltd	Recommended for larger pots, not recommended for open or plug tray raising

A technical note presenting the information in Table 1.1 was produced in January 2003 and published in the March 2003 EFRC Bulletin No 66.

A selection of these products were taken forward to be tested in objective 2.

Objective 2: To assess these non-animal based nutrient sources under UK organic plant raising conditions.

SITE AND FACILITIES

All trials were carried out at the HDRA research station, situated 5 miles south east of Coventry. Both germination and propagation was carried out in a commercial type glasshouse with heating, ventilation and supplementary lighting.

GENERAL MATERIALS AND METHODS

Test Crops
Two contrasting test crops were used, cabbage and leek. Cabbage produces vigorous growth and reaches transplant size relatively rapidly, while leek has a more extended growth period making slightly different demands on nutrients in the growing medium and from supplementary feeds.

Table 2.1: Vegetables used in the trials.

Species	Variety	Supplier	Seed Treatment
Leek	*Zermat*	Tozer Seeds	None
Cabbage (savoy)	*Vertus*	Tamar Organics	None

Module trays/block sizes
Rigid plastic trays 60x40cm containing 216 cells were used for leeks, trays of the same dimensions containing 308 cells were used for cabbages.

Sowing
Prior to use all trays were washed and sterilised using a standard solution of JET 5 (5% w/w peroxyacetic acid)

Germination
Once the seedlings emerged the germination rate was assessed on a daily basis in 50 cells of each tray, in half of the treatment blocks. Germination was considered to have taken place as soon as any part of the seedling emerged through the surface.

Glasshouse Conditions
The trays were kept on wire mesh tables to allow for air pruning and free drainage of excess water. Night time temperature was controlled within the range on 15-18^{o}C and daytime temperature in the range of 18-21^{o}C, by automatic heating and ventilation. Supplementary lighting was supplied between the hours of 6am and 6pm GMT from sodium lamps when illumination declined below 150 W m^{2}. Trays were watered as required by hand, taking care not to over water, to avoid leaching of nutrients.

Termination
The trials were terminated when the majority of the treatments were considered to be ready for transplanting.

ASSESSMENTS

Interim monitoring
There was no formal interim monitoring carried out, however, a general assessment of growth and pest and disease incidence was done throughout the trials.

Harvest Assessments
For the harvest assessment 10 plants were collected from a central block from each tray. All plants in this area were taken regardless of size, although where a seed had not germinated a plant adjacent to the area was taken. Fresh and dry weight of seedlings was assessed from 50 plants per tray, again selected from a central block and including those used for assessment of other parameters.

The parameters of assessment were colour, plant height, petiole length (cabbage only), growth stage, rooting index, fresh weight, dry weight, and uniformity, the criteria are described in more detail in Annex 2.

MEDIA TRIALS

Experimental Rationale
The overall aim of these trials was to assess the performance of commercially available growing media, which use non-animal derived sources for the base nutrient supply. Three such media were identified and a fourth was produced in conjunction with the manufacturer, for use in the trial. Supplementary feeding was done using Nu-Gro, a feed based on fish by-products, produced by and supplied by Hortifeeds which is a standard supplementary feed used in the production of vegetable transplants for organic systems.

Table 2.2: Major nutrient analysis of Nu-Gro.

Total nitrogen (g l^{-1})	100
Nitrate-N (mg l^{-1})	7.59
Ammonium-N (mg l^{-1})	15200
Total phosphorus (mg l^{-1})	32000
Total potassium (mg l^{-1})	65600

Two trials were run in parallel, one using cabbage as the test crop, one using leek. For the cabbage trial there were two treatments, with and without supplementary feed, but preliminary work showed that leeks would not survive without supplementary feed and so there was only a single treatment (+ supplementary feed) for the leek trials.

Growing Media
VapoGro and Sinclair are peat-based products while Melcourt is a peat free medium, based on coniferous tree bark and wood fibre, produced as a bi-product of the timber industry. Melcourt and Sinclair were supplied as standard commercially available products; VapGro was supplied at both standard specification and also with twice the normal amount of base feed. All media were stored for a maximum period of 1 month before use. Prior to use, chemical analyses were carried out on all media and are shown below.

Table 2.3: Growing media used in the trials

Growing media	**Supplier**
Sinclair Organic standard modular compost	BHGS Ltd
VapoGro	VapoGro Ltd
VapoGro (at double standard base feed strength)	VapoGro Ltd
Melcourt Sylvamix Organic	Avoncrop Ltd

Table 2.4: Chemical analysis of growing media used in trials, all analyses carried out on fresh weight basis except * carried on a dry weight basis and # carried out on air dry basis.

					Feed trial only
Growing Media	**Sinc**	**Vapo**	**Vapo 2X**	**Mel**	**Vapo + P**
pH	5.4	6.4	6.1	6.1	5.4
Conductivity (µS @ 20°C)	185 (1)	121 (0	203 (1)	540 (4)	316 (2)
Density (g l^{-1})	294	228	226	540	194
Total nitrogen* (Dumas) (%m/m)	1.52	1.14	1.54	0.93	1.37
Mineral Nitrogen (mg l^{-1})	2	14	202	92	90
Ammonia as N (mg l^{-1})	1 (0)	11 (0)	194 (4)	33 (1)	85 (2)
Nitrate as N (mg l^{-1})	1 (0)	3 (0)	8 (0)	59 (3)	5 (0)
Soluble Phosphorus (mg l^{-1})	<2 (0)	< 2 (0)	46 (6)	36 (5)	25 (4)
Soluble Potassium (mg l^{-1})	125 (3)	63 (2)	436 (6)	177 (4)	219 (4)
Soluble Magnesium (mg/l)	20 (3)	16 (3)	5 (0)	8 (8)	6 (1)
Total phosphorus* %(m/m)	0.14	0.08	0.14	0.08	0.23
Total potassium* (%m/m)	0.57	0.32	1.07	0.29	0.55
Calcium (mg l^{-1})	45	18	9	17	10
Sodium (mg l^{-1})	83	56	131	63	83
Chloride (mg l^{-1})	48	39	71	55	50
Sulphate (mg l^{-1})	131	59	428	45	215
Boron (mg l^{-1})	0.16	0.10	0.15	0.21	0.11
Copper (mg l^{-1})	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (mg l^{-1})	0.10	0.10	0.10	0.50	0.10
Zinc (mg l^{-1})	0.44	0.25	0.51	0.76	0.38
Iron (mg l^{-1})	0.8	0.9	1.0	0.9	0.8
Organic carbon # (%m/m)	42.3	41.2	40.7	43.1	41.8
Cellulose:acid detergent* (%)	55.7	55.9	49.2	54.0	54.2

Trial 1 - Cabbage

In this trial, cabbage was grown in four different growing media, in one cell size and with two feeding regimes.

