Research Theme

The use of woodchip compost as a peat-free propagation material in organic horticulture

Host(s)	Meeting date(s)
Tolhurst Organic Produce West Lodge, Hardwick Whitchurch on Thames Pangbourne RG8 7RA	1st Field Lab: 24 February 2014 2nd Field Lab: 07 April 2014 3rd Field Lab: 22 September 2014

Background

This trial explored the use of woodchip compost as a peat-free propagation material for horticulture, evaluating its performance relative to other growing materials.

DEFRA aims to phase out the use of peat in all horticultural systems by 2030, making it essential to identify suitable replacement materials. As peat is a non-renewable resource with a very high carbon footprint that is still very widely used in both the conventional and organic horticultural sectors, the aim of various research approaches over the years has been to identify suitable alternatives with which to replace this important substrate. Many growers in the UK also want to move away from using imported coir as a peat substitute and towards more locally available resources with a lower carbon footprint. Iain Tolhurst has been experimenting with composting woodchips on his holding for a few years and using it as (among other applications) a propagation material for transplants.

Relevant prior research

Peat builds up over millennia through the accumulation of partially decayed vegetation and organic matter (in acidic, anaerobic, saturated conditions), making it effectively non-renewable. It has a high carbon footprint due to being a major store of organic carbon sequestered in the saturated soil. When this organic carbon is exposed to air it decomposes, releasing CO_2 and methane at accelerated rates. As a growing medium, peat is still very widely used in the conventional and organic horticultural sectors as it retains moisture and supports nutrients effectively. There has been much research in recent decades looking into identifying suitable alternatives with which to replace this important substrate.

UK:

- The Institute for Organic Training and Advice (IOTA) has produced a review which identifies the most recent research results regarding propagation composts and plant raising. This review suggests ways in which organic propagation can move away from reliance on peat, addresses the problems of nutrient supply, and considers alternative methods of plant raising. It outlines the historical context and summarises previous research projects. The properties of various materials used as constituents in growing media are reviewed, including bark-based products and wood fibres. Home-made mixtures are included, together with trials of commercially available substrates. For further information see: Sumption, P & Lennartsson, M (2008) Organic plant raising: research review. DEFRA Research project OFO347, IOTA.
- The Soil Association guide to current composts and materials available to organically certified growers.
- Changes in peat use in horticulture in the UK and the move towards more sustainable alternatives: Alexander *et al.* (2008) Peat in horticulture and conservation: the UK response to a changing world. Mires and Peat 3, pg 1-10. RHS.
- Grower trials of different plant raising media for organic systems, including peat and green waste materials: Little *et al.* (2007) Assessing quality of plant raising media for organic systems. Report. OCW, Aberystwyth.

International:

- Detailed background information of peat land, organic soils, emissions, and international importance. Details the UK peat habitat area. FAO (2012) *Peatlands – guidance for climate change mitigation through conservation, rehabilitation and sustainable use.* Mitigation of Climate Change in Agriculture Series 5, 2nd edn. FAO and Wetlands International.

Articles of interest in the Organic Grower (OGA, available on request):

- Tolhurst, I (2010) Composting woodchip. Organic Grower 13.
- Lehmann, J (2011) Peat-free growing media. Organic Grower 16.
- Tolhurst, I (2012) Woodchip-based growing media. Organic Grower 18.

Field lab development

The field lab compared growing media based on woodchip compost (produced at Tolhurst Organic Produce) with Klasmann organic propagation mixture ('KKS Kompost Kultursubstrat', a standard commercial product for plant-raising in certified organic horticulture, used here as the control), and commercially available Biochar (Carbon Gold), mixed into both propagation materials. Cabbage and leek transplants were raised in each of the four mediums, and crop performance (growth, health, yield, quality of end product) was assessed throughout the growing period.

Left photo - the 4 substrate mixtures used in this trial. Right photo - transplants grown, as is customary on the farm, in woodchip compost.

Meeting 1: The first field lab took place on 24th February 2014 and introduced the trial and its methods to the group. This was followed in the afternoon by a 3 hour workshop led by Iain Tolhurst, during which he gave an overview of the production of compost and woodchip compost on his holding. The aim of the workshop was to motivate growers to produce their own growing media, and to encourage groups of growers to test other materials on their holdings and share their experiences at subsequent field labs later in the year.

Left photo - the group visiting the trial in the greenhouse at the first field lab event (24.02.2014). Right photo - trays of cabbage transplants in the chosen trial set-up (see methods section below).

During the three hour workshop in the afternoon, Iain Tolhurst described how he uses his own woodchip compost both to raise transplants and as a fertiliser and source of additional organic matter in his polytunnels and fields. Some growers expressed an interest in testing other growing materials for transplants and in setting up their own trials during the 2014 growing season (e.g. using leaf mould in propagation mixtures). Outcomes from these will be compared at the final field lab in September.


Left photo - the group during the 3-hour compost making course at the first field lab event (24.02.2014). Right photo - the group visiting the woodchip compost heap in the field at Hardwick.

<u>Meeting 2:</u> At the second meeting held on 7th April 2014, the transplants were fully developed in their growing trays, with the cabbages almost ready for planting out in the field. The results of the substrate analysis were discussed by the group, together with the first measurements of plant health and growth. Unfortunately, even though some of the participants had been inspired to set up their own comparison trials or to produce their own compost, no additional experiments had been started in the first two months.


Left photo - the group visiting the trial in the greenhouse at the second field lab event (07.04.2014). Right photo - trays of cabbage and leek transplants in the chosen trial set-up (see methods section).

<u>Meeting 3:</u> The third meeting was held on 22nd September 2014. By that time the leek and cabbage crops had already been harvested, with only a small strip of the leek trial left standing (the aim of which being to monitor any pests or diseases that might present themselves during a longer growing period, given that the rest of the leeks were harvested relatively early). It also enabled participants to visit the trial site during the final field lab event. The results of the trial (pest and disease occurrence, yield etc.) were presented and discussed by the group. Useful feedback was received from participants, and alternative options were discussed. For example, one individual had achieved positive results from a small experiment comparing the use of leaf-mould compost and a conventional growing substrate (New Horizon) for brassica transplants. Suitable methods for small trials and experiments such as this were also reflected upon; on the one hand to maximise the usability of results, and on the other to optimise the efficiency of labour and budget investments.

During a visit to the remaining leeks standing in the field (in which no noticeable differences in levels of pests and diseases were observed - see results below), Iain Tolhurst summarised the results and achievements of the trial from his viewpoint.




Top left photo - the results being presented to the group. Top right photo - the group visiting the remaining leek plants in the field. Bottom left photo - Iain Tolhurst comparing different base materials for woodchip compost, and stating that the choice of wood, tree species, or age of the trees might have a significant impact on the compost quality, slightly changing its properties from batch to batch. Bottom right photo - the group visiting compost heaps in the field.

Experimental question(s)

How does woodchip compost perform as a peat free growing medium compared to standard materials?

