Viability of proposal to recycle fertigation runoff from tabletop produced strawberries at Rosemount Farm

Cooperative Farms

Rosemount Farm, Perthshire

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Summary

This proposal analyses the viability of installing a fertigation runoff recycling system that saves runoff from 18ha of substrate produced tabletop strawberries on Rosemount Farm. The equipment to be installed would have sufficient capacity to also recycle runoff from a new development of a further 6ha of tabletop strawberries being built in the near future.

Reasons to install the recycling system are analysed along with different methods of catching and sterilising the fertigation runoff from the strawberries. The project's financial viability is considered with a range of different scenarios to illustrate possible different outcomes. Influences from within the business as well as factors from outside the business are included in the viability study.

The financial scrutiny of the project shows that at present it is not a very attractive investment, as payback of capital outlay is about 12 years and return on capital is only 7.5%. However, if conditions within or outside the business were to change, for example if the farm had to start paying to extract irrigation water, then the viability of a runoff recycling system on Rosemount Farm would be much better.

Introduction

The leaders of the Cooperative Farms business have a clear vision that it should be the “largest, most sustainable, environmentally minded farmer in the UK” (The Co-operative, 2013). This vision will require all of the different farms that operate under the Cooperative Farms banner to demonstrate sustainability on social, economic and environmental levels.

This project will weigh up the benefits and risks associated with installing a runoff recycling system at Rosemount Farm, and provide an estimate of the returns from the venture.

It will tie in with a current proposal that includes plans to increase the current area of tabletop produced strawberries on Rosemount Farm by a further 6ha, using the double-rowed Haygrove polytunnel system, thus minimising disruption to the farm, and utilising brand new equipment.

Outline of proposal

Rosemount Farm produces around 1100t of strawberries per annum from +/- 40ha of polytunnels. Of this 40ha, there are currently 18ha of tabletop strawberries that are grown in substrates (mainly peat and coir), with the balance being produced in raised soil beds.

At present, all fertigation runoff from the strawberries in substrate bags (supported on tabletops) is lost as leachtate onto the ground in the polytunnels. This represents about 15% of all the fertigation applied to the crop, and significant amounts of water and fertilisers are wasted as a result.

This proposal intends to address the problem of fertigation runoff from the strawberries by installing a suitable type of guttering underneath the tables to catch the waste runoff, and piping it to a machine capable of sterilising the leachtate so that it can be added back into fresh water and topped up with fertiliser by the existing irrigation rig before being reused on the crop again. The sterilisation unit would be required to remove the risk of spreading potentially dangerous diseases and plant pathogens throughout the farm very quickly.

Overall it is hoped that the project will clearly demonstrate the ethos that the Cooperative Farms is keen to convey- increased environmental and social responsibility through recycling resources while at the same time delivering a financial return that investors would see as a sound option.

A non-exhaustive list of equipment needed includes:

-Guttering under substrate bags on tabletops
-Piping to collect the runoff from the gutters and bring it all to a central sump/s
-Pumps to move the runoff from the sumps to storage tanks
-Filtration to remove debris from the runoff
-Storage tanks
-Sterilisation unit capable of removing any pathogens from the fertigation runoff
-Dosing unit capable of adding the clean runoff back into fresh water
-Computer capable of coordinating all the above steps

Reasons for Rosemount Farm to install a runoff recycling system

Rosemount Farm would benefit from installing a runoff recycling system for a range of reasons- a combination of pure economic sense in future savings and lower costs, reduced risks to future government and environmental policies and also a possible marketing advantage over other farmers. The reasons are summarised below:

- Fertiliser savings: If Rosemount Farm were able to reduce the fertigation runoff from the tabletop strawberries from the current farm average of 15% to negligible amounts (+/-1%), there would be a direct saving in the amount of fertiliser used by the farm if they could recycle the fertiliser runoff by putting it back into the irrigation system.

  Although the farm is already keeping average fertigation runoff much lower than the national average of 25-35% runoff (DEFRA, 2012), it could relatively easily make large fertiliser savings by installing the runoff recycling system.

