AIM Soil Working Group Study Tour to Belgium and Great Britain

September 2019 report by Ryan Barrett, AIM Project Lead

In early September 2019, members of the AIM Soil Improvement Working Group, along with two key industry partners, travelled to Europe to attend Potatoes Europe in Belgium, followed by a tour of research institutes and potato farms in south-eastern England. The goal of this trip was to investigate new technology and improved farming practices associated with improving soil health and soil quality in potato production.

Potatoes Europe:

The trip started with two days attending Potatoes Europe, an annual potato-focused trade show that rotates between Belgium, France, the Netherlands, and Germany each September. This year's edition was located in Tournai, Belgium, close to the border with France. Some highlights of the show for group members included:

- Harvesting demos on-site featuring equipment from a large number of different European equipment manufacturers, including both self-propelled harvesters and tow harvesters. Selfpropeller harvesters are the most common in Western Europe, as they can travel relatively quickly in all kinds of harvest conditions during their long harvest period (August until late October). Windrowers are relatively uncommon in Europe. Leading manufacturers include Grimme, Dewulf, AVR, and Ploeger, among others. Grimme is just introducing the AirSep harvester to Europe now. Storage tanks are common on self-propeller harvesters, and almost all potatoes are loaded into bulk wagons towed by tractors.
- Case New Holland has new precision ag sensing technology that looks promising. The Crop Xplorer is a tractor mounted sensor for measuring the amount of biomass and N uptake in the canopy. This data would then be used for making variable rate nitrogen application maps or variable rate use of herbicides for desiccation. Related to this was the Soil Xplorer, which could be mounted on a tractor or ATV. This soil scanner device is used to create maps of soil electroconductivity (EC), soil type, water content, and depth of compaction. This data would be used to determine depth of deep tillage (ripping) or planting density, among others.
- A company called Solentum has created a smartphone app called SolGrader, which uses the camera on your phone to measure the size of tubers for quick grading of potatoes. This would be targeted at growers or agronomists for estimation of yield and quality from 10 foot strips or small plots.
- There were a large number of breeding companies on display. International leaders like HZPC and Agrico were of course present, but also were a number of other smaller companies from other European countries. Agrico has a line of new late blight resistant varieties that are being promoted, including a red skin, yellow flesh variety called Alouette. We heard a number of positive reviews on the new HZPC variety Alverstone Russet, which is being grown for processing in PEI at the moment. There were also a few smaller breeding companies that have partners in

Canada, and we will follow up to investigate potential varieties that might suit for PEI. Keys traits of interest in Europe include resistance to potato cyst nematode (PCN), resistance to common scab, and resistance to late blight. The majority of varieties are yellow fleshed, but there are an increasing number of white flesh varieties for both table and processing uses.

- Miedema had a planter with their "micro-dammer" technology on display again. The AIM Tech Working Group saw this technology for the first time last fall. This is an alternative to the conventional dammer-diker technology that has been commonplace in North America for many years; however, it is hydraulically driven to create more pockets in furrows to aid water absorption while not presenting the same horsepower challenges as current dammer dikers.
- There were a number of sizing technologies on display, either for sizing at receiving/dirt elimination when loading the storage or sizing during grading. One company with multiple technologies was Downs from France. Sizing at harvest is increasingly common in Europe, as producers often send smaller potatoes to a different buyer than larger potatoes. This could also be useful for seed producers who want to separate into different sizes and store separately.
- There were a large number of companies selling bioregulator products or biostimulants. These include humic acid products marketed as improving nutrition and biological activity. Most of these companies are European-based without North American presence, but a few do have distributors in Canada. We took home information on a few products that might be interested in future trial work in PEI.



Self-propelled harvester demonstrations at Potatoes Europe in Tournai, Belgium



Soil Xplorer product from Case-New Holland



Micro-dammer system on a Miedema planter **Rothamsted Research and AHDB:**



Downs dirt-eliminator and sizing equipment

Our group then flew from Brussels to London Heathrow to begin our tour in England. The United Kingdom has become a center for research in soil health in potato production, so it seemed to be a great place to visit for our Working Group.