Method of trial(s)

The growing media compared in this trial were:

- **1.** Woodchip compost produced on site by Iain Tolhurst. The woodchip is composted for 12 - 18 months, then sieved to remove any remaining larger wood pieces and enriched with Vermiculite and Lime.
- **2.** Klasmann growing medium. A standard growing substrate for certified organic production (‘KKS - Kompost Kultur Substrat’), containing peat, coir, green waste compost, and organic fertiliser.
- For substrate **3.** and **4.**, both of the above mediums were enriched 10% v/v with Biochar Soil Improver from Carbon Gold (henceforth referred to as Biochar), which contains biochar, mycorrhizae, wormcasts, and seaweed.

The plan below shows the trial design and transplant set-up in the greenhouse:

	block 1			block 2			block 3		
	cabbage B-WC	leeks WC	cabbage Klaas	leeks B-Klaas	cabbage B-WC	leeks Klaas	leeks WC	cabbage WC	
	leeks B-WC	leeks Klaas	cabbage WC	cabbage B-Klaas	cabbage Klaas	cabbage B-Klaas	leeks B-WC	leeks Klaas	
	leeks B-Klaas	cabbage B-Klaas	leeks B-WC	cabbage WC	leeks WC	cabbage B-WC	cabbage Klaas	leeks B-Klaas	

1.2m

3.7m

	1 tray of transplants	module trays are 37x23cm
(grey)	Guard row (any of the 2 crops)	containing 40 modules/plants per tray
(green)	Woodchip compost	50 trays are needed in total (24 for trial)
(orange)	Biochar + Woodchip compost	trial 24 are used for monitoring and analysis
(purple)	Biochar + Klaasman	6 trays per substrate
(blue)	Klaasman	arranged in 3 pseudo replicates (3 blocks)
c	cabbage	2 different crops are compared
l	leeks	1 tray in each block and substrate for one crop
		3 trays per crop and substrate in total

Seedlings were grown in the greenhouse for the first few weeks, then planted out into the field on 14.04.14 (cabbages) and 23.04.14 (leeks). Health and height/growth assessments were taken prior to planting out. Pests and diseases were monitored during the growing season and evaluated before harvest. In the cabbage crop, apart from the odd slug, no notable infestations were observed. With the leeks, two fungal diseases - Rust *(Puccinia allii)* and Onion white rot (*Sclerotium cepivorum)* - were noticed and monitored. Yield was evaluated (weight and quality) on the date of harvest: 02.07.14 for the cabbages and 20.08.14 for the leeks.
As additional information, the cost of producing woodchip compost has been estimated by the grower (see below). The calculations are for 100 m^3:

Method of trial(s)

Raw woodchip	No charge, for most growers it ought to be possible to have the material delivered free to the site. A waste transfer licence might be necessary from the local authority.	£ 0.00
Turning	Using 1.5 t digger, assuming production of 100 m^3 p.a. Hire charge 3 days per annum Farm labour 3 days @ £80	£ 200.00 £ 240.00
Grading	Material for compost production	£ 160.00
Additional material	(vermiculite) and mixing	£ 500.00

This results in approximately **£1100.00 or 11p per litre**
If labour costs are not included, cost is around **7p per litre**
On-farm machinery would reduce costs further.
For most growers, the production of woodchip compost would be done as a small percentage of a larger farm composting operation, with the bulk of the material going onto cropping ground on a rotational basis. The amount used for propagation purposes would generally be a small percentage of the whole.

Limitations and assumptions

The trial was set up on a small scale, aiming to represent 'average' conditions comparable to farmers' own trials and experiments. To gain more detailed and reliable results for the different growing media, it should be conducted on a larger scale and (optimally) repeated during two or three growing seasons to account for varying weather conditions and other environmental factors.

One example of the limitations concerns laboratory analysis of the different substrates. The total amount of substrate mixture necessary for this trial was very small (40-50 litres per substrate), and for both Klasmann and Biochar only a single bag/package was needed. Due to the small amounts involved, no representative sample could therefore be taken for analysis.

Another example might be the watering regime of transplants. With any trial it's important that environmental factors be kept as similar and comparable as possible, and (in this case) also maintain site-specific customs and circumstances. However, because the growing media had different water holding properties and water management needs, it's possible that certain of their benefits/disadvantages may have been missed.

However, in terms of discussing and demonstrating methods of setting-up small scale trials, this project was very useful for all participants. In particular it produced important, site-specific results which give an overview and first impression of the comparative performance of the growing media.

Results measured after planting out in the field and at harvest need to be evaluated with care. Although it's generally very difficult (and impossible within the limits of small-scale trials) to attribute any measurements taken at time of harvest solely to the growing media used for the transplants, it's still very interesting to follow the crop all the way through to the end of the growing period and to monitor any changes in the plants started off in different substrates. Most trials which compare different growing media don't consider

Method of trial(s)

later effects in the field (such as robustness and resilience carried forward). This trial can thus be seen as initial work for future, more detailed research in this area. It revealed some interesting results that could be picked up in more specific experiments - for example, the long-term effects of growing media on tolerance against certain diseases.

Developments and adjustments

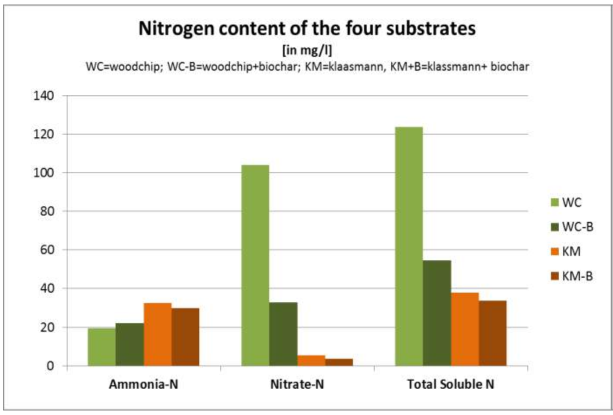
Due to the large leaves and wide plant growth of the cabbage transplants, the distance between the randomised trays in the greenhouse had to be increased by ca. 3cm in the later growing stage, to improve conditions for the leek plants.