- Herbicide savings: The current fertigation runoff from the strawberries is leached onto the polytunnel floor where it helps to support a significant weed problem. Weeds such as creeping thistles, broadleaved docks and common nettle (usually associated with fertile areas according to Finch *et al.* (2002)) are widespread on the polytunnel floors and require frequent herbicide applications throughout the year to control them.

  Any reduction in runoff of high nutrient concentration fertigation mixture would definitely slow weed growth, thus reducing the need for costly herbicide applications.

  As strawberries are extremely intolerant of most herbicides (Fennimore and Doohan, 2008), so reduced applications of herbicide would also lower the risk of inadvertently spraying off large areas of the high value crop (for example in breezy conditions).

- Water savings: Although Scotland farmers currently do not pay any charges to abstract water other than a fairly cheap abstraction licence (<£2000/yr), a fertigation recycling system that could reuse up to 15% of the current +/- 60,000m³/yr used on Rosemount Farm would reduce exposure of the farm to future increases in extraction charges.

  In other areas of the UK such as South-east England, farmers pay as much as £1.20/m³ for irrigation water (CCC, 2013) and this is a significant cost that could affect farmers in Scotland in the future. Rosemount Farm is located in the Tay Valley in Perthshire, which has very fertile soils that support a wide range of irrigated crops such as potatoes, root vegetables, brassicas and soft fruit.

The Tay River and its tributaries (the source for most irrigation water in the area) are the most highly abstracted rivers in Scotland and since 1952 there has been a significant downward trend in the water levels (CEH, 2012). Any future irrigation charges/ restrictions brought in to Scotland would almost certainly affect the Tay Valley, thus a runoff recycling system installed at Rosemount Farm would help mitigate these risks.

- Environmental stewardship**:** Rosemount Farm extracts irrigation water from both the River Ericht (northern half of farm) and Monk Myre (southern side), a reservoir/loch which is a Site of Special Scientific Interest (SSSI). There would be huge implications and possible fines from SEPA (Scottish Environmental Protection Agency) if it was proven that the loch/river had been contaminated by fertigation runoff from the tabletop produced strawberries.

  The installation of a runoff recycling system would be a sustainable way of reducing the chances of environmental contamination or eutrophication of waterways or local habitats in the vicinity of the farm.

  Rosemount Farm and the surrounding area around Blairgowrie is not in a Nitrogen Vulnerable Zone (NVZ) at present (Scottish Government, 2013). However, the leaching of high nutrient fertigation runoff from the tabletop strawberries on the farm would definitely be deemed environmentally damaging, so installation of a runoff recycling system on the farm would help to reduce the risk of large expenditures being needed in the event of new legislation that required runoff recycling. This would be similar to the massive expenditures that UK dairy farmers have had to make in the last 5-10years to bring their slurry storage in line with revised legislation.

  The environmental benefits for a runoff recycling project are very difficult to quantify, although if the Scottish government bought in ‘NVZ style’ legislation that affected soft fruit farmers and required them to install recycling systems to catch all fertigation runoff, then this project would have to be undertaken, whatever the capital outlay and returns on investment.
- Marketing angle**:** As a high proportion of the fruit from Rosemount Farm is sold under the Co-operative banner, there could be a chance to use the concept of runoff recycling to give the product a Unique Selling Point (USP), possibly along with existing measures such as reduced pesticide use. The Co-operative might be able to market these fruit as the most sustainably produced.
- Agronomic factors**:** The current irrigation system tries to keep runoff from the substrate bags (on the tabletop structures) to a minimum (<15%) so that wastage of fertiliser and water is limited. However, these reduced runoffs can lead to a build-up of potassium and sodium salts in the substrate bags leading to reductions in the yield/quality of the crop (Else and Dodds, 2010).

A runoff recycling system would allow runoffs through the bags to be run at higher levels, allowing the dangerous salts that commonly build-up in the substrate to be flushed out with the runoff, without losing valuable fertiliser and water in the process. Crop nutrition would be able to be controlled much better, and there would be a higher yield of valuable Class 1 fruit.

All of the above considerations of installing a runoff recycling system for the tabletop strawberries on Rosemount Farm give clear monetary and sustainability advantages that will help displace the high installation costs for a project of this kind.

Project Research

To try and economise the cost of installing the equipment needed to recycle fertigation runoff on Rosemount Farm, different types of equipment and infrastructure were investigated and quotes from different horticultural companies were obtained to keep costs to a minimum.