Materials and Methods

The treatments were as follows:

Test crop		Cabbage *Vertus* (organic)
Media	1	Sinclair Organic Standard Nutrient Compost (Sinc)
	2	Vapo-Gro Standard Nutrient Compost (Vapo)
	3	Vapo-Gro High Nutrient Compost (double standard base feed) (Vapo 2X)
	4	Melcourt Sylvamix Organic (Mel)
Feeding regimes	1	*Nu-Gro* - 6ml/tray in 3 feeds (18ml/tray)
	2	No feed

Sowing date: 21st November 2002
Harvest date: 30th January 2003
Length of propagation period: 70 days
Number of trays per treatment: 4

Table 2.5: Treatments used in cabbage trial

Treatment	Media	Feed
1	Sinc	Nu-Gro
2	Sinc	none
3	Vapo	Nu-Gro
4	Vapo	none
5	Vapo 2X	Nu-Gro
6	Vapo 2X	none
7	Mel	Nu-Gro
8	Mel	none

Propagation
The growing media were homogenised prior to sowing, which took place on 21st November. The trays were watered as required throughout the propagation period. Final transplant assessment took place on 30th January, when the transplants had been growing for 70 days. Assessments done at harvest were: colour, uniformity, height, petiole length, growth stage, root index, fresh weight and dry weight and pest damage (for full assessment criteria see Annex 3).

Statistical Analysis
The trial was carried out as a randomised block design. There were four replicates of each treatment; treatments were randomised within blocks.

Differences between media with and without feed were assessed using t-test or Mann-Whitney U Test for rank scores. ANOVA or a Friedman test was used to assess differences between media. Least Significant Differences (LSD) for the treatment means were calculated using a t-test at the 5% level.

Results

Media analysis
Chemical analysis of the growing media indicated that there were significant differences between the media, notably in the concentration of mineral nitrogen and soluble phosphorus, both of which were much higher in the Mel and Vapo 2X. The Vapo 2X also had a considerable higher concentration of total and soluble potassium, sodium and sulphate. The ratio of nitrate to ammonium was low in the two Vapo media, but nitrate concentration exceeded ammonium in the Mel. Sinc had negligible concentrations of mineral nitrogen (though total nitrogen was high). Detailed analyses are given in Annex 2.

Germination
Germination was similar in all treatments except for the Vapo 2X, where germination was delayed by approximately 24 hours, though eventually all treatments achieved germination in excess of 95%, within six days of sowing.

Interim monitoring
No disease problems were encountered in the trial, however a serious infestation of aphids occurred from approximately week 4 after sowing onwards, attempts to control aphis with the biological agent *Aphelinus abdominalis* were unsuccessful, by harvest the aphids were beginning to adversely affect some of the transplants. As the trial progressed the treatments with supplementary feed became increasingly susceptible to drought on sunny days.

Harvest
Colour
All plants that were fed were considered to be of acceptable quality with regards to purple colouration, indicating little nitrogen deficiency, with no statistically significance between the media. Plants that were not fed showed degrees of purple colour, except the Vapo 2X treatment, which showed little evidence of purple colour. Trays most severely attacked by aphids showed increasing yellow colouration towards the end of the trial.

Table 2.6: Colour assessment of cabbage trial.

Treatment	RHS Colour cards			
	Block A	Block B	Block C	Block D
Sinc	191A	189B	191A	191A
Sinc +	189A	189A	137A, 138A	143A
Vapo	191B	189B	191A	191A
Vapo +	189A	189A	137A, 138A	189A, 144A
Vapo 2X	189A	189A	189A	189A, 146A
Vapo 2X +	137B	189A, 189B	137A, 138A	189A, 144A
Mel	191B	190A, 144A	191A	191A, 137C
Mel +	189A, 137B	189A, 144A	144A	189A,146A

Table 2.7: Degree of purple development

Treatment	Median
Sinc	3.75
Sinc +	6.5
Vapo	3.25
Vapo +	6
Vapo 2X	6.5
Vapo 2X +	6.5
Mel	2.75
Mel +	6

Purple index: 1 very purple – 7 no purple colour

Assessment of individual growing media with and without supplementary feed

All of the growing media required supplementary feed to produce transplants of acceptable quality, except for the Vapo-Gro with double the normal strength of base feed. There was no significant difference between the performance of this medium with and without the supplementary feed, except for aphid damage, which was worse where supplementary feed was applied. Vapo2X contained much larger concentrations of mineral nitrogen and soluble phosphorus and potassium than the other media, explaining its good performance. The only parameter not to show a difference between treatments with and without supplementary feed was rooting. This may be a result of resource allocation away from roots in the high nutrient environment of the transplants with feed, resulting in reduced root:shoot ratios. This is likely to have been reinforced by compensatory growth in treatments with feed, which suffered more aphid damage.

Table 2.8: Statistical comparison of individual growing media with and without supplementary feed (t-test or Mann-Whitney U Test as appropriate).

Comparison	Sinc vs. Sinc +	Vapo vs. Vapo +	Vapo 2X vs. Vapo 2X +	Mel vs. Mel +
Purple	*	*	ns	*
Height	**	***	ns	***
Petiole Length	**	***	ns	***
Growth Stage	*	***	ns	*
Rooting	ns	ns	ns	ns
Fresh Weight	*	**	ns	**
Dry Weight	ns	*	ns	**
Uniformity	ns	*	ns	ns
Aphids	***	***	***	***

ns = not significant
* = significant at P < 0.05
** = significant at P < 0.01
*** = significant at P < 0.001

Comparison of growing media with supplementary feed

All media produced transplants that were considered to be of acceptable quality when supplied with supplementary feed, and were comparable with transplants produced in previous trials. In most cases there was no significant difference between the growing media when supplied with supplementary feed, the exception being in fresh and dry weight. The fresh weight of the Vapo and Sinc transplants was significantly greater than the Mel and Vapo 2X, while the dry weight of the Vapo 2X was significantly greater than the other treatments. The Mel medium produced transplants significantly lighter than the other treatments.

Table 2.9: Statistical comparisons of media with supplementary feed. ANOVA or appropriate non-parametric equivalents

Factor	Blocking	Treatment
Height	ns	ns
Petiole Length	*	ns
Growth Stage	*	ns
Rooting	ns	ns
Fresh Weight	*	*
Dry Weight	*	**
Uniformity	ns	ns
Aphids	*	ns

ns = not significant
* = significant at P < 0.05
** = significant at P < 0.01
*** = significant at P < 0.001

There were significant block effects for most of the measured parameters. This is probably as a result of the aphid infestation, which was itself different between blocks.

General comments

Supplementary feeding produced larger, more advanced transplants, however it also produced transplants that were more susceptible to pest attack, in this case aphids. In contrast, the Vapo 2X without supplementary feed produced transplants which were of acceptable quality, not significantly different from those produced in Vapo, Sinc and Mel with supplementary feed, they also suffered less aphid damage.

Table 2.10: Mean* or median # values as appropriate, for assessment criteria.

TMT	Height*	Petiole*	Grow Stage*	Rooting #	Aphid damage #	Fresh Weight*	Dry Weight*	Uniform #
Sinc	81.4	16.3	3.2	1.00	1.50	26.62	6.14	4.0
Sinc +	153.4	52.0	8.1	1.50	4.00	67.81	9.83	3.5
Vapo	56.5	7.20	1.9	1.00	1.00	13.14	3.86	4.0
Vapo +	155.0	53.4	8.6	1.75	3.75	62.12	9.02	3.5
Vapo 2x	140.2	47.7	5.7	1.00	3.50	55.86	9.81	3.0
Vapo 2x +	171.7	58.3	7.2	1.00	4.00	83.49	12.88	3.5
Mel	70.5	9.1	2.7	1.00	1.00	15.21	3.70	3.0
Mel +	139.8	42.4	7.6	1.00	4.00	49.74	7.28	4.0
LSD	16.7	9.4	1.7	na	na	16.03	2.00	na

Uniformity: 1 varied sizes – 5 total uniformity
Growth stage: 1 least developed – 12 most developed
Rooting index: 1 weak – 5 strong

Conclusions

- The Sinclair, VapoGro and Melcourt media all produced transplants of an acceptable quality when supplementary feed was used, with no supplementary feed transplants were not of an acceptable quality.
- The VapoGro medium with double the normal strength of base feed was able to produce transplants of acceptable quality without the need for supplementary nutrients.
- When supplied with supplementary feed the VapoGro medium with double the normal strength of base feed produced significantly larger transplants than the other three media, though they were not more advanced in terms of growth stage.
- The VapoGro medium with double the normal strength of base feed was able to produce transplants without the addition of supplementary feed, which were not significantly smaller than those produced in the Sinclair and Melcourt growing media with supplementary feed. Though they were at an earlier growth stage.
- Adding supplementary feed to all the media resulted in more severe aphid infestation.