Our first visit was to Rothamsted Research in Harpenden, near Luton. Rothamsted is one of the first agricultural research stations, started in the 1840s by a wealthy estate owner who made a fortune patenting one of the first phosphate fertilizers. One of the key features of Rothamsted Research is the Broadbalk long term experiments, where they have been investigating winter wheat research in the same field since 1843! Part of the field has seen no change in rotation or experimental design for 175 years, and the difference in plots was very evident. Where winter wheat has been grown every year for 175 years with no fertilizer, yields were about 1 T/ha. Right next to it, plots receiving annual application of beef manure had yields of up to 14 T/ha. Over the years, there have been a couple of changes to sections of the trial, including evaluation of different levels of supplemental nitrogen and evaluation of continuous wheat versus a limited crop rotation with oats and dry beans.

Next to the Broadbalk experiment is the newest long-term rotation experiment at Rothamsted, comparing different types of rotations and tillage methods. One part of the field compares minimal soil movement/minimum tillage versus conventional moldboard ploughing. Another section is comparing different types of crop rotations: a conventional 2 year rotation of winter wheat and canola, a 5 year rotation of wheat, barley, canola, faba beans, and a 7 year rotation of the same crops plus 2 years of perennial grasses. They are trying to assess the impact of reduced tillage and more use of soil building crops to improve soil organic matter, compaction, and overall soil health. In this part of the country, corn is seen as problematic due to high erosion potential. A weed called blackgrass, seemingly unique to England, has become a major concern requiring changes in rotation.

Also at Rothamsted, we visited with two other researchers with teams investigating other potato related fields:

- Jon West and his team are investigating the use of spore trapping for detection of late blight and other fungal diseases. They have developed two conventional spore trapping technologies which are in use in Britain that have similarities to spore trapping done in Canada. The newer of these technologies, with small sticky rods affixed to a fan, might have potential for use in Canada. This team has also worked with a local company to develop a new automatic spore sampler unit that also does real-time analysis, removing the requirement to collect samples and send them to a lab. It provides a positive or negative reading for presence of late blight spores and only needs to be resupplied once a week, sending test results by text message. Currently, these units cost approximately £15,000, but the price may go down over time.
- Chris Shortall and his team shared their research into developing aphid suction traps that are now deployed across the country. They have 12.2 meter permanent versions that are constantly sucking in aphids and are collected and tested 2 to 3 times per week throughout the growing season. They also have shorter versions and portable versions that can be run off of portable power or battery. These aphid suction traps collect considerably more aphids than yellow pan traps and are particularly good for collecting non-colonizing aphids. They only need one aphid trap for every 50 miles, meaning that they have less than 20 of these traps for the whole country. Results are then shared with growers and agronomists

via an app and website on a weekly basis. They have more than 50 years of aphid data from these types of traps, and they are looking into new technology (lasers, PCR) to make counting more automatic. The cost for a permanent, tall aphid suction trap is approximately £2500, plus the cost of weekly analysis. This may be an option for PEI, as we would not need a lot of traps to cover the whole province. Rothamsted has also developed a collapsible, portable version that may be even more possible for implementation.



Collapsible aphid suction trap

Spore Trapping Device

Long term experiments at Rothamsted

We then proceeded on to Kenilworth to visit with the folks of the Agriculture and Horticulture Development Board (or AHDB), a levy funded organization that works for multiple sectors of agriculture in funding research, extension, and marketing activities. It shares some similarities with the Potato Board, except that it works across many sectors, including dairy, cereals & oilseeds, beef, and more. We were met by a team of research leads and program coordinators, including James Holmes (soil scientist) and Rob Clayton (potato program lead).

We were first given a quick overview of potato production in the UK. East Anglia (where we are to do most of our farm visits) is the largest potato production area in the country. However, changes to access to well water may have an impact on potato production in this region in the near future. Scotland is the primarily seed producing area, maintaining a voluntary ban on potato seed imports in an effort to limit PCN and blackleg. McCain has been growing significantly in recent years with processing plants in Peterborough and East Yorkshire. There are 1900 potato growers in the UK, growing 117,000 ha (293,000 acres) of potatoes. However, 50% of the crop is grown by 282 growers. As well, 50% of potatoes are grown on rented land, providing issues with control over crop rotation in many cases. Eighty percent of the crop is grown on contract (across processing, fresh and seed), and more of the crop is destined for fresh pack consumption than processing. Planted area can change by plus or minus 6% a year in recent years, which can cause prices to fluctuate by more than £100/tonne. Despite this

level of production, the UK are still net importers of potatoes, primarily in the form of frozen products from Western Europe.