Options for sterilisation of fertigation runoff

This is one of the most important considerations for the project- any fertigation leachtate that would be collected would need to be thoroughly disinfected before being recycled through the system. Strawberries are easily affected by waterborne diseases such as Phytopthora (Red Core), Verticillium Wilt and a range of viruses (AHDB, 2010) - these pathogens would need to be controlled to stop them being very quickly spread throughout the farm in recycled fertigation runoff. A sterilisation rig would also control any algal growth in the irrigation circuit that could cause blockages in the small piping and fittings.

A range of options for the project were assessed:

-Heat Pasteurisation: Runoff water is heated to >70ºC for >30 seconds using a heat exchange mechanism (Marlow, 2006). This method is widely used in areas with subsidised piped gas (for example in the Netherlands), and so was deemed unsuitable at the outset for Rosemount Farm due to the crippling cost the farm would have to pay for energy.
-Ozonation: Runoff water is treated with a very low concentration of ozone gas that oxidises any pathogens. However, it is an even more expensive procedure than heat pasteurisation so it is also concluded to be unsuitable for the sterilisation unit needed at Rosemount Farm.
-UV Disinfection: Ultra violet light is passed through the fertigation runoff, killing all pathogens. The systems available can also be adjusted so that they can produce UV at different wavelengths, allowing partial disinfection (much cheaper due to a lower UV wavelength being used) or total disinfection depending on the range of pathogens being found in the runoff (Marlow, 2006). The products available are capable of sterilising large volumes of runoff at high speeds.

-Hydrogen peroxide: This method works in a similar way to ozone disinfection; however ozone is a more powerful oxidising agent. Hydrogen peroxide is not able to kill all pathogens that could be present in the runoff.
-Iodination: Similar to the processes used to sterilise drinking water, fertigation runoff could be sterilised with iodine. This method is unreliable and the iodine can only be fully relied upon to kill fungi in the runoff, not any other pathogens (Marlow, 2006).

Options for guttering to catch fertigation runoff
The 18ha of existing polytunnels would all need to be modified to have guttering that caught the fertigation runoff from the substrate bags. This would involve the largest investment in procuring and installing +/- 108,000m of guttering to the tunnels on the farm.

A cheap, sturdy, UV light stable (there are very high levels of UV light in the polytunnels) and long-lasting material (>20yr lifespan) would be required for the project. Options include:

-Galvanised metal: Definitely the most suitable material but also the most expensive. It would cost >£5/m (>£500,000 needed just for the guttering) to install galvanised metal gutters to the tabletops, which would make the whole project a much less worthwhile investment.
-Plastic: Although not as durable as metal, and also with problems of UV stability in the polytunnels, this material showed promise for the guttering. It could also be formed on site from flat plastic sheets in a shape specified by the farm.
-Canvas: This is the cheapest option researched, although it would not have the lifespan of the other 2 materials and would need replacing in <10years.

Site Survey

A survey of the current site at Rosemount Farm resulted in a number of important considerations for any installation being considered:

- The topography of the farm dictates that there are 2 different irrigation rigs already servicing 2 separate blocks of polytunnels due to the farm being on the top of a hill. The irrigation system flows in opposite directions, North and South off the hill in the centre of the farm. This would require there to be multiple sumps to catch the fertigation runoff, with pumps and piping to transport it to suitable storage tanks in close vicinity to the sterilisation rig.
- Runoff rates were measured on several different polytunnel blocks and averaged out to give an average runoff rate of 1.96m^3/ha/day in different weather conditions (plants have different water usage in hot versus cold weather). Thus, a sterilisation unit with a capacity for 60m^3/day (20% extra capacity for possible expansion in the future) would be needed for the project.
- The possibility of using the fertigation runoff from the tabletop strawberries to irrigate maincrop strawberries (in raised beds in the ground) was considered.

This could be advantageous as the soil would help to buffer any salt imbalances in the runoff when it was subsequently applied to the maincrop. It was concluded to not be a good idea as these maincrop strawberries are only irrigated for 4 months/yr and there would be a requirement for huge tanks to store the runoff for the rest of year.