Trial 2 – Leek

In this trial, leek was grown in four different growing media, in one cell size and with one feeding regime.

Materials and Methods

The treatments in the trial were as follows:

Test crop Leek *Swiss Giant* (organic)

Media
1 Sinclair Organic Standard Nutrient Compost (Sinc)
2 Vapo-Gro Standard Nutrient Compost (Vapo)
3 Vapo-Gro High Nutrient Compost (double standard base feed) (Vapo 2X)
4 Melcourt Sylvamix Organic (Mel)

Feeding regime *Nu-Gro* - 6ml/tray for 6 feeds (36ml/tray)

Sowing date: 21st November 2002
Harvest date: 13th February

Length of propagation period: days 84
Number of trays per Treatment: 4

Table 2.11: Treatments used in leek trial

Treatment	Media	Feed
1	Sinc	Nu-Gro
2	Mel	Nu-Gro
3	Vapo	Nu-Gro
4	Vapo 2X	Nu-Gro

Propagation

The growing media were homogenised prior to sowing, which took place on 21st November 2002. The trays were watered as required throughout the propagation period. Final transplant assessment took place on the 13th February. Assessments done at harvest were: uniformity, colour, height, growth stage, root index, fresh weight and dry weight (for full assessment criteria see Annex 3).

Statistical Analysis

The trial was carried out as a single factor randomised block design. There were four replicates of each treatment, treatments were randomised within blocks.

ANOVA or a Friedman test was used to assess differences between media. Least Significant Differences (LSD) for the treatment means were calculated using a t-test at the 5% level.

Results

Media analysis

Chemical analysis of the growing media indicated that there were significant differences between the media, notably in the concentration of mineral nitrogen and soluble phosphorus, both of which were much higher in the Mel and Vapo 2X. The Vapo 2X also had a considerable higher concentration of total and soluble potassium, sodium and sulphate. The ratio of nitrate to ammonium was low in the two Vapo media, but nitrate concentration exceeded ammonium in the Mel. Sinc had negligible concentrations of mineral nitrogen (though total nitrogen was high). Detailed analyses are given in annex 2.

Germination

Germination was delayed in the Vapo 2X treatment, though percentage germination in this medium eventually achieved a similar level to the other media. Germination was most rapid and complete in the Sinc and Vapo media, though the difference between these and the other media were not significant.

Interim monitoring

No disease problems were encountered in the trial, however sciarid fly (family *Sciaridae*) became an increasing problem during the trial, their effects are discussed below.

Harvest
Colour
Plants grown in the Sinc, Vapo and Mel treatments were of acceptable quality with regards to yellow colouration and were relatively consistent. Those in the Vapo 2X treatment were of a yellow colour, but this was caused mostly by die back, explained further below.

Table 2.12: Colour assessment of leek trial

Treatment	RHS Colour cards			
	Block A	Block B	Block C	Block D
Sinc	136B	137A	139A	137A
Vapo	137A	139B	138A	137B
Vapo 2X	137A	137A	137B	137B
Mel	137A	137B	137B	137B

Table 2.13: Degree of Yellowing in leek trial

Treatment	Median
Sinc	6.5
Vapo	8
Vapo 2X	5.5
Mel	7.5

1: more yellow than green – 9 no yellowing

Statistical comparison of transplant performance in the four media

Table 2:14: Statistics for leek trial

Factor	Blocking	Treatment
Height	ns	***
Growth Stage	ns	ns
Rooting	ns	ns
Fresh Weight	ns	***
Dry Weight	ns	***
Uniformity	ns	*

ns =not significant*=significant at P < 0.05
** =significant at P < 0.01
*** =significant at P < 0.001

During the trial, sciarid flies were a problem, attacking plants in all of the media. However, the Vapo 2X medium was particularly badly affected. A large number of plants died in some of the blocks, and many of the survivors were stunted. Because of this, the assessments for Vapo 2X were done on the ten best plants in each tray, rather than those from a block in the middle, as with the other media. This was in order to try and make an assessment of the quality of the media in the absence of pests, though it must be remembered, that taking the trays as a whole, the Vapo 2X performed badly.

All of the plants were considered to be of acceptable quality for transplanting. However the Mel medium produced the tallest transplants, which also had significantly greater fresh and dry weight than those grown in the other media and they remained sturdy. They also had the strongest root system, though this difference was not significant.
There was no significant effect due to blocking.

Table 2.15: Harvest results for leek trial means * and medians # as appropriate

TMT	Height*	Grow Stage*	Rooting #	Fresh Weight*	Dry Weight*	Uniformity #
Sinc	27.9	8.65	1.0	38.71	4.46	4.0
Vapo	29.4	9.23	1.0	39.85	4.33	3.0
Vapo 2X	24.6	8.65	1.0	28.85	3.56	4.5
Mel	32.6	9.75	1.5	62.58	6.64	2.0
LSD	**2.84**	**0.88**	**na**	**8.68**	**0.87**	**na**

General comments

The Mel medium produced the highest quality transplants. They were the largest, both in terms of height and weight and had the largest root systems (though not significantly so). The Mel growing medium also seemed less favourable to sciarid fly, perhaps because of its coarse nature. The reason for the very serious sciarid fly damage in the transplants in the Vapo 2X medium is unclear.

Conclusions

- In this trial all media were supplied with supplementary feed and all of them were able to produce transplants of acceptable quality.
- The largest most vigorous transplants were produced in the Mel medium.
- The Vapo 2X medium was able to produce acceptable transplants, but they were severely attacked by sciarid fly, which caused large losses.

FEED TRIALS

Experimental Rationale

The overall aim of this trial was to assess the performance of cabbage and leek transplants grown in a standard media with a range of commercially available, non-animal derived supplementary feeds. Preliminary investigation identified four such feeds available in the UK.

Feeds

The four feeds were AmegA BIOFEED 5.0-0-2.5, produced and supplied by Amega Sciences; Westland Organic Tomato and Vegetable liquid feed (WTV), produced by Environmentally Conscious Solutions and distributed by Westland Horticulture; Bioplasma NATURAL GROW, produced by Biotech Industries AB and supplied by Bioplasma Ltd. and Gem Fruit 'n' Veg Fertilizer, produced by Joseph Metcalf Ltd. and supplied by Gem Gardening. These feeds were compared with a conventional feed made up to the following specification. A stock solution was made of 90g l^{-1} potassium nitrate and 20g l^{-1} ammonium nitrate. This stock solution was diluted 1:200 to provide a nitrogen concentration of 300mg ml^{-1}. Nu-Gro, which is a standard organic feed based on fish residues, used extensively in the production of transplants for organic systems, and produced and supplied by Hortifeeds, was used to provide an organic comparison. Nutrient analysis of the organic feeds is shown below. It is interesting to note that results of the analyses indicate that all of the feeds differed from the values quoted by the manufacturers in their NPK content.