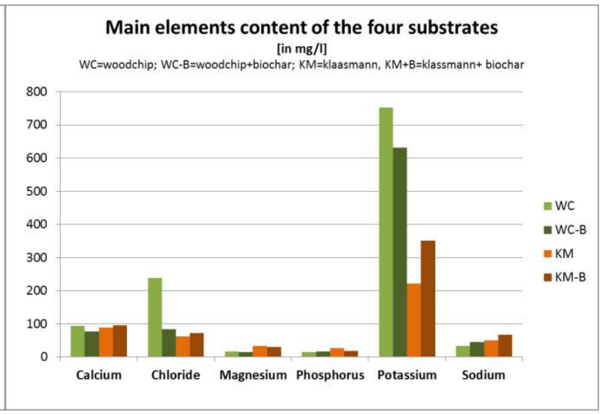
Outcomes/results

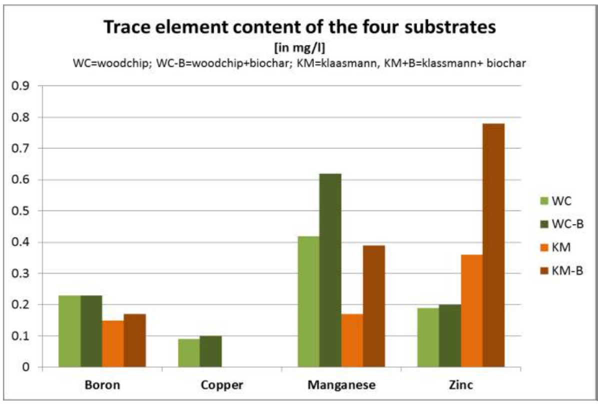
Substrate Analysis

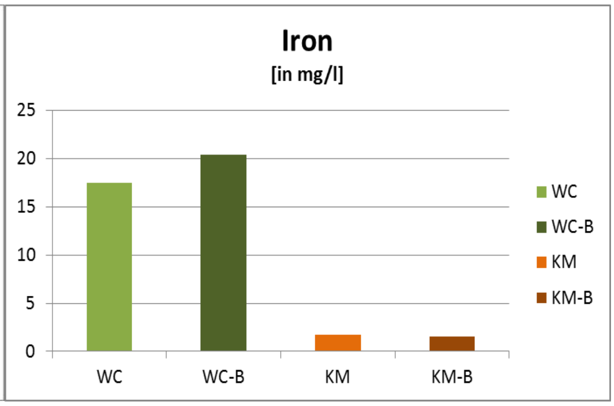
All four substrate mixes were sampled during the pricking out process at the end of February 2014 and their nutrient content, pH, density, and heavy metal concentrations analysed in a laboratory (NRM). The results can be viewed in the graphs below. None of the mixes exceeded the limits set for heavy metals in green waste compost by either EU regulation (EC 889/2008) or the Soil Association standards. As described above, these results need to be interpreted with great care. The total amount of substrate mixture required for this trial was very small (40-50 litres of each), and only a single bag/package of both Klasmann and Biochar was used. Due to the small amounts involved, no representative sample could therefore be taken for this analysis.