Rob Clayton provided us with a great overview of the strategic goals of AHDB for the potato industry, encompassing research, extension and marketing:

- Productivity has plateaued in recent years. Looking to address this in many ways, but an emphasis on grower benchmarking using software applications is seen as a priority.
- PCN continues to be one of the largest challenges, as about 60% of fields test positive for PCN. Development of resistant varieties and use of biofumigant crops is increasing.
- Access to water will be a growing issue, particularly with access to groundwater in the southeast. Finding ways to more efficiently use water is an area of active research.
- The EU is eliminating CIPC next year without many readily available products to replace it for long-term storage. Improving storage management while finding and implementing alternatives to CIPC is an immediate focus.
- The EU is also eliminating diquat (Reglone) this year, so alternative crop desiccants is also a research priority.
- Recently, conversations around Brexit have dominated the industry. AHDB is not allowed to lobby, but they are active in providing growers with information on how to respond to the uncertainty around Brexit as well as providing information to policy-makers. A "no-deal" Brexit has the potential to be devastating for the potato industry, particularly the seed industry in the UK.
- There is an increasing use of late blight forecasting tools, particularly as mancozeb is under reevaluation (the same as in Canada). Early blight (Alternaria solani) is not quite as big of an issue in the UK but is increasing for some varieties.
- One of the key ways that research and extension is done is by working with individual farms to demonstrate best practices. These Strategic Potato Farms (SPot Farms) sign three year agreements to work with AHDB and researchers on mutually interesting projects and host open house days to demonstrate these best practices. There are more than 80 participating SPot farms in the UK.

We then talked with some other AHDB support staff on a range of topics:

- Wireworm is increasingly a concern in the UK. They have the same wireworm species as we do in PEI, and are losing their primary insecticide (Mocap) next year. They are doing some investigation into the Attracap system from Germany. They are using the light traps developed by Christine Noronha at AAFC for trapping, particularly in organic systems.
- Similarly to us, they do yellow pan trapping for aphids. They have more than 100 sites across the country.
- AHDB has a great resource site called the Great Soils program
 - Doing grower surveys on land use to benchmark fields for the impact of rotation or production methods on yield. Also incorporating economic analysis into this process.
 - From survey data only, they see a trend toward cover cropping ahead of potatoes having up to a 10 T/ha yield benefit.
 - Use of cover crops seems to indicate less fuel use in resulting tillage.

- In on-farm trials in 2017, they saw a 5 T/ha (or 10%) improvement in yield when using manure or compost. This wasn't replicated in 2018, but weather conditions were different.
- In on-farm trials in 2018, they saw a 7 T/ha (or 12%) improvement in yield when using cover crops. This wasn't as evident in 2017, but again it appears that the amount of rain in the winter has a big impact on the value of cover crops or amendments on a year to year basis.
- As we learned at Rothamsted, blackgrass is a growing weed problem which can really only be battled by extending rotation.
- Cover crops consistently have an effect of reducing bulk density in soil.
- Extension around soil compaction is a growing subject of interest. Development of the new website <u>www.terranimo.uk</u> to model compaction from different types of machinery is a valuable tool. It should be fully operational in March 2020.
- There are a number of great factsheets available at <u>www.ahdb.co.uk/greatsoils</u>
- Recently, increased focus on nutrient management research, including optimum rates of nitrogen and sulfur and differential needs of different varieties.

Suffolk Farm Visits:

The next day, AHDB organized two farm visits for us in the Suffolk region. Our first visit was to James Foskett Farms, a second generation farm on very sandy soil. Here, we met with farm manager Mike Shapland and their independent agronomist, Graham Tomalin. They farm over 1200 ha (3000 acres), of which 400 ha (1000 acres) are potatoes. They grow a significant amount of seed (both for themselves and for sale) as well as fresh pack and creamer potatoes. In addition to potatoes, they also grow 150 ha of onions, 200 ha of various organic vegetables, and a number of grain and pulse crops. They employ 25 people full time and 75 people part time at busy times of the year.

James Foskett Farms is reliant on irrigation, as they only get 500 mm of rainfall per year and they have very sandy soils with relatively low organic matter that don't hold a lot of water. They grow potatoes on a six year rotation, but this rotation generally has a row crop every second year (potatoes, onions, sugar beets, carrots), alternated with winter grains or canola (oilseed rape). As 90% of their land base is rented, it presents some issues in controlling rotation. For land that they have long-term tenancy over, they are able to do more with soil-building crops and biofumigation. For land that they have in-and-out rental agreements, there is less use of cover crops. They are increasing their use of brown mustard for biofumigation ahead of potatoes, particularly for battling PCN. They are also using mixtures of forage crops like common vetch and red clover to build soil nutrition ahead of organic vegetables. They are also now using much more oilseed radish in an effort to build soil organic matter.

