

Questions and Answers:

Soil health and circular economy: A sustainable future for agriculture.

1. Has this benefit of combining organic 1 amendments and mycorrhizae been seen in arable crops?

- Answered during the webinar.
- *Natallia Gulbis (PlantWorks)*: while organic amendments can improve nutrient supply, inoculation with mycorrhizal fungi can enhance plant nutrient uptake. Here are some scientific articles about effectiveness of the application of mycorrhizal fungi and organic amendments.

<https://www.sciencedirect.com/science/article/abs/pii/S1164556311000495>

https://scielo.conicyt.cl/scielo.php?script=sci_arttext&pid=S0718-95162010000100009

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6076214/>

2. Ralph - Are humic acid amendments common/useful?

- **Resource - Jeremy Hitcham 11:28 AM**

Re Humics

Please recognise below as the person who originally prepared the bigger article.

This paper was prepared by Astute Communications, Calgary, Alberta.

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The little numbers throughout the article relate to the bibliography.

I hope this helps.

3. AN UNTAPPED RESOURCE: HUMIC SUBSTANCES

Both conventional and organic farmers need a solution to increase the output and profitability of their operations while avoiding many of today's environmental concerns. Humic substances may provide such a solution - they have the potential to increase crop yields from existing acreage without causing further problems with soil quality. These organic components of the Earth's sediments and coal seams have been known for many years to improve plant growth and soil health, but it is only recently that scientific testing and field trials have been applied to study their specific effects. So, what are humic substances?

Humic Substances Are NOT Compost

First, some myth busting. Humic substance...

3. How does the availability of organic amendments compare to inorganic amendments?

- *Lydia Smith:* Inorganic amendments are very easily available in the UK, whereas organic material availability is related to your regional farming and industry types. In the west there is farm –derived manures of various kinds, but in the East of England, this is much more limited as the region is more dominated by arable farming. However, more recently there is significant production of Anaerobic digestion Digestate and this available for purchase in some cases/areas. Many innovative farmers will use both on-farm crop residues added to whatever is available locally such as tree prunings straw, food processing waste etc. to make bespoke composted material to add to farmland; but they are unlikely to make this available outside of their own farm.

Other materials such as mushroom compost are locally available but each of these above can have its own limitations, in the case of this latter, for example, can have a high salt content.

Ruben Sakrabani at Cranfield University has made a study of this and together with a group of project partners put together a useful report for Defra that he would probably be happy to share.

4. **Hi Ralph-Great talk. This is from Cambond in NIAB Agritech Innovation Hub. One question, when you mention paper waste-based mulch, do you apply the paper waste directly on the top of soil to reserve water/heat or in a roll of sheet to use?**
 - Answered by Ralph Noble in the webinar
5. **In the real field condition, With the nutrient-rich compost culture is it also possible that other pathogens rapidly grow?**
 - Answered by Ralph Noble during webinar.
 - *Natallia Gulbis (PlantWorks):* not related to Ralph’s presentation, just wanted to mention that I also have data which proves that biocontrol (Trichoderma in my case) works synergistically with mycorrhizal fungi
6. **Are biocontrol and mycorrhizal fungi premixed with compost before application? or can they be applied separately?**
 - *Lydia Smith:* They can be supplied and added separately from separate suppliers e.g. Plant works ltd in Kent for mycorrhizal inoculum.
7. **With regards to putting arable land into leys periodically, are there concerns around the pest problems in the following crops? Do you think this is something that can be overcome with the potential benefits?**
 - *Lydia Smith:* See a report from Jonathon Storkey, Rothamsted and the NIAB cover crop report available online on this subject. The irritating answer is it depends on the situation and the following crop. One cautious approach to minimise any negative impact is to avoid following with closely related species. So a leguminous crop like pea or bean would avoid

too many legumes in a previous cover crop; similarly a brassica crop like OSR or cabbage would not include fodder radish or other brassicas in a previous cover crop.

8. Have the leys just been tried with sheep, or have they been attempted with beef cattle too?

- Answered in the webinar.

9. Removing inputs is obviously a long-term problem for the agri-chemical industry's profitability. Do you think that this may undermine the research and development?

- Answered by Craig Livingstone during the webinar

10. Are you finding that dense roots like chicory pose a challenge for precision drilling wheat into the ley?

- *Lydia Smith:* We drilled a wheat crop into land previously growing a mixed herbal ley on land near Duxford underlaid by chalk without difficulty following either direct drill or ploughing and both were achieved without difficulty – we are waiting to see how many volunteers return. A collaborating farmer drilled in heavier land also without problems

11. Craig, thinking about NFU's 'enhanced hedgerows and tree planting' vision for net zero, what are your thoughts about subdividing your fields further, to separate out some of those soil types rather than adjusting treatments in-field?