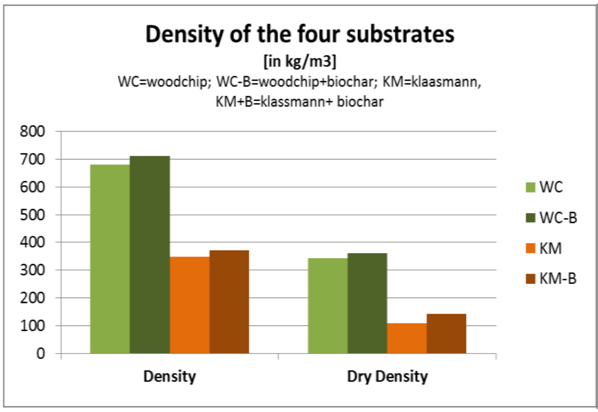
Outcomes/results

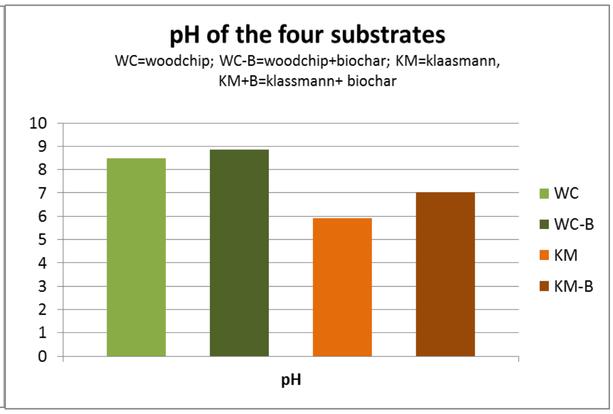










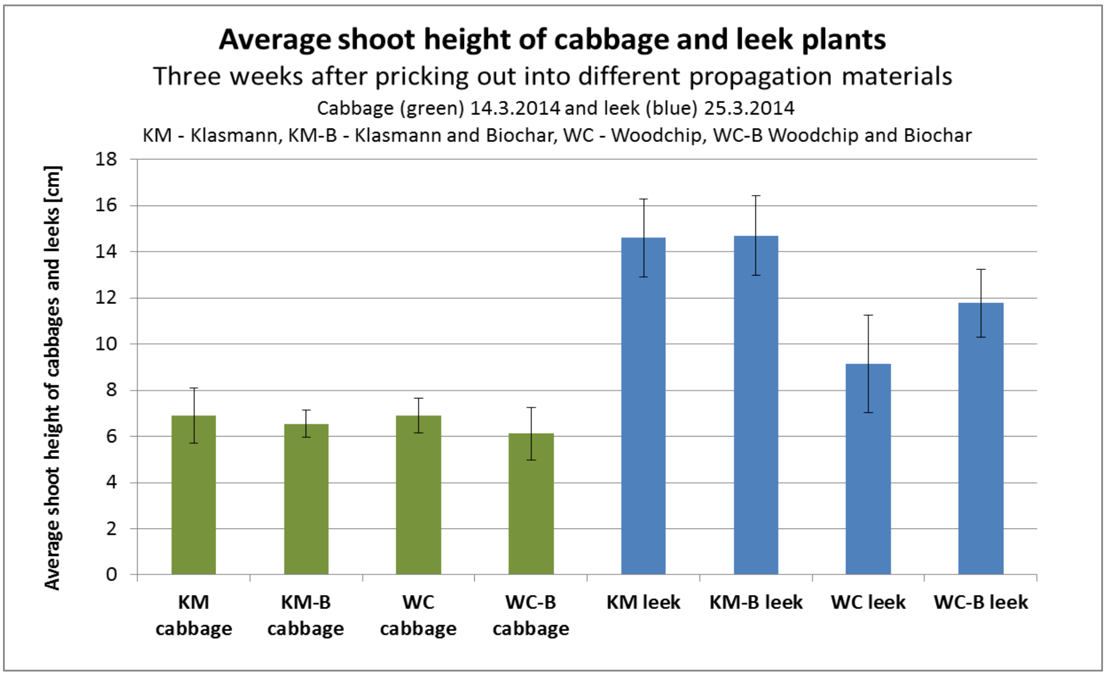


Growth assessments

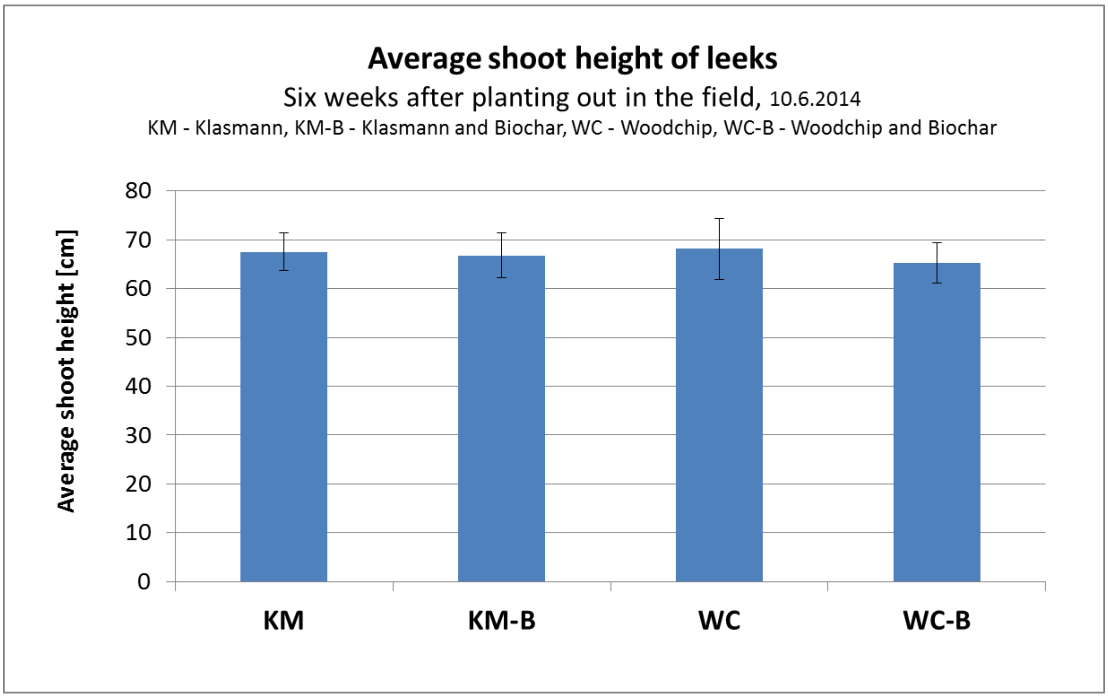
Height measurements taken three weeks after pricking out showed no difference in the length of cabbage plant shoots. With the leeks however, the plants grown in Klasmann substrate (both with and without added Biochar) appear to have grown quicker as a longer shoot length was measured. This could be due to the higher nutrient content of this commercial propagation material, which gives an earlier and higher supply from the start of the growing phase.

All graphs in the results section below show average values, with the error bars indicating the standard deviation.

Outcomes/results



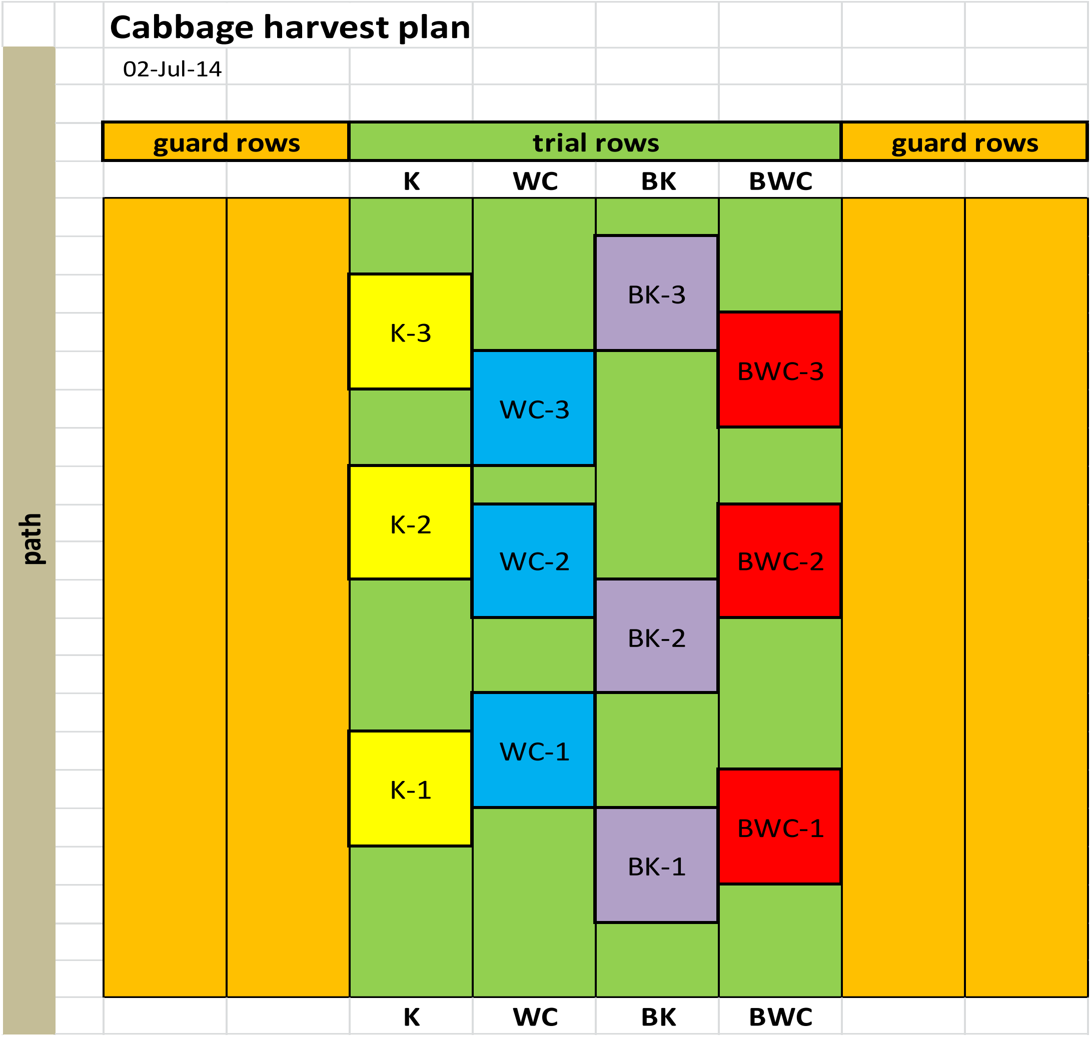
The diagram below shows height measurements of the leek plants taken six weeks after planting out in the field (10.06.2014). The early growth advantage of the transplants started off in Klasmann substrate seems to have levelled out - the ones grown in woodchip compost have caught up.



