AHDB HORTICULTURE

Grower Summary

PO 020a

The development of an experimental deep pool hydroponics system to investigate its potential for cut flowers.

Final Report 2019

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GROWER SUMMARY

Headlines.

- Column stock production has been more challenging than other cut flowers in deep pool hydroponics owing to disease issues and a high oxygen requirement in the solution.
- However, two years of trials have shown that deep and shallow pool hydroponics seem to be possible systems for cut flower production although engineering solutions are now needed to develop the system on a commercial scale.
- The production of column stocks could be possible in vertical systems (eg aeroponic tubes) but a bespoke support system would need to be developed.
- It is possible to produce column stocks in tulip pin trays using a clay pellet substrate but without an engineering solution to provide crop support, this system results in bent and hence unmarketable stems.
- The production of stocks is possible in pots or modules on an ebb and flood bench system without the need for crop support.

Background

The control of *Fusarium oxysporum* is a major issue for flower growers, especificationially those producing *Matthiola incana* (column stocks) and Lisianthus. Despite a number of AHDB funded projects, the only reliable control is still the expensive and time consuming technique of steam sterilisation, but even this is only a partial cure and large losses can still be seen in steamed glasshouses. In an attempt to overcome these issues the industry has been looking at the possibility of moving completely out of soil into a hydroponics system. The preferred option was some form of solution hydroponics rather than substrate hydroponics and the simplest system seemed to be deep pool hydroponics where the crop is grown on floating rafts in a large pool of water 25 to 30 cm deep. After a trip in December 2014 to look at lettuce production in deep pool hydroponics, Phil Collison of J A Collison and Son decided to construct a small trial pool (7 m x 3.8 m) in order to undertake AHDB funded trials during 2015. There was very little documented work on the production of stocks in a solution hydroponics system and none in deep pool. The purpose of the first year trial (2015) trial was therefore to simply explore some of the basics of production to determine if a marketable crop was even possible. The second year trial (2016) built upon the findings of the 2015 results as well as looking at a number of other potential systems. During the 2015 and 2016 trials other techniques emerged such as producing crops using a LECA (lightweight expanded clay aggregate) and growing in modules (eg 9cm pots) on an ebb and flood system. These techniques were further investigated in 2017 and 2018.

Summary

YEAR 1 (2015)

The deep pool hydroponic trial facility was constructed in December 2014 and was filled with water in mid-March 2015 ready for the trial to commence in late March 2015.

A number of different floating trays were made from 600 mm x 400 mm x 25 mm dense polystyrene sheets which enabled both plugs and blocks to be investigated. The nutrient status was controlled by an existing "Heron" controller using a traditional A and B tank as well as concentrated nitric acid for pH control. The initial nutrient recipe was drawn up by Paul Challinor of May Barn Consultancy and this was slightly modified for the use of either reservoir or mains water (see table 6 and 7). The water was constantly circulated and entered the pool via a perforated pipe at one side of the pool and was drawn out by a similar perforated pipe at the other side. Oxygenation was initially provided by a "Venturi" which introduced air into the solution. The first plantings were a mixture of stocks propagated in both blocks and plugs, floats of lettuce blocks to act as a "check" specificationies as well as blocked statice and Lisianthus plugs.

It soon became clear that the stocks were not thriving and while the other specificationies (especificationially the lettuce) were growing away very vigorously, the stocks looked very sick. The block propagated stock plants initially seemed to be performing better, but as soon as the roots reached the water they began to turn brown and decay. This contrasted starkly with the lettuce which were ready to harvest within a few weeks and had very vigorous, healthy white roots. This clearly demonstrated that there was no fundamental problem with the pool design but in its current form it was obviously not conducive to the production of column stocks.

A number of brassica were then planted to determine if the system was suitable for Cruciferae (the same family as stocks) in general in the deep pool system. A modified air gap was also introduced to some of the stock trays so that the block or plug was not directly sitting in the water. Aster, ericoides and chrysanthemums were also planted at this stage to broaden the assessment.

A month later the brassica (including, cabbage, sprouts and cauliflower) had put on substantial growth, the aster ericoides and lettuces were thriving but the stocks continued to die. None of the changes that had been made seemed to have made any difference but there were a few random stock plants that had made a marketable flower despite those around them being either dead or very sick. This suggested that stocks have the potential to thrive in the system with further development of the set up.

After researching the issue further one factor that kept coming up was oxygenation of the water, and there was a suspicion that perhaps stocks required more oxygen than the other crops that were growing in the pool. Accurate oxygen measuring kit and some additional oxygenating equipment in the form of air pumps and air stones were obtained to test this theory. Without additional oxygenation (beyond the venturi system) initial measurements of dissolved oxygen were low (around 2 mg/l or 20% saturation) but once the air stones were introduced, the area immediately around the stone rose to around 8.5 mg/l (85% saturation) and the concentration a few feet away from the stone rose to around 6 mg/l (60% saturation). Soon after increasing the oxygen concentration positive results were seen, with the stock plants immediately above the air stone producing both healthy leaves and more significantly, healthy white roots. However this positive effect was very localised with plants growing two rafts away from the air stone being no better than before even though the oxygen saturation had increased three fold. This clearly demonstrated that stocks seem to need a much higher oxygen concentration than anyone had initially appreciated.