- A smaller project that would link in with current plans the farm has to install a further 6ha of tabletop strawberries (that already have guttering in the tunnel structure) was considered: the plans were to link the new 6ha into another existing block of 6ha of polytunnels- however, the levels of return on investment were below 5% and so not a viable investment.

Proposed runoff recycling system to be installed at Rosemount Farm

After researching and compiling quotes from various companies, the following project was decided on:

- At the time of installation of new 6ha block of polytunnels (which come with guttering as part of the structure), install piping and equipment to recycle the runoff from the existing 18ha table-top strawberries on Rosemount Farm. (Total area of tabletop strawberries = 24ha).
- Using a Priva UV-C HD Vialux sterilisation unit capable of sterilising 60m³ of runoff per day. This includes a computer rig that will control the whole recycling cycle. The Priva Vialux unit would disinfect the fertigation runoff using UV light at a wavelength of 150mjcm², enough to kill all fungi and bacteria in the runoff but not viruses (there would be the option to alter the wavelength to kill everything in the runoff if needed).
- A pre-control EC sensor (electroconductivity is a measure of salts present in the runoff) that would alter the rate that sterilised runoff would be added back to fresh water entering the fertigation rig.
- Bato plastic guttering for 108000m (18ha) of tabletop rows including fittings and endplates.
- 3300m of 20mm PVC piping to join the gutters under the substrate tables to 50mm PVC piping (3400m) running at right angles to the end of the polytunnels. The 50mm piping would move the runoff through gravity into 3 separate sumps (at low points on the farm) where 3 pumps would pressurise the runoff and pump it through the 63mm PVC pipe (1000m) to the storage tanks.
- Valves, saddles, elbows and fittings to join all piping and equipment together.
- 2x72m³ concrete footed storage tanks capable of storing >2days of runoff.
- 3 screen filters (3m³/hr flow) to be installed at each of the 3 drainage sumps to remove most debris from the leachtate. 1 sand filter (6m³/hr flow) for use before the runoff flows through the UV sterilisation rig.

Table 1 below shows a breakdown of the investment needed by Rosemount Farm to install a runoff recycling system such as the one above:

Table 1: Cost of capital investment for runoff recycling system

	Number of units	**Total (£)**	**Scenario C** *(no guttering needed)*
Plastic guttering (m)	108000	**118800**	0
PVC piping and fittings -20mm (m)	3300		
PVC piping and fittings -50mm (m)	3400		
PVC piping and fittings -63mm (m)	1000	**8005**	8005
Pumps + sumps	3	**4168**	4168
Concrete tank footings	2	**5000**	5000
Tanks (72m³)	2	**5144**	5144
Sand and screen filters	4		
Priva UV-C HD Vialux sterilisation unit	1	**45626**	45626
Labour (installation)	estimation	**20000**	20000
TOTAL	**£**	**206743**	**87943**

(Source: Author's own)

Scenario C shows how much more attractive the venture would be if a tabletop system such as those sold by Haygrove or Protech (tunnels that include a gutter as part of the tabletop system) was being used the farm.

Financial analysis of proposed system

Any plans for a major investment (in this case >£200,000) for Rosemount Farm such as this runoff recycling system need to be financially viable for it to actually happen.

The costs of fertiliser and herbicide that would be saved due to the recycling system being installed are estimated below (herbicide savings would result from less weed growth due to no runoff being lost onto the polytunnel floors).

Table 2: Estimation of fertiliser and herbicide savings after runoff recycling system is installed

	Cost/ha/yr (£)	Estimated savings (%)	Savings/ha after installing system (£)	Total area (ha)	Total savings/yr (£)
Fertiliser	3000	15	450	24	**10800**
Herbicides	500	50	250	24	**6000**

(Source: Author's Own)

Although the farm doesn't have to pay anything at present to use irrigation water from the River Ericht or Monk Myre, Table 3 below shows the costs that would be incurred if a new charge were to be introduced by the Scottish government in the future. A range of different prices/m³ water have been worked out so that an

understanding of possible savings from future water recycling can be factored into the financial analysis of this project

Table 3: Savings if irrigation water charges were introduced in Scotland

Cost of water/m³(£)	Estimated Savings (%)	Savings/ha (£)	Total area (ha)	Total savings/yr (£)
0.40	15	150	24	**3600**
0.60	15	225	24	**5400**
0.80	15	300	24	**7200**
0.87 (Coldham Estate)	15	326	24	**7830**
1.00	15	375	24	**9000**
1.20	15	450	24	**10800**

(Source: Author's own)

Table 4 overleaf analyses the viability, return on investment and payback period of 3 different scenarios:

Scenario A: This analyses the viability of the current plan with capital expenditure that includes the cost of retrofitting guttering to the 18ha of existing polytunnels on Rosemount Farm. The savings shown do not include the cost of irrigation water.