Cabbage harvest

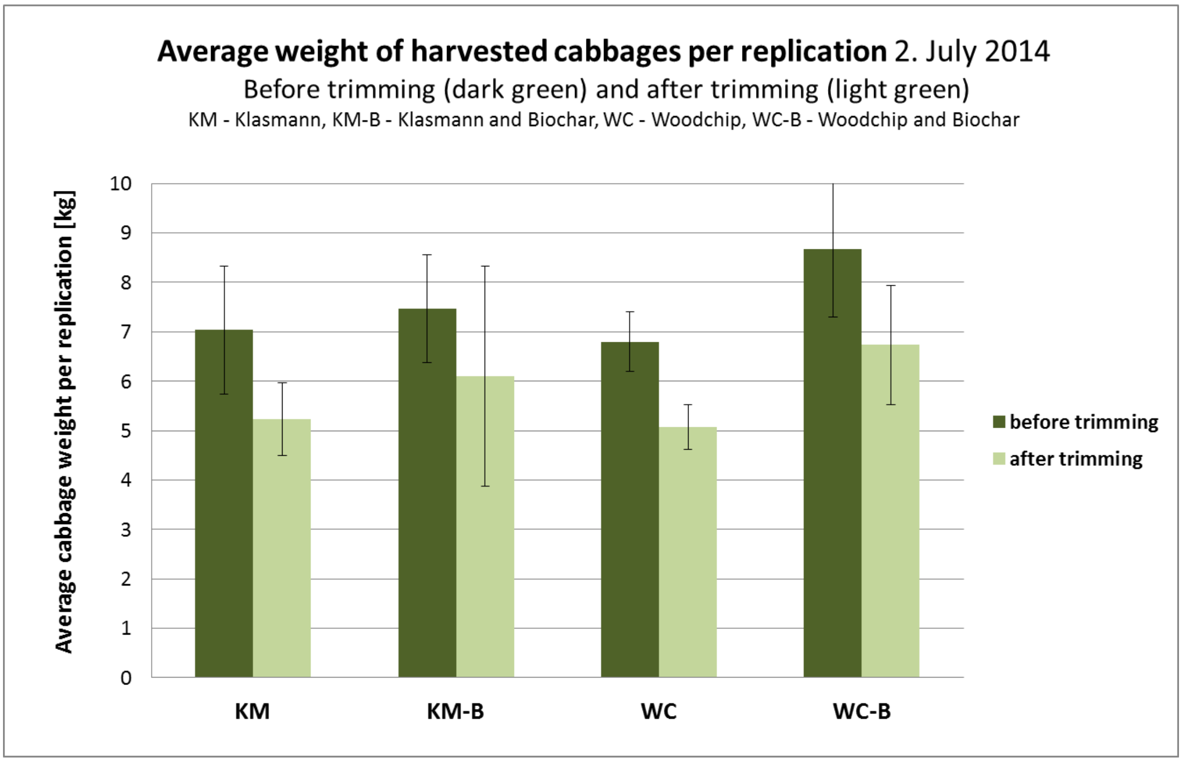
Outcomes/results

Harvest plan showing guard rows and harvest windows of 5 metres in length, with three replications in each row (harvested 02.07.2014):

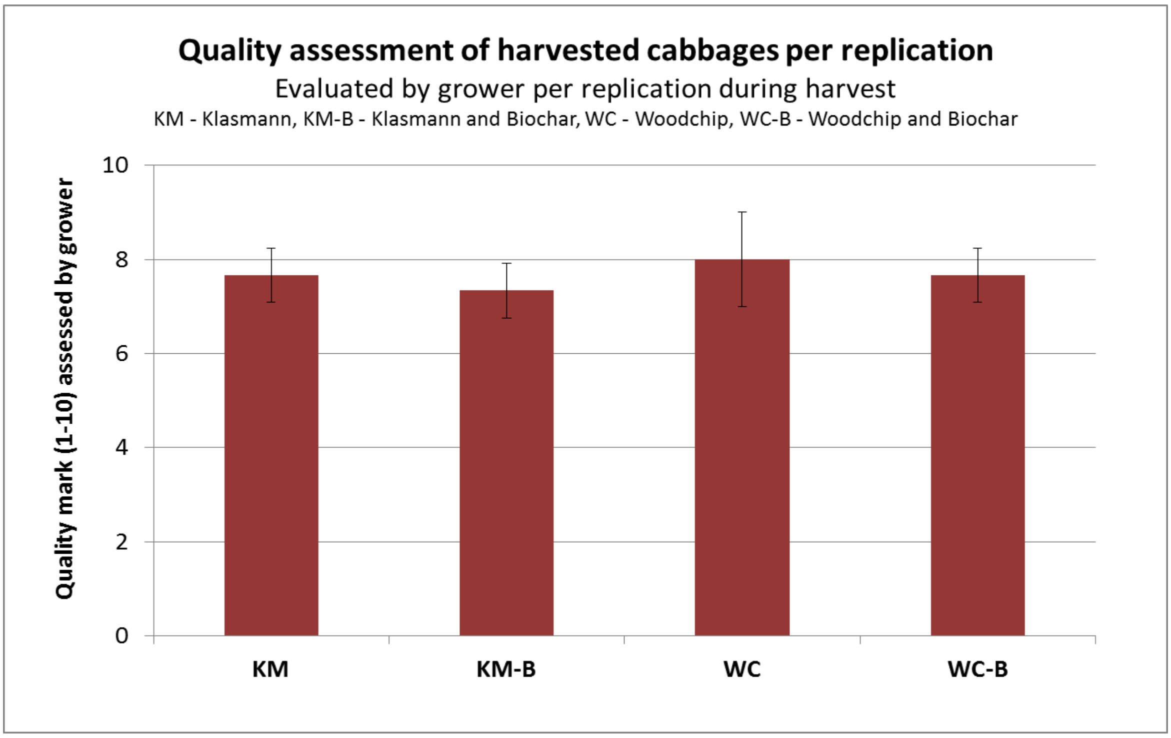


The average cabbage weight/quality as assessed by Iain Tolhurst on date of harvest is shown in the graph below. In each replication 26 cabbages were harvested. No significant differences are noticeable in the data. However, the cabbages raised in substrates with added Biochar yielded slightly heavier/larger cabbages, particularly those ones raised in woodchip compost and Biochar.

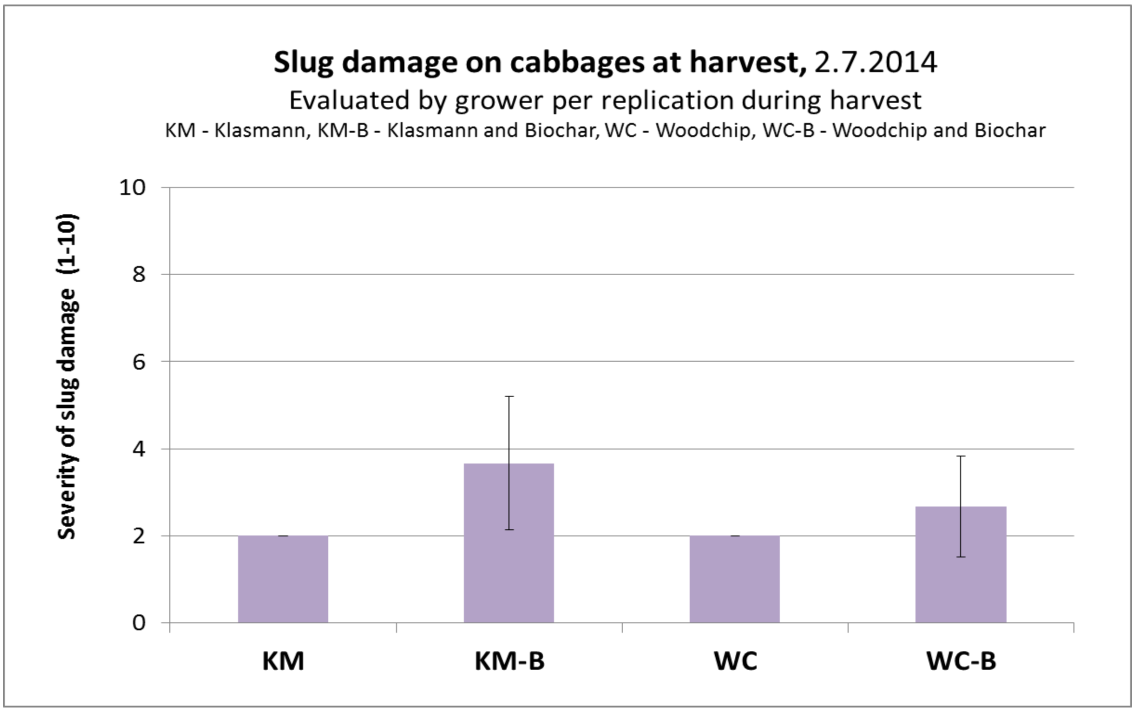
Outcomes/results



Quality assessment was performed by the grower himself, ranking the harvested crop of each replication with a number between 1 and 10 (1 being very low quality and 10 being highest quality). No significant differences were found, with the average quality of the four variations ranging between 7 and 8 (see below).