Media

Vapo-Gro standard mix growing medium was used with a base fertiliser of 6kg m^3 of Vitagrow 5-1-10 pure vegetable fertiliser. As the Amega feed was reported to contain no phosphorus, a further batch of Vapo-Gro was supplied with an additional application of phosphorus added to the medium as redzlaag. (This is the producers recommended practice.)

Table 2.16: Major nutrient analysis of commercial feeds used, with producer/supplier quoted values in brackets. Note: nitrate-N values may not be reliable due to colour interference from the products in the analytical procedure.

	Total N ($g\ l^{-1}$)	**Nitrate-N ($mg\ l^{-1}$)**	**Ammonium-N ($mg\ l^{-1}$)**	**Total phosphorus ($mg\ l^{-1}$)**	**Total potassium ($mg\ l^{-1}$)**
AmegA BIOFEED 5.0-0-2.5	73.3 (50)	197	11200	1610 (0)	18200 (25000)
Westland Organic Tomato and Vegetable liquid feed (WTV)	57.8 (60)	58.2	15800	23100 (20000)	49600 (60000)
Nu-Gro Original	100 (80)	7.59	15200	32000 (78000)	65600 (72000)
Bioplasma NATURAL GROW	0.935 (0.660)	1020	1000	110 (184)	745 (722)
Gem Fruit 'n' Veg Fertilizer	1.16 (no data)	<0.01	162	126 (no data)	1870 (no data)

Trial 1 - Cabbage

This trial was designed to assess the performance of cabbage.

Materials and Methods

The treatments were as follows:

Test crop 1 Cabbage *Vertus* (Organic)

Media 1 Vapo-Gro Standard Nutrient Compost (Vapo)
2 Vapo-Gro Standard Nutrient Compost + redzlaag (Vapo+P)
Sowing date: 23rd October 2002
Harvest date: 18th December 2002

Length of propagation period: 63 days
Number replicates: 4

Table 2.17: Treatments used in cabbage trial

Treatment	Media	Feed
1	Vapo	None
2	Vapo	Conventional
3	Vapo	Nu-Gro
4	Vapo	Amega
5	Vapo	WTV
6	Vapo	Bioplasma
7	Vapo	Gem
8	(Vapo+P)	Amega
9	(Vapo+P)	None

Propagation
The growing medium was homogenised prior to sowing, which took place on 23rd October 2002. The trays were watered to requirements throughout the propagation period. Final harvest took place on the 18th December. Assessments done were as with the media trial (see also Annex 3).

Feeding regime
Amega, Nu-Gro, WTV, and the conventional feed were applied at a rate intended to supply 1800mg/tray of nitrogen (total N), over three feeds, weeks 4, 5 and 6, in 0.5l of water per tray per application. The exception to this was the conventional feed, which was applied three times per week, again in 0.5l per tray per application. Bioplasma was applied at a rate equivalent to 3l m^2 of 5% solution four times in weeks 4,5,6 and 7 as recommended. Gem was applied at approximately double the recommended rate (no data regarding nitrogen content was available from the producer). However analysis of the feeds showed that they were all different to the specifications supplied by the producers. Therefore the actual amount of nutrients supplied were as shown below.

Table 2.18: Estimated and actual amounts of nitrogen supplied

	Estimated N supplied per tray (mg)	Actual N supplied per tray (mg)
AmegA BIOFEED 5.0-0-2.5	1800	1979
Westland Organic Tomato and Vegetable liquid feed (WTV)	1789	1300
Nu-Gro Original	1807	1800
Bioplasma NATURAL GROW	95	134
Gem Fruit ‘n’ Veg Fertilizer	unknown	28
Conventional	1800	1800

Statistical Analysis
Analysis of Variance (ANOVA) was used to determine whether differences due to treatments were significant in the feed trial, except for rank scores and parameters where ANOVA assumptions could not be met, where a Freidman test was employed. Least Significant Differences (LSD) for the treatment means were calculated using a t-test at the 5% level.

Results

Germination
Germination was satisfactory with no difference between the two growing media.

Interim monitoring
Differences became apparent between treatments even before the first feed. Those trays containing the medium amended with redzlaag were more vigorous than those without. It was particularly noticeable that treatment 9, with redzlaag but without supplementary feed retained strong vigour until the last couple of weeks of the trial when it declined relative to other treatments.

Harvest
Colour
There was a large amount of variation in colour between the different feeds. In general the low nitrogen feeds (none, BioPlasma, Gem) produced transplants of a blue grey colour and the high nitrogen feeds plants of a more pure green colour, though interestingly the conventional feed also produced transplants of a grey green colour and the none + P plants of a more pure green colour. Purple colouration followed a similar pattern with the low nitrogen feeds produced transplants with a high degree of purple colour and the high nitrogen feeds plants with little or no purple colour (statistical significance at the $P<0.001$ level), though unlike the overall colour the conventional feed performed more like the high nitrogen feeds and the no feed + P like the low nitrogen feeds.

Table 2.19: Colour assessment of cabbage trial

Treatment	RHS Colour cards			
	Block A	Block B	Block C	Block D
None	133C	133C	136C	133B
Conventional	133B	133C	133C	133B
Nu-Gro	138B	139A	137B	139A
Amega	136A	139A	136B	137A
WTV	137B	138A	136A	137A
Bioplasma	133C	133C	133C	133C
Gem	133C	138B	136C	136C
Amega + P	138A	137B	139A	137A
None + P	137B	137B	137B 139B	136C

Table 2.20: Degree of purple development.

Treatment	Median
None	3.25
Conventional	6.5
Nu-Gro	7
Amega	7
WTV	7
Bioplasma	3.75
Gem	3
Amega + P	7
None + P	3.5

purple index: 1 very purple – 7 no purple colour

Pests and disease
There were no disease problems during the trial, however, aphids began to attack the trial approximately two weeks before the end.

Table 2.21: Median aphid infestation index

Feed	Aphid index
None	4.00
Conventional	3.00
Nu-Gro	1.25
Amega	2.25
WTV	2.15
Bioplasma	3.70
Gem	4.25
Amega + P	2.05
None + P	2.95

5 none - 1 >30 individuals

There was a significant difference between the level of infestation in the different feeds, with the highest levels of infestation on the Nu-Grow, Amega and WTV treatments.

Feed affects
The table below shows the growth parameters tested and level of difference between the different feed treatments.

Table 2.22: Statistical comparisons of different feeds

Response	Blocking	Feed
Uniformity	ns	*
Height	ns	***
Petiole Length	ns	***
Growth Stage	ns	***
Rooting	ns	*
Fresh Weight	ns	***
Dry Weight	ns	***

n = not significant
* = significant at P < 0.05
** = significant at P < 0.01
*** = significant at P < 0.001

The different feeds produced transplants of widely varying quality. Generally speaking, the highest quality transplants produced with the new feeds were those fed with Amega + P, these were almost as high a quality as those produced with the standard Nu-Gro feed. Though WTV also produced transplants of acceptable quality, particularly as the amount of N added in this feed was lower than the Nu-Grow and Amega. In contrast, Bioplasma and Gem produced poor transplants, which were not significantly different from zero feed for most parameters. This is not surprising in view of their very low nutrient content. The most surprising result was from the zero feed + P treatment, which produced relatively good transplants. However, the medium with added P also contained more nitrogen and potassium (table 5-3), which may also account for the exceptionally good performance of the Amega + P treatment. Though Nu-Grow and Amega + P produced the best transplants for most parameters, the rooting index for theses feeds was lower than for the other feeds and lower even than zero feed. This may reflect a switch in resources from roots to shoots in an environment of high nutrient content but is likely to have an effect on transplant performance after planting out in to the field. There were no significant differences between blocks.