Unfortunately two weeks later some of the healthy plants in the floats over the air stones began to wilt. Closer inspecificationtion showed that the problem was in the stem base which resulted in the roots and stem being detached from one another. This was subsequently confirmed by STC plant clinic as being *Phytophthora* and a recommendation was made to apply metalaxyl as Subdue to the pool. Unfortunately because it was by now so late in the season, no more plugs could be obtained so it was only possible to look at the effect of Subdue on the existing plants rather than a new batch. However the results of the Subdue did seem to be have a marked effect and very few additional plants seemed to succumb to *Phytophthora* although those already infected did not of course recover. By the end of September a number of flowering stems had been achieved and since the addition of the Subdue, it seemed that the positive effect of the air stones was wider than just the float immediately above them.

In addition to the main deep pool trial a small secondary trial was undertaken in three 1.2 m x 1.2 m shallow pools which are only 10 cm deep and are designed to be used with rolling tables. This was started very late in the season so only one round could be produced hence the results must be treated with caution. However, one of these shallow pools had the addition of an experimental form of electrolysed water which allows free available chlorine (FAC) to be released into the solution and this produced some of the best stems of the season although they did not crop until late October.

To summarise, for stocks in the deep pool hydroponics system, none of the earlier variables that were investigated i.e. plugs or blocks, different forms of air gap (or no air gap), different varieties and different planting dates made any difference to the performance of the plants. It was only the introduction of additional oxygen bringing the level up to around 8 mg/l (80%

saturation) that started to result in the production of marketable stems even though some of these subsequently succumbed to *Phytophthora* before Subdue was introduced to the water. The additional trial looking at shallow pool hydroponics has given an indication that it may also be a system that can be utilised for column stock production but as with the deep pool trials it needs to be further investigated to ensure that the encouraging results obtained at the end of the 2015 trials can be both repeated and replicated.

YEAR 2 (2016)

The second year of trials concentrated on just column stocks and incorporated two of the key findings of year 1, i.e. high oxygen concentrations and fungicides to control oomycete disease. These were applied from day 1 of planting in the deep and shallow pool trial. In order to better control the pH and nutrient status, a new IntelliDose controller was fitted complete with peristaltic pumps to deliver the A & B tank nutrient as well as the nitric acid.

Air stones were again used to oxygenate the water and by careful placing of the stones an oxygen gradation was created across the trial. The results of this clearly verified the findings of the 2015 trial and showed that high levels of oxygen in the water are required to produce a healthy root system and subsequent good quality flowers. The use of oomycete fungicides also seemed to adequately control root and stem diseases in the 2016 trial.

The 2016 trials showed that by the use of appropriate fungicides and high oxygen levels in the water, it is possible to produce marketable stems of column stocks in both deep and shallow pool systems. However, in order to now move from a small trial to a commercial scale system, an engineering solution would need to be developed to adequately oxygenate the water to an appropriate level. This will be more difficult with a shallow pool than a deep pool system owing to having a large number of units that all need to be individually oxygenated rather than the one large single system required by the deep pool. It may also be possible to redesign the floats to, for example, have an air gap when using plug-grown in net pots.

It was also clear from both the 2015 and 2016 trials that the plants need to be supported, and if the floats are moved around the system from planting to harvest (as is the case with deep pool lettuce production) the support system would probably need to be an integral part of each individual float. This would also require a commercial engineering solution to resolve the issue.

In addition to the deep and shallow pool trials in 2016, a trial to investigate a vertical aeroponics system was undertaken. While the quality of the stems indicted that it is possible to produce stocks in such a system, a crop support system would need to be devised. This is not an insurmountable issue and the Project Manager has seen support systems used in other vertical hydroponic systems, however careful costing would need to be undertaken before embarking on such a system.

Following on from a very encouraging demonstration seen at Greenmount in the spring of 2016, a trial was set up to look at the use of extruded clay pellets (LECA) as a reusable substrate in tulip pin trays as an ebb and flood system. Two rounds were produced using this system and encouraging results were obtained where the water was drained away completely by using an ebb and flood drain plug. Further trials were the undertaken using LECA substrate during 2017 & 2018.

Propagation in modules was also investigated using 4.5, 5.5 and 9 cm net hydroponic pots and 4 cm oasis blocks. None of these modules showed any advantage for the deep and shallow pool systems. Perhaps the most surprising result of the 2016 trials was the fact that high quality (and apparently self-supporting) stems of stocks were produced in a 9 cm net pot using what can only be described as a "Heath Robinson" ebb and flood system. This was a result that warranted further investigation using commercial ebb and flood system.