Outcomes/results



Regarding slug damage (also assessed by the grower), no significant differences between the four substrates were observed. Once again a scale ranging from 0-10 was used, with 0 standing for no damage and 10 standing for very high slug damage. However, a slight trend towards a higher pest occurrence in plants raised in substrates with added Biochar can be seen (the range of numbers within these replications being larger).

Outcomes/results

Cabbage harvest and analysis on 2nd July 2014:

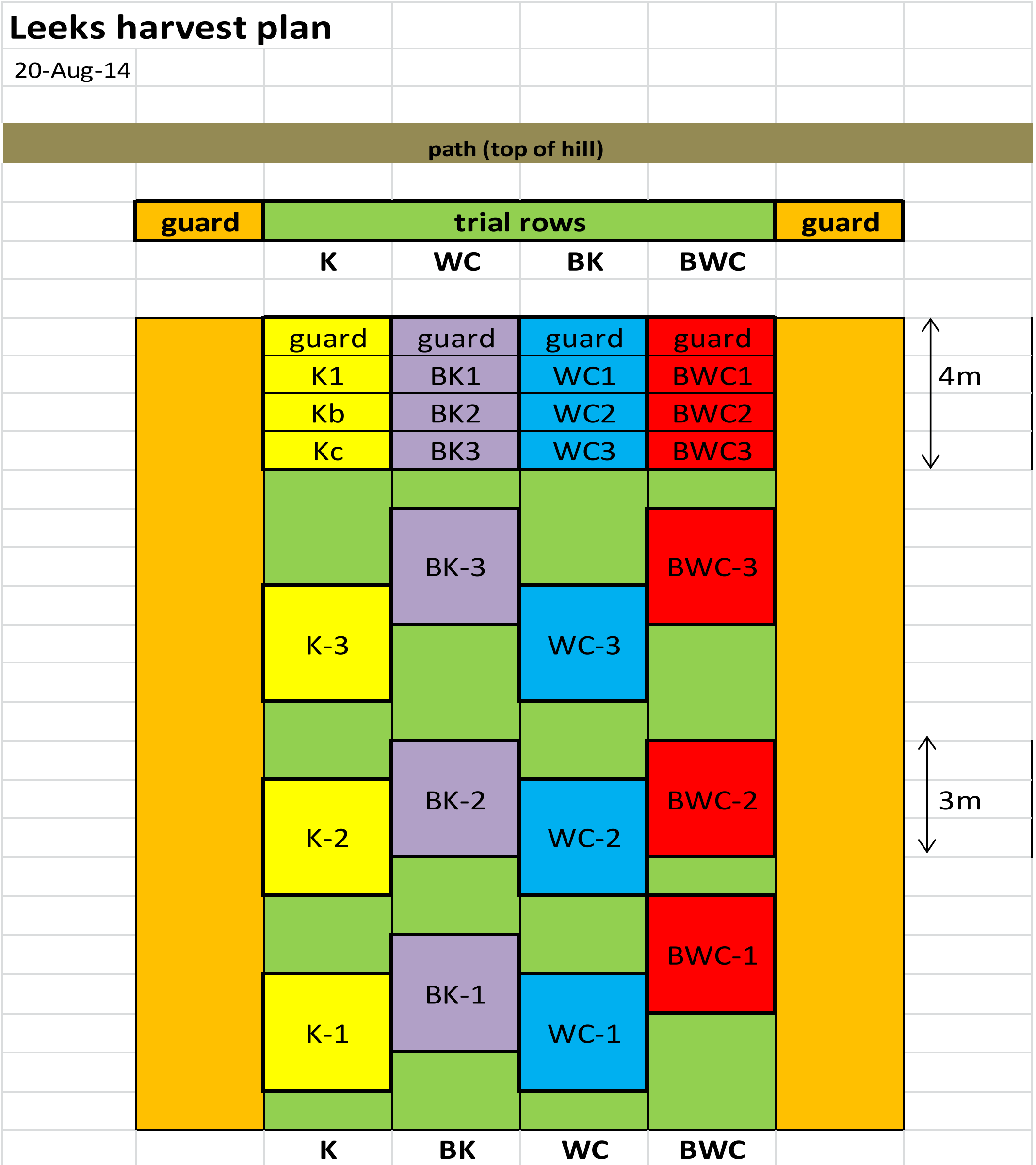



Top left photo - the cabbage trial in the field on the harvest date, comprising four rows of the four compared substrates plus two guard rows on either side. Top right photo - the harvest windows in each row of the trial; 3 windows of 5 metres were harvested in each substrate/row. Bottom two photos - slug damage found on some of the cabbage heads.

Outcomes/results

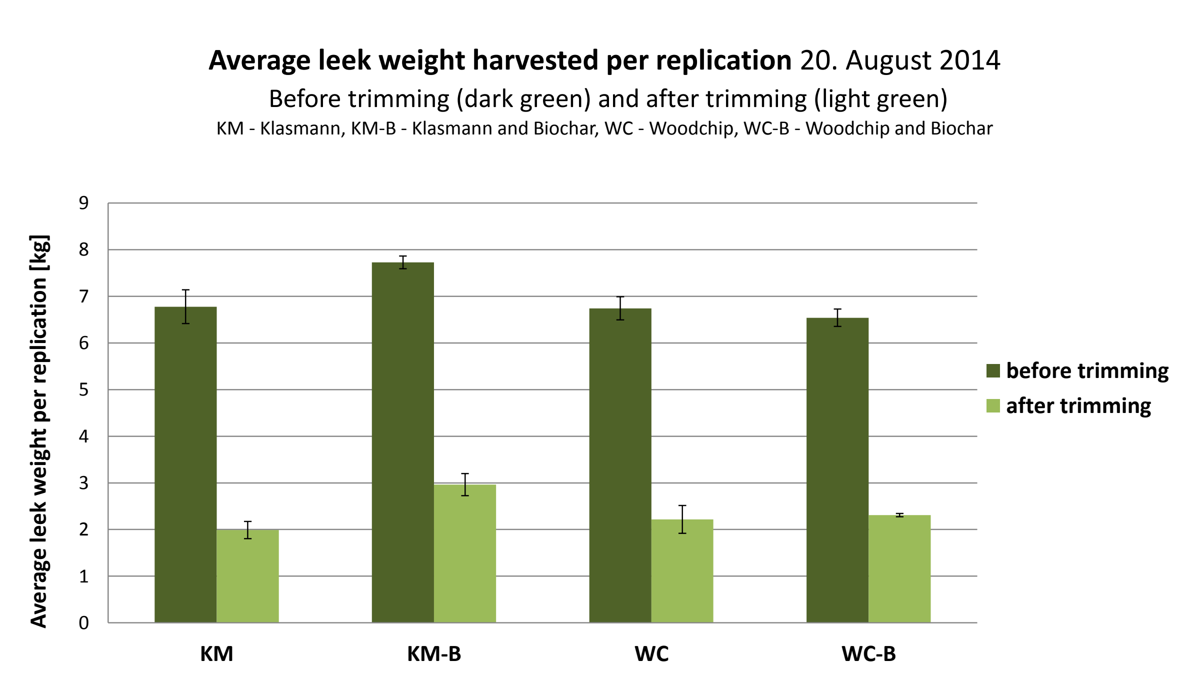
Leek harvest

The harvest plan below shows guard rows and harvest windows of 3 metres in length, with three replications in each row (harvest date 20.08.2014). A small 4 metre strip at the top of the field was left to grow until the final field lab event on the 22nd September, enabling any further development in pests/diseases to be monitored up to that date.