Table 2.23: Mean* or median # values as appropriate, for assessment criteria. Numbers followed by [a] are significantly greater than zero feed, those followed by [b] are significantly less than zero feed.

Feed	Uniformity# (1-5)	Purple index# (1-7)	Height* (mm)	Petiole* (mm)	Grow Stage*	Rooting index# (1-5)	Fresh Weight* (g)	Dry Weight* (g)
None	4.0	3.25	61.03	8.33	1.93	3.25	16.73	7.78
Conventional	5.0	6.50	88.66[a]	19.53[a]	3.30	4.25	40.40[a]	9.19[a]
Nu-Gro	3.0	7.00	136.75[a]	38.95[a]	5.90[a]	2.75	63.14[a]	9.04[a]
Amega	5.0	7.00	88.75[a]	16.78[a]	4.03[a]	2.75	35.44[a]	9.30[a]
WTV	3.0	7.00	108.30[a]	26.40[a]	5.50[a]	3.00	44.57[a]	8.80[a]
Bioplasma	4.5	3.75	69.88	10.08	2.08	4.00	19.19	7.96
Gem	3.0	3.00	65.63	8.05	1.68	3.25	15.94	7.72
Amega + P	4.0	7.00	143.30[a]	41.30[a]	6.63[a]	2.75	71.33[a]	10.97[a]
None + P	3.5	3.50	100.78[a]	16.70[a]	4.18[a]	3.50	35.98[a]	10.55[a]
LSD	**na**	**na**	**12.92**	**4.32**	**1.41**	**na**	**8.47**	**0.911**

Uniformity: 1 varied sizes – 5 total uniformity
Purple index: 1 very purple – 7 no purple colour
Growth stage: 1 least developed – 12 most developed
Rooting index: 1 weak – 5 strong

Conclusions

This trial tested four potential non-animal derived, organic supplementary feeds for production of cabbage transplants, against standard animal derived organic and conventional mineral fertiliser feed.

- Two of the feeds, WTV and Amega + P produced transplants of acceptable quality, comparable to those produced with Nu-Gro, the standard organic supplementary feed.
- Amega alone produced lower quality transplants.
- Bioplasma and Gem produced very poor quality transplants, not significantly different from zero feed.
- The exception to this was the degree of rooting, which was lower in the feeds with largest shoots, Amega + P, and WTV.
- Amega and WTV merit further investigation, particularly regards their field performance.

Trial 2 – Leek

This trial was designed to assess the performance of leek.

Materials and Methods

Test crop	1	Leek, Swiss Giant *Zermat* (Organic)
Media	1	VapoGro Standard Nutrient Compost (Vapo)
	2	Vapo-Gro Standard Nutrient Compost (Vapo+P) + redzlaag

Sowing date: 23rd October 2002
Harvest date: 22nd January 2003

Length of propagation period: 91 days
Number of replicates: 4

Table 2.24: Treatments in cabbage trial

Treatment	Media	Feed
1	Vapo	None
2	Vapo	Conventional
3	Vapo	Nu-Gro
4	Vapo	Amega
5	Vapo	WTV
6	Vapo	Bioplasma
7	Vapo	Gem
8	(Vapo+P)	Amega
9	(Vapo+P)	None

Propagation

The growing medium was homogenised prior to sowing, which took place on 23rd October 2002. The trays were watered to requirements throughout the propagation period. Assessments done were as with the media trial (see also Annex 3).

Feeding regime

Amega, Nu-Gro, WTV, and the conventional feed were applied at a rate intended to supply 3600mg/tray of nitrogen (total N) over six feeds (weeks 4-9) in 0.5l of water per tray per application. The exception to this was the conventional feed, which was applied three times per week, 3-10, again in 0.5l per tray per application. Bioplasma was applied at a rate equivalent to 3l m^2 of 5% solution 12 times in weeks 4-9 as recommended. Gem was applied at approximately double the recommended rate (no data regarding nitrogen content was available from the producer). However analysis of the feeds showed that they were all different to the specifications supplied by the producers. Therefore the actual amount of nutrients supplied were as shown below.

Table 2.25 Estimated and actual nitrogen supplied

	Estimated N supplied per tray (mg)	Actual N supplied per tray (mg)
AmegA BIOFEED 5.0-0-2.5	3600	3958
Westland Organic Tomato and Vegetable liquid feed (WTV)	3578	2600
Nu-Gro Original	3614	3600
Bioplasma NATURAL GROW	190	268
Gem Fruit 'n' Veg Fertilizer	unknown	56

Statistical Analysis

Analysis of Variance (ANOVA) was used to determine whether differences due to treatments were significant, except for rank scores and parameters where ANOVA assumptions could not be met, where a Freidman test was employed. Least Significant Differences (LSD) for the treatment means were calculated using a t-test at the 5% level.

Results

Germination

Germination was satisfactory with no difference between the two growing media.

Interim monitoring
There was no apparent difference between treatments before the first feed. Leeks in treatment 8 (Amega + P) began to undergo distorted growth from approximately week nine onwards; by the time of harvest they were completely prostrate.

Pests and disease
There were no disease problems during the trial; however, sciarid flies (family *Sciaridae*) became an increasing problem during the trial. Their effects are discussed below.

Harvest
Feed affects
The different feeds produced transplants of widely varying quality. Generally speaking, the highest quality transplants using the new feeds, were produced with, Amega + P and WTV. These were broadly comparable with Nu-Gro. Though WTV produced slightly smaller plants than Nu-Gro and Amega + P, it produced plants with a larger root system, which is likely to be of importance on transplanting into the field. The rooting system of Amega + P transplants was particularly poor as a consequence of severe attack by sciarid fly in the last two weeks of the trial. Though all treatments were affected to some degree, the Amega + P plants were the most severely attacked. When the plants were examined at harvest some were found to have almost their entire root system eaten. Gem produced the poorest transplants, which were not significantly different from zero feed for most parameters. This is not surprising in view of the very low nutrient content of this feed. Bioplasma also produced relatively poor transplants, as did the conventional feed, though Bioplasma did produce transplants with the largest root system. Again the zero feed + P treatment produced relatively good transplants probably because the medium with added P also contained more nitrogen and potassium (table 2.4).

Table 2.26: Statistical comparisons of different feeds.

Response	Blocking	Feed
Uniformity	ns	*
Yellowing	ns	***
Height	ns	***
Growth Stage	ns	**
Rooting	ns	ns
Fresh Weight	ns	***
Dry Weight	*	***

ns = not significant
* = significant at $P < 0.05$
** = significant at $P < 0.01$
*** = significant at $P < 0.001$

There were no significant differences between blocks except for dry weight ($P<0.043$). In this case the most northerly block in the glasshouse was significantly smaller in weight than the two most southerly blocks and therefore seems to be a light effect, as the glasshouse receives slightly less light on the northern side.

Table 2.6: Mean* or median # values as appropriate, for assessment criteria. Numbers followed by [a] are significantly greater than zero feed, those followed by [b] are significantly less than zero feed.