As can be seen in the table, there is a return on investment of 7.57% in Year 1, and payback of the capital expenditure will be achieved in Year 12.

Scenario B: This scenario analyses the viability of Scenario A with the added savings that would be made if the farm was charged for extracting irrigation water. A water charge of £0.87/m³ was used as this is the average amount paid at another Cooperative Farms business in Cambridgeshire (Coldham Estate) for extracting irrigation water.

Returns on investment in Scenario B are much higher (11.36% in Year 1) while payback for the project would be in Year 9.

Scenario C: This analyses the success of how good an investment in a runoff recycling system would be if a farm had polytunnels that did not need a gutter to be retrofitted to them to catch any fertigation runoff. Most new polytunnels builds in the last 5 years (that have soil-less systems in them) all have guttering fitted as standard.

Returns on investment are 17.81% in Year 1 and the capital outlay would be recouped within 4 years.

The option of obtaining a government grant to help pay for the recycling project was also investigated- support from the Scottish Rural Development Programme could pay for up to 20% of the costs for the project (SRDP, 2013). This would greatly increase the viability of any investments to be made at Rosemount Farm.

Table 4: Viability of runoff recycling project and payback periods

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
	Fertiliser + Herbicide Savings	16800	17472	18171	18898	19654	20440	21257	22108	22992	23912	24868	25863
	Maintenance and Running Costs	1140	1483	3327	1573	3620	1669	1718	3770	1823	1878	4134	1992
Scenario A	**Total savings before water costs**	**15660**	**15989**	**14844**	**17325**	**16034**	**18771**	**19539**	**18338**	**21169**	**22034**	**20734**	**23871**
	Payback % (excluding water cost)	*7.57*	*7.73*	*7.18*	*8.38*	*7.76*	*9.08*	*9.45*	*8.87*	*10.24*	*10.66*	*10.03*	*11.55*
	Outstanding money invested	*191083*	*175094*	*160250*	*142925*	*126892*	*108121*	*88582*	*70244*	*49075*	*27041*	*6307*	*-17563*
Scenario B	Water @£0.87/m³ (24ha)	7830	8065	8307	8556	8813	9077	9349	9630	9919			
	Total savings including water costs	**23490**	**24054**	**23151**	**25881**	**24846**	**27848**	**28889**	**27968**	**31088**			
	Payback % (including water cost)	*11.36*	*11.63*	*11.20*	*12.52*	*12.02*	*13.47*	*13.97*	*13.53*	*15.04*			
	Outstanding money invested	*183253*	*159199*	*136048*	*110168*	*85321*	*57473*	*28585*	*617*	*-30471*			
Scenario C													
	Payback % (excluding guttering costs)	*17.81*	*18.18*	*16.88*	*19.70*								
	Outstanding money invested	*64453*	*40399*	*17248*	*-8632*								

(Source: Author's Own)

Assumptions for all the calculations of viability for this proposal:

-All fertiliser, water, herbicide and maintenance costs are inflated by 4% per annum

-10% contingency plans worked into all quotes that have been provided by companies

-Running costs include an electricity cost of £0.024/m³ of runoff, as well as maintenance cost (bulb change, cleaning of equipment, labour) every 3 years of £1800 (inflated at 4%/yr)

-Average fertigation water usage of 2500m³/ha/yr and an average fertigation runoff of 15%

Conclusion

The proposed runoff recycling project at Rosemount Farm involves significant investment; whatever the final system that may be installed.