Outcomes/results

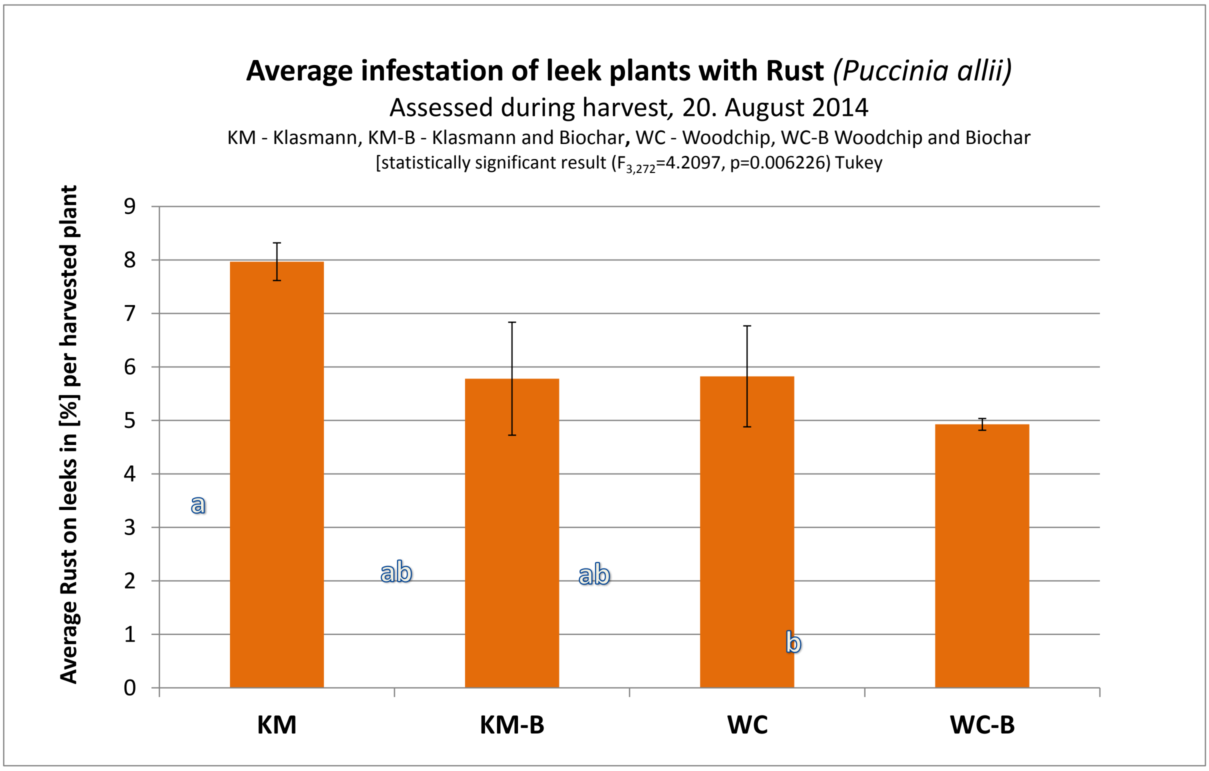
The leeks in the marked harvest windows were loosened with a fork, pulled out with their roots intact, then freed of all attached soil. Each replication was then weighed and assessed for fungal diseases and quality (see diagrams and photos below). After all assessments had been completed, the stalks were trimmed and weighed again to calculate the total sellable yield (shown in light green below).



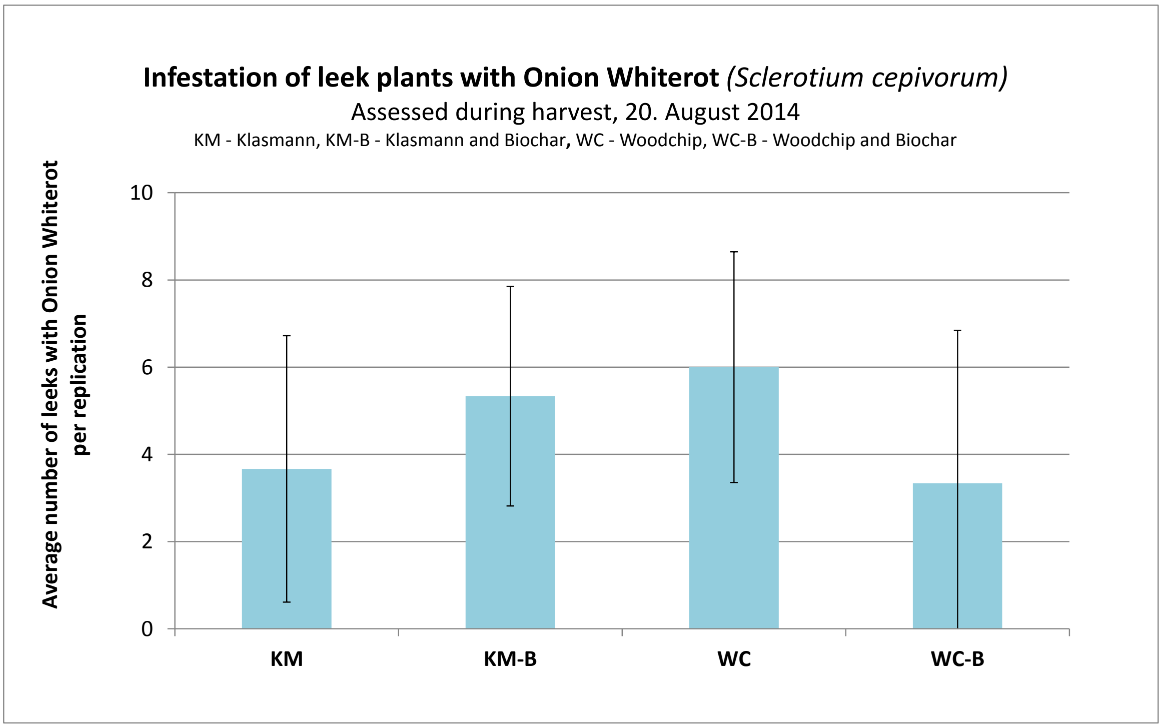
As shown in the diagram and photos below, Rust *(Puccinia allii)* was beginning to show in leek plants in all substrates and replications. Fortunately the infection had not spread severely and had no effect on the trimmed/saleable end-produce. For this assessment, all harvested leek plants were evaluated (24-29 per replication and 3 replications per substrate). The disease spread was estimated as a percentage of all the leaves on the plant. It was found that plants raised in Klasmann substrate showed a higher rate of Rust infestation than those raised in the other three substrates (around 8% compared to 5-6%). In fact, there is a statistically significant result in this regard ($F_{3,272}$=4.2097, p=0.0062). *Post hoc* testing using Tukey's HSD test indicates that there is a significant difference between the control (Klasmann substrate) and the woodchip compost with added Biochar (p adjusted=0.00423).