Yields for fresh pack varieties regularly yield between 50-60 T/ha (440-530 cwt/ac), depending on variety. They primarily grow a lot of the well-known British fresh varieties like Maris Piper, Maris Peer, and King Edward. Foskett Farms has a partnership with a group of other growers on marketing and packing operation, primarily selling into UK supermarket chains. They also hold contracts with McCain for French fry potatoes, using King Russet and Royal. The Royal variety can produce yields up to 90 T/ha (790 cwt/ac).

As noted, irrigation is done on most fields, especially the sandiest fields. For creamer varieties, irrigation is done often early in the season (every 4 days, 20 mm each time) to prevent common scab and then is backed off a little later in the season. The opposite type of schedule is employed for conventional fresh pack or processing varieties. Irrigation is done using reel and gun or travelling boom equipment. There is a limited amount of drip tape employed on fields where it makes sense. They follow AHDB irrigation recommendations for optimum yield and scab control, but do very little irrigation on seed acres. All seed is planted whole, with the ideal size 45-55 mm in size. They will plant as small as 25 mm, but prefer larger seed. They start to grade seed in November using a Downs moving screen grader which grades into 5 sizes. It isn't quite as accurate as a shaker table grader but is easier on the seed (less bruising), enabling them to grade seed at colder temperatures.







Using brown mustard to fight PCN

We then travelled about 10 minutes down the road to Wantisden Hall Farms, where we met with their farm manager Tim Pratt. This farm is on some of the sandiest soil in East Anglia, entirely reliant on irrigation for production. They farm a total of 4000 acres, including 600 acres of potatoes among 2000 total acres of vegetable production and 2000 acres of grain crops. They also grow onions, carrots, and parsnips. At this farm, they are planting or harvesting something every month of the year, enabling them to maintain a full-time labour force continually through the year. They also have partnered with a group of fellow potato growers to establish a packing shed called Three Musketeers, located on the site of a former US Air Force base on a property behind the farm. In addition, they operate a 4 megawatt anaerobic digester producing electricity. It is primarily fed by corn silage, along with waste products from their vegetable production.

At Wantisden Hall Farms, 60% of production are "baker" potatoes, with the rest being new potatoes and creamers. The first potatoes are planted in early March, with harvesting taking place between July and October, depending on the market. Supermarkets are increasingly demanding smaller sized potatoes, so they have adapted their production to smaller varieties.

Because their soil is naturally so light, with over 80% sand and often only 1% soil organic matter, cereal crops don't produce as well. This is one reason they moved to grow corn for the digester (which they irrigate). Following potatoes, they have now introduced one or two years of free range pigs on their fields. An outside company rents the fields from them and then brings sows to the fields to farrow and raise piglets. Each sow has a small hut and their own fenced off area. All of this work is done by the pig company and then is taken down at the end of the year. Pigs are fed a pelleted feed but also root out a lot of weeds and volunteer potatoes, which is great for control of PCN. They also introduce a lot of

manure back onto the field along with the straw that is used for bedding on the field. This year they rented 140 acres to pigs.

Increasingly, cover crops are being used to retain soil moisture, battle soil-borne disease, and help build soil organic matter. The current mixture of choice is black oats, vetch, oilseed radish and stubble turnips. As they have a relatively mild winter without much snow or frost, they graze these cover crops during the late fall and winter with a flock of Dorset sheep that can lamb in the fall. This enables them to sell lambs in the spring (when prices are the best), deriving additional value from the cover crop. This also adds manure back onto these fields in addition to the value of keeping the field green as much as possible.

Fertility plans are quite variable, depending on how much manure or organic amendments are used in the rotation. In the UK, they have an environmental program called Nitrogen Vulnerable Zones (NVZs) that dictate maximum nitrogen that can be applied to prevent nitrate contamination.