12. Craig, have you had any issues with cover crops delaying the drilling time of your spring crops compared to when you didn't use them?

13. Craig we really struggle on the heavy soils in Northamptonshire to establish an autumn cover prior to a spring crop and if we do get a good cover crop, we struggle to then get the spring crop established. Any hints or tips to get this to work or is it that this is not suitable on some soils?

14. When a cover crop is ploughed in does the nitrogen in the crop get used up by the microbes to help compost it down

- Answered in webinar.

15. What would be the implications to the amount of land used if more leafy salad crops were produced via hydroponic systems in the UK? Would there be a vast reduction in the land needed for production or marginal differences?

- *Graham Taylor:* That is a great question. In general, indoor growing does hold some good potential for reducing the land area currently devoted to leafy salad crops production in the

field. This is mainly driven by the advantages of enabling increased growing densities of crops without significantly compromising yields when compared to the field. This is because nutrient competition in hydroponic or similar systems is reduced. A further benefit of indoor soilless systems to raise yield on an area basis is the possible higher survival and germination rates, year-round growing potential, and reduced pest and disease inflicted damage over field-grown crops. There are a number of other significant factors at play, however, that would further affect the scale of any further land reduction. Farmers engaged in soil-based leafy salad production would need to be willing to invest in new infrastructure and so the appetite and economic means to do so would be an initial hurdle to achieving land reductions. Most new operations in the sector lean heavily on Venture Capital funding to raise the required capital to do so, which this may be a barrier to entry to the market segment. Another aspect is if vertical crop stacking is feasible. If an indoor growing system is stacked vertically on multiple tiers and crops grown successfully, it would significantly reduce land area requirements when compared a one-tier system. However, a vertical stacking approach is more energy demanding and suits some larger growth habit crops such as spinach or swiss chard less. This is because these crops may demand more vertical spacing between stacking tiers compared to smaller growth form crops such as rocket or water cress. Many indoor vertical farming operations are also currently focused heavily on being situated close to a large market base in urban centres on cheap available land - often brownfield sites. This approach reduces the supply chain costs that would otherwise bring the economic viability of the indoor growing model further into question. However, this does mean that sites of marginal soil quality or non-ideal climate could also in effect become highly productive for soilless indoor growing, freeing up better quality land for production of other more staple crops for example, with possible added yield benefits. Some emerging companies in the indoor growing sector such as in Farm have developed stacked growing systems to grow crops on existing supermarket chain outlet floors, directly reducing the amount of arable land needed for production. High-value crops (on a cost per unit weight basis) such as microgreens or herbs are also likely to be used in such indoor systems over some lower value, large bulking bagged salad crop such as spinach, which currently yield too low of a financial return in commercial indoor growing systems. For these low-value crops, it is difficult to make an economic case to justify the transition from the field to an indoor farming setting at current technology costings and consumer spending behaviours – any land reduction for these crops would be marginal. However, if new cheaper and innovative ways can be developed to grow these kinds of lower value crops in an intensive way indoors, the land-area reduction benefit could be significant – the Hy4Dense project that NIAB is part of is looking at this, so stay tuned!

16. Graham, how much Algae actually can be produced in a real hydroponics system unit as by-product?

- *Graham Taylor*: That is an interesting concept which has received quite some attention over the past decade. It is a difficult question to provide a direct answer to due to the number of factors involved. The traditional approach with hydroponics has been to reduce the algae development for a number of reasons. Particularly for germinating or juvenile crops, algae can smother and outcompete crops at these stages. Excess algae can reduce dissolved oxygen in the hydroponic solutions, leading to a growth-impaired crop, and affect the pH balance of the nutrient solution, adversely affecting nutrient uptake. However, algae have been shown to be beneficial to some crops by altering the competition dynamic of the plant-root environment.

This has led to some hydroponic systems to be modified so that they can farm algae, usually from the reticulation stream or waste stream. This could be used to generate algae on a scale to sufficiently supply algae in quantities for pharmaceutical use e.g. for Spirulina type-supplements. Ideally, hydroponic systems focused solely-on plant growing would never have any excess nutrients in waste streams, as a good nutrient management practice would dictate that all or close to all nutrients would be used by plants, leaving little to no remaining nutrients in the waste or reticulation streams. With algae added to the production system, this becomes more complex to manage, and possibly involves system modification with added costs. A standalone algae farm system sourcing waste nutrient from a hydroponic system would probably be the most pragmatic approach. However, the economic and yield case for farming algae jointly with plant production would be something that would have to be examined on a case-by-case basis.

17. Graham - can you elaborate on the nitrate issue in salads? Is it nitrate content in salad leaf or in soil and how do you think this issue may affect hydroponics?