However, as mentioned above, these results need to be evaluated with great caution. After a long growing phase in the field, during which all plants had similar or comparable conditions and nutrient supply, it's difficult to draw conclusions about specific reasons for any differences. A number of other environmental influences could have caused this slight but significant difference in the spread of Rust. Attributing these results to the growing media used for the transplants can't be done with certainty and requires more in-depth research.

Outcomes/results



In terms of Onion Whiterot *(Puccinia allii)*, no significant differences were noted. In all replications of each substrate (despite ranging relatively widely), a number of stalks showed the beginnings of this fungal disease (see diagram and photo below). However, most of the damage could be removed when trimming because the disease was still in an early stage. It therefore had little to no influence on the volume of sellable produce.



Outcomes/results

Harvesting and assessing leeks - 20th August 2014:

Top left photo - the leek trial in the field (background) during harvest; four rows of the four compared substrates (two guard rows on each side were harvested the week before). Top right photo - rust *(Puccinia allii)* on leek leaves. Bottom left photo - onion white rot *(Sclerotium cepivorum)*. Bottom right photo - harvest windows in each row of the trial; 3 windows of 3 metres each were harvested in each substrate/row.

Conclusions

Set up as a small scale on-farm experiment, this trial has directly reached over 50 growers and interested stakeholders, inspiring them to try producing their own compost/growing medium and/or to compare alternative substrates. Within the constraints (financial, labour, space etc.) of this one-season experiment, very useful results were found, and a small network of enthusiastic and engaged growers and advisors has formed who hope to exchange knowledge and experiences on this subject again in the future.

The trial was useful for demonstrating possibilities and methods of trialling new products or methods on a small scale, specifically tailored to the circumstances of a holding or business. As for farmers' own trials in general, it's very important

Conclusions

to find a suitable balance between scientific research approaches/rigour and site-specific, practical, feasible experimental methods. Within limited budgets for example, it's not always possible to cover all potential influences and aspects of the evaluated research question, but it is possible to answer prioritised questions and to address specific needs focused on the site, thus providing a valuable basis for decision making about future investments or strategies.

In this case, the trial has revealed clear results showing that woodchip compost can be successfully used to replace a commercial growing substrate containing peat. The results indicate that growth, health, and even yield of the assessed crops were comparable, with only small differences in weight and quality (in some cases the plants raised in woodchip compost and biochar performed better than the control), and suggest that woodchip compost can provide a good alternative to commercially available, peat-based growing media.

Although the woodchip mixture requires a slightly different treatment with regards to water and nutrient management, with adapted management strategies, similar (and possibly better) results can be achieved.

Future experiments with this promising alternative growing medium should deliver more in-depth knowledge about its effects on crop health and nutrient management. Although it may possess some disadvantages with regards to weight/structure or water holding capacity, it provides several advantages (environmental and economic) in other areas relevant to growers and all other stakeholders.

Grower feedback

Feedback from Iain Tolhurst:

The objective of the trial from my perspective was to evaluate the efficacy of the four different substrates with respect to plant-raising (the removal of peat from substrates being the main challenge). We have been mixing our own plant substrates using a variety of materials since we started growing in 1976. In 1997 we gave up peat as an input, along with fertilisers based on animal waste, and began to concentrate on green waste materials as the main component. To this end, the decision was made to trial two completely different plant types:

- **Brassica – cabbage**. This plant does not present any particular challenge to grow in a module with substrate as the plant grows rapidly and has a high chance of success - the main requirement being to ensure enough nitrogen for the lifespan of the module (around 5 weeks). We have had many years' experience of plant raising with modules and this crop.
- **Allium – leek**. A more difficult plant to module raise due to the longer time the plant occupies the module (up to 10 weeks). Nitrogen supply during this period of time is the main challenge. It was chosen because it's the most difficult plant to module-grow and would offer some useful information. We do not normally raise leeks in modules due to this difficulty, and because we have found that raising them as bare-root transplants is much easier, cheaper, and more reliable.

Conclusions

Although the main objective was to trial substrates for plant-raising, the opportunity arose to follow the crop through to final harvest. Therefore the decision was made to make further evaluations of yield and pest/disease attack during the growing period and at point of harvest. This was particularly interesting as growers tend to feel that plant quality has a big effect on final crop yield and quality. This was not particularly evident from the trial though.

We have been mixing our own plant substrates since we started organic growing in 1976, and nitrogen supply was the usual limiting factor, necessitating the use of a larger than normal module size. Eventually we found a composition of materials that offered consistent and reliable results; it is based on woodchip compost that we produce on site, having previously composted the raw material for around 18 months. With the addition of vermiculite to improve drainage and dilute the high nutrient content plus a little lime, the material has passed a 10 year trial within our system and we are satisfied with the results. Some informal trials with 5 other grower members of *Thames Organic Growers* showed that the material could be used on other holdings and still produce comparable results to manufactured peat based products.

So we were interested to see if this would be the case in a properly controlled trial with full and regular evaluation, measured against the industry standard substrate which is known to be reliable and has had many years use by organic growers who trust the product. The opportunity also arose to trial the effects of biochar on each of the two substrates.

For us as growers it was interesting to be using a peat-based substrate, and it was obvious why growers like peat as it is physically easier to use, lighter, and better for watering than anything we were used to. This is clearly why it is so important to the industry. The use of other materials may mean a modest modification to the propagation system used by growers.

The results of the trial from my perspective were very interesting as it was clear that our material, which is low tech, reproducible on-farm, and produced from predominately local materials, was a very good match against a peat-based imported product. The addition of biochar in the case of leeks did show a slight improvement of plant quality and is worthy of further investigation and trials.

I would like to see further trials of this type rolled out to a larger number of growers, as this would even out any advantage that I personally may have in respect of using the woodchip compost on our site. As a result of these trials, I would hope that growers may gain more confidence in producing their own substrates, or in finding a supplier that could produce locally-sourced and sustainable growing medium using woodchip as base material.

If organic producers are going to meet the deadlines imposed by the regulation in respect of replacing peat with renewable materials then this initiative needs to be underway very soon. The organic producer needs to be seen to be leading the way on this subject and to get ahead of conventional producers in this development.

Iain Tolhurst, 1st October 2014

Future trials

The trial was set up on a small scale, with the aim of representing 'average' conditions comparable to farmers' own trials and experiments. To gain more detailed and reliable results for the different growing media, it should ideally be conducted on a larger scale, and repeated during two or three growing seasons to account for variability in weather conditions and other environmental factors.

It can be seen as initial work for future, more in-depth research in this area as it revealed some interesting results which can be picked up in more detailed experiments. For example, assessing the long-term effects of woodchip compost on crop tolerance against certain soil borne fungi and diseases.

For the growers, the field lab has strengthened their knowledge of trialling their own research questions which are tailored to their own holding/environment and address their specific needs. This will help them to be more independent and less reliant on conventional and generalised research approaches.