Crop rotation with pigs to fight PCN and build soil organic matter at Wantisden Hall Farm



Very sandy soil at Wantisden Hall, with less than 1% soil OM in many fields

NIAB – Cambridge University Farm:

Following a tourist day in London on the Sunday, we travelled on Monday to Cambridge to meet with Dr. Mark Stalham and Dr. Elizabeth Stockdale of NIAB-CUF. NIAB (National Institute of Agricultural Botany) took over the Cambridge University Farm in 2013 and is one of the primary research institutes in the UK doing potato research. They partner with AHDB, Rothhamsted Research, and a number of other institutions on levy-funded research according to grower priorities. Dr. Stalham has been active in research on soil compaction, irrigation management, and rotation management in potatoes. Dr. Stockdale is primarily engaged in research related to soil health and soil organic matter.

We started our conversation delving a little deeper into the survey work done with potato growers, which included what crops were grown, tillage and field operations performed, NPK applied, marketable yields, manure or compost applied, and what was done with crop residues. This information can then be used to assess the impact of different production practices (ie. use of cover crops) as well as the economic performance of different systems. One factor in the UK is that "brown waste" (ie. non-food compost) is more readily available and less restricted for vegetable production than in Canada, providing an additional source of amendments. From preliminary surveys, cover crops are associated with improved yields in potato rotation, and more data is being added every year. Straw is highly valuable across the country and is almost always baled and taken off the field, usually trucked across to the west

of the country for livestock producers. This further necessitates use of outside manures or organic amendments in rotation.

We had a valuable discussion on the value of manure or compost in potato rotations. A recent project by NIAB had shown that four consecutive use of manure could increase soil organic matter by up to 1%, which is a rapid rate of increase. In another experiment, manure was regularly applied to part of a field in contrast to no manure applied. Even after this experiment was discontinued and then brought back a number of years later, there was still a significant difference in yields between the areas with historical manure applied and those without. Treatments with manure always had improvements in bulk density and usually had better yields of multiple crops. While sometimes there was a short term effect of manure, the long term improvements to soil quality and yield were more important. As a result, it may be less important to target manures directly ahead of potatoes but in other parts of the rotation when it is easier to manage and food safety issues are minimized. NIAB did have some data to show that high rates of manure directly ahead of potato production can increase total yield, but with a corresponding decrease in dry matter percentage (specific gravity). Applying manure earlier in rotation could help to avoid this issue.

NIAB also had data to demonstrate the yield reductions that can result from soil compaction. One trial showed up to 6 T/ha (54 cwt/ac) yield loss due to soil compaction, even more than the difference seen from use of compost. Severe soil compaction can be equal to a moisture deficit of 200 mm in some fields. The key to fighting compaction is identifying how to prevent compaction as much as possible through smaller equipment sizes and controlled traffic, as well as mitigating compaction with deep tillage where necessary. Recent research into the use of electroconductivity (EC) along with soil texture data to map soil compaction could be used to create variable depth tillage maps. There may also be the possibility of using fuel consumption or power output/speed maps from GIS equipped tractors for the same purpose. Both Case New Holland and John Deere have developed this technology and it is becoming more commonplace in Europe.

NIAB research on cover crops has shown that bulk densities in soil are consistently lower where cover crops have been grown. It has also been shown that some cover crops can delay drying of soils in the spring in very wet winters or in situations with high biomass accumulation, but this is a bit specific to British conditions where cover crops generally stay green all winter. In PEI, this would likely be less of a concern. Oilseed radish is one of the most widely used cover crops due to amount of biomass as well as being a non-host for many soil borne diseases. Mustard, black or winter oats, and other grasses are also quite common. According to AHDB/NIAB economic evaluation, cover crops cost approximately £200/ha to establish but generally return at least double that value in net return to the farm.



Meeting with Dr. Mark Stalham and Dr. Elizabeth Stockdale, NIAB-CUF



Lots of different plots at the NIAB-CUF farm site for fertility/product/variety trials

East Anglia Farm Tours:

Euston Estate:

After leaving NIAB, we travelled north east from Cambridge to the Euston Estate near Thetford on the Norfolk/Suffolk border. The Euston Estate is a 10,500 acre hereditary estate owned by the Duke of Grafton and family. They have a mixed farming enterprise, including three chicken farms, a herd of Red Poll cattle, crops such as wheat, barley, and sugar beet, and a number of vegetable crops, including potatoes. All of their vegetable crops are grown on contract by the Abrey family, who live nearby and grow more than 2000 acres of potatoes and 8000 acres of total crops. Over 500 acres of their potatoes are grown at Euston Estate.