Feed	Uniformity# (1-5)	Yellow index# (1-7)	Height* (mm)	Grow Stage*	Rooting index# (1-5)	Fresh Weight* (g)	Dry Weight* (g)
None	4.5	1.0	175	6.33	3.00	12.80	2.30
Conventional	3.5	3.0	214	6.40	3.00	20.61	3.70[a]
Nu-Gro	1.5	9.0	330[a]	9.48[a]	3.00	74.07[a]	6.82[a]
Amega	2.5	4.0	217	7.75	3.00	26.62[a]	3.50
WTV	1.5	7.0	271[a]	8.95[a]	3.25	46.01[a]	4.48[a]
Bioplasma	2.5	3.0	202	7.30	3.50	19.90	2.81
Gem	3.5	2.0	171	5.65	3.25	13.65	2.33
Amega + P	4.0	4.0	278[a]	8.83[a]	2.50	49.96[a]	4.83[a]
None + P	2.0	5.5	236[a]	8.40[a]	2.75	34.27[a]	3.87[a]
LSD	**na**	**na**	**52**	**1.66**	**na**	**11.50**	**1.22**

Uniformity: 1 varied sizes – 5 total uniformity
Yellow index: 1 more yellow than green – 9 no yellowing
Growth stage: 1 least developed – 12 most developed
Rooting index: 1 weak – 5 strong

Conclusions

This trial tested four potential non-animal derived, organic supplementary feeds for production of leek transplants, against standard animal derived organic and conventional mineral fertiliser feed.

- Two of the feeds, WTV and Amega + P produced transplants of acceptable quality, broadly the same as those produced with Nu-Gro, the standard organic supplementary feed.

- Amega alone produced lower quality transplants.
- Conventional feed, Bioplasma and Gem produced poor quality transplants, not significantly different from zero feed.
- The exception to this was the degree of rooting, which was highest with Bioplasma and lower in the feeds with largest shoots.
- Amega + P suffered severe sciarid fly attack
- Amega and WTV merit further investigation, particularly regards their field performance.

Discussions and Conclusions.

The project has met its objectives of identifying and assessing non-animal based nutrient sources for organic plant raising in the UK. It was clear from the survey of available products that there was a wide range of products available (both media and supplementary feeds) and this range was made avialable to plant raisers through the EFRC bulletin.

Four media were tested under glasshouse conditions using cabbage and leek as model crops (because of there differing plant raising needs). It was encouraging that these media were all successful in producing acceptable cabbage transplants. However, in their standard formulation they did not produce acceptable leek transplants without suplementary feeding.

Four of the identified supplimentary feeds were tested under glasshouse conditions again using cabbage and leek as model crops and with a standard growing media. Two of the supplimentary feeds performed well when compared with the most common animal based feed used currently in the industry.The other two feeds performance was poor, but in line with expectations from their nutrient content, they do not warrant further investigation. The two feeds which performed well require further work to determine performance of plants when transferred to the field .

This study has shown that there area range of non-animal based organic base and supplementary feeds available to the UK organic plant raiser. Although only a limited range of feeds were trialled on a limited number of species (cabbage and leeks) it is likely that the products available will produce suitable quality organic transplants.

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Annex 1: Survey of possible suitable non-animal based plant raising nutrient sources.

PRODUCT NAME	CONTENTS / NPK	SUPPLIER	UK AVAILABILITY	ORGANIC STATUS	STATE	OTHER INFO
Alfalfa Meal (2-0.5-2)	Contains natural growth stimulants & trace minerals, N 2%, P 0.5%, K 2%	Whitney Farms Organic Garden Products - USA	No I believe it's only available in USA?	Says its "organic"		Fertiliser supplement for roses & other flowering shrubs, & vegetable gardens.
AmegA BIOFEED 2.5-0-5.0	Organic Sugar Beet extract from Belgium & France, 2.5% Nitrogen, 5% Potassium Oxide, Calcium, Magnesium, sulphur, Iron & Manganese (N 2.5%, P 0%, K 5.0%)	AmegA Sciences	Yes from AmegA Sciences	Soil Association Certified (unrestricted) suitable for use in organic farming systems	Liquid	100% Organic raw materials, 100% non – animal origin, based entirely on plant extracts
AmegA BIOFEED 4-0-4	Organic Sugar Beet extract from Belgium & France. 4% Nitrogen, 4% Potassium Oxide, Calcium, Magnesium, sulphur, Iron & Manganese (N 4%, P 0%, K 4%)	AmegA Sciences	Yes from AmegA Sciences	Soil Association Certified (unrestricted) suitable for use in organic farming systems	Liquid	100% Organic raw materials, 100% non – animal origin, based entirely on plant extracts
AmegA BIOFEED 5.0-0.2.5	Organic Sugar beet extract from Belgium & France. 5% Nitrogen, 2.5% Potassium Oxide, calcium, magnesium, sulphur, iron & manganese (N 5%, P 0%, K 2.5%)	AmegA Sciences	Yes from AmegA Sciences	Soil Association Certified (unrestricted) suitable for use in organic farming systems	Liquid	100% Organic raw materials, 100% non – animal origin, based entirely on plant extracts
Biobact	Waste product of paper industry	Sweden?	?			Currently being used by organic plant raisers with granular from of alfalfa meal
Bio-Forge	Blend of various organic compounds, Complexed carbamides, carboxylic acid salts	Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Biological growth enhancer for forage and several non-forage crops will greatly stimulate root & tip.
Biolplasma NATURAL GROW	Suspension of algae N 0.07%, P 0.018% & K 0.07% with trace elements, Fe 5.6 mg/l, Cu 3.7 mg/l, S 310 mg/l.	Bioplasma Australia Pty Ltd	Imported from Australia	Certified by IFOAM and the Soil Association	Liquid	Foliar or root feed, once inside plant cell nutrient enriched microscopic bioplasma cells attach to plant cells & transfer nutrients.
Bio-system	Microbial based powder	Humate International / John McLauchlan Horticulture	Yes from John McLauchlan Horticulture	Again just says "our organic Bio-system"	Powder	Use with Humate & plants flower better & crops yield improve
Comfrey Plant Fertiliser	Comfrey crop cut 3 times a year – placed in barrels where leaves disintegrate leaving black liquor – which after a month is drained and pasteurised	HDRA or Chase Organics (or root cuttings can be purchased from Ragman's Farm for small patch in garden)	Through HDRA, Chase Organics or Ragman's Farm	Says its organic and is sold at HDRA and Chase Organics – so assume must be organic	Liquid	High in Potassium. Use for Veg, Flowers, Lawns & young trees. highly recommended for tomatoes & Peppers
Faba bean meal	N min % 1.7	Can be self produced or Purchased through a supplier	?			FiBL tried – found not as successful as animal based products. Tested by the Dept. of Ecological Agriculture, Germany who found that it is only valid, economically, from own production