YEAR 3 & 4 (2017 and 2018)

A further 2 years of trials were undertaken on growers holdings to further investigate the use of LECA pellets and the production of stocks in modules on ebb and flood benches.

The LECA trials were undertaken at J A Collison & Son (with an additional small trial at Belmont Nursery in 2018) The bespoke trial system used in both years was developed by J A Collison. It enabled a 1.2 m x 1.2 Mm mobile bench insert (the same as those used in the earlier shallow pool trials) filled with LECA pellets, to be flooded on a regular basis (for one minute, six times per day) and the nutrient solution then drained back into a catchment tank.

In 2017, two rounds of crops were produced, the first round using a nutrient solution electrical conductivity (EC) of 1.5, 2 and 2.5. While all of the different EC levels produced stems of a potentially marketable specification regarding length and weight, the lowest EC produced severe symptoms of what was believed to be Manganese deficiency in the first planting. As the other two EC levels did not seem to cause any issues with the crop, a decision was taken to just use the higher value (2.5) in subsequent trials. All of the subsequent LECA trials at J A Collison produced stems that exceeded the required specification in terms of stem strength, and both stem and flower spike length.

However, while the LECA system seems to provide an ideal air and water balance which produces strong healthy roots in stocks, it does not provide a strong enough support structure to the roots as would be the case in soil (or compost), which means that the stems cannot support themselves, leading to bent and curved stems making them effectively unmarketable. Therefore until an engineering solution can be found to overcome this problem of crop support, column stock production in a LECA substrate is unlikely to be adopted by the industry.

The 2017 trials investigating the possible production of column stocks in modules on an ebb and flood bench were undertaken at Neame Lea nursery. The first planting was made in week 2 into 18 hole packs (with an overall dimension of 31 cm x 54 cm) and 9 cm pots in 18 hole carrier trays (about 30 cm x 53 cm). This gave a spacing of around 107 plants per sq/m for the packs and 117 plants per sq/m for the pots. The varieties planted were Mathilda cream and Figaro lavender with a second planting being made in week 6 and a third in week 10, both using Francesca. All plantings were then split into two and one half grown on in a warm environment (about 16°C day and night) where tulips were being grown and the other half in a cold environment (around 5°C day and night) where hardy bedding plants were being grown.

All of the plantings produced a marketable crop and unlike the LECA trials no support was required in order to produce straight stems. As expected, the colder crop took longer to produce a marketable crop (in fact the week 6 cold planting of Francesca flowered at the same time as the week 10 warm planting of the same variety) than the warm crop, and also produced stronger heavier stems. The weight and strength of the cold crop was in fact comparable to the stems produced in the LECA trials. These trials demonstrated that module production on an ebb and flood system is a viable production technique and this has in fact been used on a commercial scale during 2018.

Financial Benefits

To provide an economic assessment of a deep pool hydroponics system is not easy because for it to be economically viable a crop would need to be produced all year round as is the case with lettuce. At this stage it is not clear what crop could be produced in summer and autumn to follow on from the stocks.

The fact that the deep pool system still requires some fundamental engineering solutions (to increase oxygenation and develop bespoke trays with integral plant support) means that it is also not possible to provide an accurate cost for setting up a commercial system. However, as a guide, to set up a 0.1 ha deep pool hydroponic system, the cost would be an estimated £5 per sq/m for the liner (£5,000 for 0.1 ha), around £25 per sq/m to concrete the floor (£25,000 for 0.1 ha), £30,000 for the irrigation plus control system and a further £5,000 for labour and other miscellaneous costs. This would make a total ball park figure of around £65,000 to set up a 0.1 ha (quarter of an acre) basic deep pool system.

Regarding the trials at Neame Lea, the value of a column stock crop alone would not justify the installation of an ebb and flood system, but is applicable to existing systems (perhaps being used for tulips or bedding) where the production of stocks would fit a production window when the system was not being fully utilised with the other crops. In such a situation it was estimated by the growers undertaking these trials that the main extra cost of using a module system, i.e. the growing medium, was offset by not having to steam the soil, which is the case in a normal soil based production system. There could also be labour saving costs in the pot system assuming the nursery has an automated potting system that can transplant the plugs into the module.

Action Points

- Consider small scale trials of deep and shallow pool hydroponics for cut flowers but further engineering solutions are required to develop this on a commercial scale
- Vertical aeroponic and hydroponic systems are a possibility for the production of column stocks but support is required and the chosen system would require careful economic evaluation (for further details see .http://www.aponic.co.uk/ and http://www.saturnbioponics.com/trial-crops/column-stock-flowers/)
- Growers could consider trialling tulip pin trays with a clay pellet substrate (LECA) but an engineering solution needs to be found to support the crop.
- If the nursery already has an ebb and flood system in place the grower could consider producing column stocks in a module system such as 9 cm pots.