At Euston, they follow a seven year rotation. They also have an anaerobic digester for power generation, the majority of which is produced by growing corn silage. However, the liquid and solid digestate is a valuable source of organic amendments to go back on the land. The Abrey family also operates a digester, fed with corn and rye silage as well as vegetable wastes. Their plan is to use corn and rye silage as the principal feed source for the digester until it is fully paid back, after which they plan to use mostly waste materials for electricity generation. They are able to use almost all of the energy generated from their 700 kW digester to power their farm and tenant properties, with very little energy sold back to the grid. The way the power system works in the England, they receive less money for energy sold back to the grid than the value of the energy they would pay for on their own properties, so it is most profitable to be able to directly use most of their generated power. These digesters became popular about 5 years ago in an effort to generate green power in the UK. They were accompanied by significant subsidies for establishment and operation as well as a 20 year subsidy for the price of electricity. As noted, they also return significant organic amendments back to the soil beside power generation. They estimate a 7-8 year payback time for the digester.

The soils in this area are approximately 15 inches deep of alluvial till with significant rocks that must be windowed to the side during potato rotation. They aren't removed from the field because it would be too large of a job besides being an issue with soil structure and drainage. The region is underlain by veins of chalk, at some points close to the soil surface. You can often see lines in the fields where the chalk deposits are closer to the surface, as these deposits hold more moisture.

The Abreys and the folks at Euston Estate have been doing more cover crops in recent years to prevent soil erosion and build soil organic matter. Their preferred mixture at the moment is stubble turnips, oilseed radish and rye, because it is cheap and establishes well. The majority of cover crops are grazed by sheep or mowed during the winter. They direct seed the cover crops following harvesting of cereal crops, at which time digestate or manures are also added to the fields. They have enough digestate to cover a quarter of their land each year.

Potato yields generally ranged from 32 T/ha for creamers up to 75 T/ha for Royals for French fries. Irrigation is essential to get these yields, as soils are generally sandy with lower soil organic matter. Irrigation is done early and often to keep scab off the creamers and fresh-pack varieties. The Abreys showed us a series of large reservoirs they constructed (with EU funding) to hold enough water to irrigate all of their vegetable crops. They operate more than 70 different reel and gun irrigation units each season, requiring considerable manpower to manage. To fill these reservoirs, they pump water from rivers during the winter and early spring to fill the reservoirs when water levels are high. They pump water from 17 miles away to fill these reservoirs...a considerable investment to ensure they have access to water.



Visit to Euston Estate, examining their cover crop



Massive reservoir at Abrey Farms



Soleanum species used as a PCN trap crop



Anaerobic digester at Abrey Farms (700 kW)

B & C Farming:

The next day, we concluded our tour with three farm visits in East Anglia. We started the day just north of Norwich at B & C Farming near Aylsham. We were greeted by Tony Bambridge, farm owner who farms with his daughter Sophie. He is a former Nuffield scholar who is a first generation farmer. He was particularly drawn to seed production, growing 175 ha (440 acres) of potatoes are seed, but they also grow some potatoes for fresh pack and French fry production with McCain and another processor called Birdseye. Russet Burbank and Shepody are among the varieties grown for seed and processing, and we were able to visit one of his Russet Burbank fields where he had a 50 T/ha (440 cwt/ac) crop soon ready to harvest.

At B&C, they harvest seed primarily between August and September. Potatoes are harvested directly into boxes, minimizing the amount of handling of the potatoes and making storage handling and grading efficient. They grade a small amount of seed in the fall for export, but the majority of grading takes place starting in November through to planting time in March and April, where the majority of seed is delivered just in time for planting, except for seed that is brought home early to be managed for accelerated emergence (chitting, ethylene). They constructed a new Tong seed grading and sizing line last year, which they are very happy with. The grading line includes an optical grader for eliminating rocks and clods and an enclosed booth for hand grading to reduce dust and noise. Potatoes then proceed over a series of chain meshes that grade into four different sizes (30-40 mm, 40-50 mm, 50-55 mm and 55-60 mm). Potatoes under this size are graded out for cullage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size are graded out for cultage and potatoes over this size

approximately £600,000 to install, with the Tomra optical unit costing £100,000. The capacity for the line is approximately 12 tonnes per hour.