PRODUCT NAME	CONTENTS / NPK	SUPPLIER	UK AVAILABILITY	ORGANIC STATUS	STATE	OTHER INFO
Fast Cab		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Foliar supply of Calcium & Boron (boron helps improve calcium uptake) to fruit plants
Fast Cab'y		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Foliar supply of Calcium & Boron (boron helps improve calcium uptake) to fruit plants
Field Peas Coarse meal	Field Peas – N min % 1.0	Can be self produced or purchased through a supplier	?			Tested by the Dept. of Ecological Agriculture, Germany. Found that it is less suited from self production nor purchased sources due to high costs.
Gem Fruit 'n' Veg Fertilizer.	Suspension Nitrogen fixing bacteria and organic nutrients. < 3% N, 1.8% Mg, 0.38% Cu, 1% Fe, 0.35% Mn 0.06% Mo, 0.42% Zn no other data on nutrients	Joseph Metcalf Ltd	Yes, through Gem Gardening	"Fully organic". Endorsed by HDRA	Liquid	All fruit, vegetable and salad crops
Harvest Plus		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Suitable for potatoes – foliar feed
Hexabio		www.hebaxio.com	?			FiBL tried – found not as successful as animal based products
Humate As (soluble)	Formed from decomposition of plant material over 1000's of years. Humic and Fulvic acid content is between 64-74%	Humate International / John McLauchlan Horticulture	Yes from John McLauchlan Horticulture	Just says " our organic Humate"	Dry (dissolved in water)	Spray dried version of humate liquid, which is manufactured from granular Humate. Ideal for foliage & roots in liquid fertiliser solution
Humate Granular	Formed from decomposition of plant material over 1000's of years. Its composition is approx 70% (Humic & Fulvic acids) and 30% inorganic	Humate International / John McLauchlan Horticulture	Yes from John McLauchlan Horticulture	Just says " our organic Humate"	Granules	3 different grades of granular Humate – Coarse (3mm to powder), Medium (1-0.5mm), Fine (less then 0.5mm) Spread onto soil – breakdown slowly.
Humate Iron Chelate	Formed from decomposition of plant material over 1000's of years. Total Nitrogen 6%, Soluble potash 2%, chelated iron 10%	Humate International / John McLauchlan Horticulture	Yes from John McLauchlan Horticulture	Just says " our organic Humate"	Dry (dissolved in water)	For foliar and soil applications, Used for correcting deficiencies of Iron in soil & composts
Lupin seed meal	Lupin seeds – N min % 2.8	Can be self produced or purchased through a supplier	?			Tested by the Dept. of Ecological Agriculture, Germany. Found that it is a valid substitute for horn meal.
Maltaflor	Ricinus cake – N min % 3.0	www.maltaflor.de	?			FiBL tried – found not as successful as animal based products. Tested by the Dept. of Ecological Agriculture, Germany
Maxicrop Liquid Seaweed – professional strength	made from Norwegian seaweed	Maxicrop Organic Plant stimulants www.maxicrop.com	Yes from Maxicrop, Northants	Says "Organic Plant Stimulants"	Liquid	Benefit plant growth, improve soil conditions, enhance natural development & increase resistance to stresses.
Maxicrop Liquid Seaweed (plus Iron)	Made from Norwegian Seaweed	Maxicrop Organic Plant Stimulants	Yes from Maxicrop, Northants	Says "Organic plant stimulants"	Liquid	Benefit plant growth, improve soil conditions, enhance natural development & increase resistance to stresses.

PRODUCT NAME	CONTENTS / NPK	SUPPLIER	UK AVAILABILITY	ORGANIC STATUS	STATE	OTHER INFO
Maxicrop liquid seaweed-soluble seaweed and kelp meal	Made from Norwegian Seaweed	Maxicrop Organic Plant stimulants	Yes from Maxicrop, Northants	Says “Organic Plant Stimulants”	Powder	Benefit plant growth, improve soil conditions, enhance natural development & increase resistance to stresses.
Organic blocking Compost	Fine grade, well decomposed Sphagnum peat (N 474 g/m^3 , $P_2 0_5$ 318 g/m^3, K_2O 288 g/m^3)	Sinclair Organic Composts	Yes from William Sinclair Horticulture	Says its “organic”	Compost	Suitable for: vegetables, salad crops & AYR chrysanthemums
Organic Liquid Fertilisers and composts		West Riding Organics, HDRA, Chase Organics, Tamar Organics, Edwin Tucker & Sons, Central Farmers Ltd.	Yes EU and UK deliveries daily from West Riding Organics or from the other suppliers	says “Organic Composts and fertilisers”	Liquid and Compost	Free of animal input and Peat free composts
Organic Low Nutrient Modular Compost	Fine grade, moderately decomposed Sphagnum peat (N 218 g/m^3 , P_20_5 146 g/m^3, K_2O 132 g/m^3)	Sinclair Organic Composts	Yes from William Sinclair Horticulture	Says its “organic”	Compost	Suitable for: modular transplants, seed sowing, and rooting cuttings. Preferred choice for non-vigorous brassica transplants
Organic Potting & Bedding compost	Medium grade, moderately decomposed Sphagnum peat (N 514 g/m^3 , $P_2 0_5$ 345 g/m^3, K_2O 312 g/m^3)	Sinclair Organic Composts	Yes from William Sinclair Horticulture	Says its “organic”	Compost	Suitable for: all year round raising of salad, veg, bedding & potting plants.
Organic Standard Modular Compost	Fine grade, moderately decomposed Sphagnum peat ((N 435 g/m^3 , $P_2 0_5$ 292 g/m^3, K_2O 264 g/m^3)	Sinclair Organic Composts	Yes from William Sinclair Horticulture	Says its “organic”	Compost	Suitable for: modular transplants, seed sowing, and rooting cuttings. 1st choice for onions, leeks & celery
Perform T.O.G. 8% Calcium Premium Liquid Nutrient	Derived from Calcium Nitrate & trihydroxyglutoric organic acid, Total N 4%, 8% soluble calcium.	Aqua-aid and John McLauchlan Horticulture	Yes John McLauchlan Horticulture	“Organically chelated liquid Calcium”	Liquid	Addresses plant’s calcium needs & growing media’s pH to ensure Calcium & other nutrients are available to plant
Protein from Potatoes			?			FiBL tried – found not as successful as animal based products
Stoller Calcium 5X		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Supplies Calcium to strengthen cell walls & stimulates cell division – applied when fruit is small
Stoller Nitrate Balancer		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Foliar product that decreases the excess vegetative growth of fruit trees (created by too much nitrogen) and potatoes
Stoller Nitro-plus		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Root uptake of soluble Calcium to the fruit and potatoes – improves tuber quality
Stoller SET		Stoller International Ltd	Yes distribution throughout UK from Stoller International Ltd			Guard against tuber calcium loss by applying Foliar calcium feed during stress & high growth periods

PRODUCT NAME	CONTENTS / NPK	SUPPLIER	UK AVAILABILITY	ORGANIC STATUS	STATE	OTHER INFO
Vitagrow 5+1+10 100% Organic Pure Vegetable	100% organic Mini Gran, 100% Pure Vegetable organic fertiliser. 5% total N, 1% P_2O_5, 10% K_2O, 43% organic matter from vegetable sources	Avoncrop Ltd and Vapo Gro Ltd	Yes Avoncrop has Bristol, Bracknell and Boston depots in UK	Certified by the Soil Association for restricted use in organic systems		Uses: for restricted use in organic systems, In soil grown crops under glass & outside, where animal sourced fertilisers are prohibited.
Westland Organic Tomato & Vegetable Liquid Feed	Lucerne Meal, Organically cultivated yuka, Kali Panasse, Rock Phosphate, Molasses, Sugars. N 4%, P (as P2O5) 2%, K (as K2O) 6% and trace elements	Westland's Horticulture	Yes from Westland Horticulture, or DIY stores (i.e. Homebase, Focus)	Says it's "the 1st truly complete organic liquid plant food"	Liquid	Uses: feeding vegetables, fruits & flowers

ANNEX 2: Analysis of growing media.