- *Graham Taylor:* Thanks for the question. Under current EU regulations, the nitrate content in leafy salad crops should not exceed certain thresholds as a result of some bodies of scientific evidence which suggests a causative link between high nitrate levels in foodstuffs and cancer prevalence in humans. However, findings in some other studies do not support such a link, suggesting that cancer prevalence in humans who consume leafy salad crops is actually reduced. Given the uncertainty on this, the precautionary principle has been applied to EU regulations on nitrate levels in leafy salad crops. Under the EU regulations on nitrates, nitrate threshold levels are crop, level of crop protection (e.g. protected or open field), and season dependent. For example, in rocket, a maximum nitrate level of 6000 mg/kg tissue at harvest is applied under EU regulations for a summer harvest, while a nitrate level of 7000 mg/kg applies to rocket harvested in winter. The higher value for a winter harvest is because lower natural irradiances at that time of the year in Northern Europe tends to elevate nitrate levels in leaves as chlorophyll production in leaves increases. The assessment of nitrate levels for these thresholds is always applied at harvest for the end product that is consumed i.e. the leaves, in the case of leafy salad crops. As you allude to, there is usually a strong association between nitrogen availability in soil and leaf nitrates, so a grower in a hydroponic or soil system setting would have to keep a close eye on fertiliser applications to ensure nitrate thresholds are not exceeded in the harvested product. In the UK, the problem is considered relatively small compared to other EU-member states. In the Netherlands, for example, recent restrictions on nitrogen use by farmers (and in other sectors such as construction) mean that nitrogen application to soils could be the subject of increasing pressure by governments trying to reduce nitrogen toxicity (and other human health and environmental problems connected this). Compared to open-field soil systems, hydroponics has the advantage of allowing nitrogen applications to be more tightly controlled and monitored, which if done properly, can lead to reductions in excess nitrogen entering the natural environment in waste streams from open hydroponic systems. By manipulating (increasing) the irradiance of luminaires in indoor environments where crops are typically grown hydroponically (especially near harvest), a hydroponic grower has another means to reduce nitrates artificially. This may be contributing pull-factor for farmers in future considering switching to hydroponics on soils where nitrogen availability is excessive and be beneficial to the soilless cultivation sector as a whole.

18. Natallia - was the micronutrient content of the wheat tested - were there differences when SR3 was applied and when it wasn't?

- *Natallia Gulbis (PlantWorks)*: No, we did not have an opportunity to test micronutrient content.

19. What bacterial genera were used in your trials? Have you tried this in oilseed rape?

- Answered in webinar.
- *Natallia Gulbis (PlantWorks)*: Bacillus, Agrobacterium, Gluconacetobacter and Derrisia genera. There is different product SR3 specially designed for OSR and contains bacteria from different genera. We confirmed that particular strains of bacteria only successful with particular crops.

20. Both wheats were effectively second wheats. Could SR3 have an effect on take all?

- *Natallia Gulbis (PlantWorks)*: It could have indirect effect on take-all disease: beneficial bacteria (a) will compete with pathogen for nutrients and space, (b) will make the crop stronger by providing more nutrients to the plant bacteria that will help either compensate damage from take-all or/and resist pathogen, (c) beneficial bacteria will boost plant's natural immunity

21. Surely the battery manufacturers should pay you to recycle the batteries and this would make the product cheaper and more cost effective.

- Answered in webinar
- *David Harrod*: in Finland, yes, they pay a 'gate fee' into the factory which helps towards production costs so we can compete in the global market... it's all 100% sulphate-based ZN & Mn

22. Educating consumers is very important but as you've mentioned the supermarkets don't allow the flexibility to account for environmental conditions, what do you think is the solution to this? Consumer pressure? Government intervention? Tapping into local markets more?

- Answered by Craig Livingstone during webinar

23. Have you seen any effect on the sale of "wonky veg" reduce the pressure of producing perfect leafy crops or allow the sale of slightly imperfect leaves?

- *Lydia Smith*: Some farmers have reported the converse to be true; attempting to get wonky veg back into shops has reduced sale of perfect produce and thus reduced the margin for them. Since the profit margin for horticultural produce in the UK is usually less than 2% for even the best farmers this is not an ideal outcome.

But there are more solutions out there and these are to be encouraged. The recently introduced 'ODDBOX' scheme, for example is looking very promising – sourcing just those veg that would have been wasted for a range of reasons.

24. Adam - Graham discussed as well, he may also have some ideas, to what extent does yellowing and leaf damage actually impact salad taste, i.e. is it just a 'wonky veg' issue which contributes to food waste and should be addressed in the commercial sector?

Please note, we are still awaiting some answers from our panellists and will continue to update this document with their answers as they come in.