The topography of the farm and polytunnel design of the current 18ha of tabletops would be expensive to bypass and retrofit guttering to. This reduces the returns on investment to 7.6% which for such a large capital outlay is not sustainable. A payback of 11+ years would not be acceptable to most lenders. At present, this shows that it is not a viable project to undertake on Rosemount Farm

If the farm was installing a large new development of polytunnels that had guttering as part of the tabletop structure, then this project would be very attractive, offering 17.8% return on investment. If there were no guttering costs to pay, then the capital investment for this project would be paid back within 4 years. The installation of a runoff recycling system in any new polytunnel development would be a very sound investment.

If government legislation were to change so that either the farm would have to pay to extract water or NVZ type regulations were bought in that affected the farmers growing soft fruit on tabletop soil-less systems, then this project's viability would become much more attractive. The scenario of having to pay £0.87/m^3 such as the prices that Coldham Estate pay for their irrigation water would increase the return on investment to 11.4%. A payback of just over 8 years would make the investment possible even with the huge costs of retrofitting guttering to the existing tabletop structures on Rosemount Farm.

Government grants/support would help to decrease the amounts of capital that Rosemount Farm would have to invest on the recycling system and make the project more eye-catching.

It is impossible to quantify the environmental and marketing benefits that would be realised if a recycling system was installed. However, the project would definitely increase the sustainability of Rosemount Farm if it was integrated into the existing soft fruit operation.

References

AHDB (Agricultural and Horticultural Development Board). 2010. *Crop walker's guide: Strawberry.* Stoneleigh Park: Horticultural Development Council. ppD1-D16.

CCC (Climate Change Committee). 2013. Provisioning services- agriculture and forestry. *Managing the land in a changing climate*. Chapter 2. p30. [On-Line]. Climate Change Committee. Available from: http://www.theccc.org.uk/wp-content/uploads/2013/07/ASC-2013-Book-singles_2.pdf [Accessed on 09 July 2013].

CEH (Centre for Ecology and Hydrology). 2012. *River Tay at Ballathie Annual Trends.* [On-Line]. National Environment Research Council. Available from: http://www.ceh.ac.uk/data/nrfa/data/trends.html?15006 [Accessed on 15 July 2013].

DEFRA (Department for Environment, Food and Rural Affairs). 2012. *Evaluation report of the UK's National Strategy for sustainable operational programmes in the fruit and vegetables sector*. [On-Line]. DEFRA. Available from: http://ec.europa.eu/agriculture/fruit-and-vegetables/country-files/uk/evaluation-report-of-national-strategy-2012-uk_en.pdf [Accessed 12 October 2012].

Else, M and Dodds, P. 2010. *Managing water, nitrogen and calcium inputs to optimise flavour and shelf-life in soil-less strawberry production.* p5. [On-Line]. Horticultural Development Council. Available from: http://www.hdc.org.uk/sites/default/files/research_papers/SF%20107%20year%201%20report%202010.pdf [Accessed on 26 July 2013].

Fennimore, S. and Doohan, D. 2008. The challenges of speciality crop weed control and future directions. *Weed Technology.* 22(2). pp364-372. [On-Line]. Weed Science Society of America. Available from: http://www.bioone.org/doi/abs/10.1614/WT-07-102.1 [Accessed on 8 October 2013].

Finch, H. Samuel, A. and Lane, M. 2002. *Lockhart and Wiseman's crop husbandry*. 8th ed. Cambridge: Woodhead Publishing. pp95-99.

Marlow, D. 2006. *Disinfection of horticultural and greenhouse waste water.* [On-line]. Priva North America. Available from: http://www.gpnmag.com/sites/default/files/020609.pdf [Accessed on 23 June 2013].

Scottish Government. 2013. *Strathmore and Fife NVZ Parish Map.* [On-Line]. Scottish Government. Available from: http://www.scotland.gov.uk/Topics/farmingrural/Agriculture/Environment/NVZintro/StrathmoreFifeNVZmap [Accessed on 19 August 2013].

SRDP (Scottish Rural Development Programme). 2013. *Tayside Region- Business viability and competitiveness.* [On-Line]. Scottish Government. Available from: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Tayside [Accessed on 18 July 2013].

The Co-operative. 2013. *Ethical Plan.* [On-line]. The Co-operative. Available from: http://www.co-operative.coop/join-the-revolution/our-plan/keeping-communities-thriving/farming/ [Accessed 12 July 2013].