Growing Media	Sinc	Mel	Vapo	Vapo 2X	Vapo + P
pH	5.4	6.1	6.4	6.1	5.4
Conductivity (µS @ 20°C)	185 (1)	540 (4)	121 (0	203 (1)	316 (2)
Density (g l^{-1})	294	540	228	226	194
Total nitrogen (Dumas) (%m/m)	1.52	0.93	1.14	1.54	1.37
Mineral Nitrogen (mg l^{-1})	2	92	14	202	90
Ammonia as N (mg l^{-1})	1 (0)	33 (1)	11 (0)	194 (4)	85 (2)
Nitrate as N (mg l^{-1})	1 (0)	59 (3)	3 (0)	8 (0)	5 (0)
Soluble Phosphorus (mg l^{-1})	<2 (0)	36 (5)	< 2 (0)	46 (6)	25 (4)
Soluble Potassium (mg l^{-1})	125 (3)	177 (4)	63 (2)	436 (6)	219 (4)
Soluble Magnesium (mg l^{-1})	20 (3)	8 (8)	16 (3)	5 (0)	6 (1)
Total phosphorus %(m/m)	0.14	0.08	0.08	0.14	0.23
Total potassium (%m/m)	0.57	0.29	0.32	1.07	0.55
Calcium (mg l^{-1})	45	17	18	9	10
Sodium (mg l^{-1})	83	63	56	131	83
Chloride (mg l^{-1})	48	55	39	71	50
Sulphate (mg l^{-1})	131	45	59	428	215
Boron (mg l^{-1})	0.16	0.21	0.10	0.15	0.11
Copper (mg l^{-1})	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (mg l^{-1})	0.10	0.50	0.10	0.10	0.10
Zinc (mg l^{-1})	0.44	0.76	0.25	0.51	0.38
Iron (mg l^{-1})	0.8	0.9	0.9	1.0	0.8
Organic carbon (%m/m)	42.3	43.1	41.2	40.7	41.8
Cellulose:acid detergent (%)	55.7	54.0	55.9	49.2	54.2

ANNEX 3:: Methods of assessment

LEEKS

Colour Index
R.H.S cards were used to determine the colour of treatments. The colour was scored on an overall tray appearance.

Yellowing
A second colour key was used to account for the degree of yellowing of the transplants. The key ranged between 1 and 9 where:

Index **Description**

Index	Description
1	More yellow than green
2	The second leaf completely to half way yellow. The overall tray appearance is very yellow, approx. 40%
3	The second leaf anything between completely yellow to only yellow at the tip. The overall tray appearance is about 30% yellow
4	The second leaf is half way yellow or yellow at the tip. The overall yellow appearance of the tray is about 25%.
5	The overall yellow appearance of the tray is about 20%
6	The tip of half the second leaf is yellow. The overall tray appearance is about 15% yellowing.
7	The odd tip of the second leaf is yellow. The overall tray appearance is about 10% yellowing.
8	The odd tip of the second leaf is yellow. The overall tray appearance is about 5% yellowing.
9	No yellowing

A block of 10 plants from the centre of each tray was removed and the following assessments made

Height
Height was measured from the upper edge of the plug to tip of the longest leaf tip.

Growth Stage
Growth stage was assessed by counting the number of leaves and using the following key:

Index For analysis	**Index** For recording	**Description**
1	1	One leaf fully open (not counting the first not folded leaf)
2	$1^{2'}$	One leaf fully open and the second leaf tip (up to 2 cm long) emerging
3	1^{2}	One leaf fully open and the second leaf longer than 2 cm but not yet open
4	2	Two leaves fully open
5	$2^{3'}$	Two leaves fully open and the third leaf tip (up to 2 cm long) emerging
6	2^{3}	Two leaves fully open and the third leaf longer than 2 cm but not yet open
7	3	Three leaves fully open
8	$3^{4'}$	Three leaves fully open and the fourth leaf tip (up to 2 cm long) emerging
9	3^{4}	Three leaves fully open and the fourth leaf longer than 2 cm but not yet open
10	4	etc.

Root Index
Rooting vigour was assessed using a scale of 1-5, where 1 = weakest and 5 = most vigorous..

Fresh and Dry Weight
In addition to the 10 plants used for other assessments, another 40 plants were pulled out from the centre of each tray. Every cell in a given square was used regardless of the size of the plant, providing a plant was present. The plants were cut off at the top of the compost and weighed before and after drying at 80^{o}C.

CABBAGE

Colour Index
R.H.S cards were used to determine the colour of treatments. The colour was scored on an overall tray appearance.

Purple
In order to account for purple colouration that develops in cabbages, an assessment of purple colouration was made using an index of 1 to 7 as follows:

Index	Description
1	Very purple
2	Clearly purple
2.5	Leaves are very purple at the back of the leaves and beginning to get quite purple at the front. 30-40% of the leaves appear purple on an overall basis.
3	Leaves are purple at the back of the leaves. Only starting to get a hint of redness at the front. Approximately 20% of the leaves are purple.
3.5	As above (3) but only about 5% of the leaves are purple at the front.
4	Purple at the back of some of the leaves, but not at the front.
4.5	Some purple (5%) but otherwise the same as below (5).
5	Hardly any purple; only a hint at the back of the leaves on some of the plants. The tray as a whole does not appear purple at all. The green colour of the leaves is a bit more yellow than the grey-green shade of 3 and 4.
6	A darker green than any of the above colours. Not as grey-green as 3 and 4 and not as yellow green as 5. Some leaves are purple at the back; less than 5%.
7	Dark green without any purple. Less grey-green than 3 and 4.

A block of 10 plants from the centre of each tray was removed and the following assessments made

Height
Height was measured from the top of the compost to the tip of the longest leaf.

Growth Stage
Growth stage was assessed by counting the number of leaves and using the following key:

Index For analysis	**Index** For recording	Description
1	$2^{'}$	2 leaves and the 3rd visible but not yet developed into a leaf, (only a bud)
2	2^{3}	2 leaves and the 3rd developed but not yet fully opened, (still cupped)

Index For analysis	**Index** For recording	Description
3	3	3 leaves
4	3'	3 leaves and the 4th visible but not yet developed into a leaf, (only a bud)
5	3^4	3 leaves and the 4th developed but not yet fully opened, (still cupped)
6	4	4 leaves
7	4'	4 leaves and the 5th visible but not yet developed into a leaf, (only a bud)
8	4^5	4 leaves and the 5th developed but not yet fully opened, (still cupped)
9	5	5 leaves
10	5'	5 leaves and the 6th visible but not yet developed into a leaf, (only a bud)
11	5^6	5 leaves and the 6th developed but not yet fully opened, (still cupped)
12	6	6 leaves
13	6'	6 leaves and the 7th visible but not yet developed into a leaf, (only a bud)

Length of Petiole of the Second True Leaf
The petiole of the second true leaf was measured. The second leaf was used as this was generally the largest leaf. This measurement was used as it could provide a good indication of the 'legginess' of the plant.

Rooting Index
Rooting vigour was assessed using a scale of 1-5, where 1 = weakest and 5 = most vigorous.

Fresh and Dry Weight
In addition to the 10 plants used for other assessments, another 40 plants were pulled out from the centre of each tray. Every cell in a given square was used regardless of the size of the plant, providing a plant was present. The plants were cut off at the top of the compost and weighed before and after drying at 80^{o}C.