The seed system employed at B&C and in much of the UK does not involve payment for seed in by the tonne but instead by the hectare to be planted. This takes into account the size of the seed and the required planting density. This incentivizes the seed producer to produce optimum sized whole seed of the desired size profile with increased tuber number, rather than relying on total yield per acre. The 40-50 mm size is seen as ideal, but producers will generally receive two different sizes of seed per variety and will be provided with planting density charts by variety and seed size. Only processing varieties like Shepody and Russet Burbank are cut (single cut) and they are cut and cured before they are transported to the seed buyer.

B&C Farming are part of the Greenvale AP marketing system and grow approximately 20 varieties between Greenvale and McCain. Where possible, they like to make direct seed sale arrangements with growers or with these two companies to avoid dealing with seed agents, which often charge a considerable markup without adding value to the seed. They don't warm seed up before they start to grade so as not to break dormancy and create condensation. They store seed at about 4 degrees C and employ positive ventilation to dry down the seed quickly with lots of air flow. They have been working closely with research institutes to optimize their storage and production over the years. Ethylene is used for sprout suppression and is used in a smaller storage for some varieties to encourage greater tuber numbers (mostly the creamer varieties).

As for crop rotation, the Bambridges employ an eight year rotation, with seed grown mostly on rented land that hasn't had potatoes planted in many years. Fresh and processing potatoes are largely on their own land or on land with long term rental. Their land is a bit less sandy than other farms we visited, with soil organic matter levels closer to 3 percent. Nematicides are used on fields with detectable PCN levels. Other crops grown in rotation include sugar beet, wheat, malting barley, grass seed, peas, and canola. They are growing less canola in recent years due to issues with flea beetle, exchanging it for grass seed and other grains. In the future, they hope to phase out more of the sugar beets as subsidies for that crop are reduced. They feel that their longer crop rotation provides them with effective PCN control as well as better soil health than many of their neighbors. Where they take straw off of fields they are sure to add back manure or other organic amendments. They have access to a municipal compost from aerobic digestion that is heated to high temperatures at least twice to reduce the risk of bacterial contamination. These amendments provide both nutrient value as well as adding structure to the soil and helping to maintain or build organic matter levels. Irrigation is not done on seed fields generally but is employed on their commercial fields. They generally irrigate most fields 5 or 6 times per season. They are also trying to reduce the amount of tillage in their rotations where possible and using more cover crops. Before we left, we were able to visit a field where they were harvesting potatoes directly into boxes to be transported back to the home farm for storage.



Tong seed grading system at B&C Farming



Loading seed potatoes directly into boxes at B&C Farming in Norfolk



Mesh grading system, easier on tubers than shaker grader system



Checking out Tony Bambridge's Russet Burbank crop at B&C Farming

WO & PO Jolly:

We then headed southwest toward Thetford to meet with Will Jolly of WO & PO Jolly Farms. They have been farming for about 30 years in this area, on land that previously was not farmed because it was so sandy. However, with significant investments in irrigation, they have been able to get great yields of potatoes and other vegetable crops from this sandy, low organic matter soil. They grow potatoes in an eight year rotation along with free range pigs (for volunteer control), corn, carrots, parsnips, barley, sugar beets, and coriander. They also have a small acreage of semi-permanent asparagus near the farm. They own a block of land close to the home farm, but also rent quite a bit of land nearby. This is a family-owned and operated farm along with a small group of full time employees.

In three out of the eight years of rotation they apply some sort of organic amendment (mushroom compost, chicken manure, straw based manure, pigs). At the moment, they have significant soil disturbance every two years in rotation. Will's plan is to try and eliminate two years or destoning and soil disturbance by employing more grass, which will also serve to build soil organic matter. At the moment, most of their fields are at 1 percent or less organic matter and is very sandy, with a very abrasive quality of sand. This requires that they dig potatoes for direct delivery to processing plants, as they would have too much skin damage during harvest to store. As a result, they don't store any potatoes on the farm.

The Jollys were the only farm that we visited that was entirely producing for processing. They grow for McCain, Lamb-Weston, and Pepsico (Walkers crisps) and grow varieties such as Shepody, Ivory Russet, Challenger, and Taurus. They have more control of variety choice than we have in PEI and they try and

suit the variety to the needs to the field, depending on soil type and PCN resistance. Late blight is not seen as much of an issue as they deliver straight from the field.

They are 100% reliant on irrigation, which they get from four 18 inch wells that are up to 100 m deep. They have summer water licenses for water extraction, irrigating a total of 800 total hectares of all crops. All wells are metered and they have annual water limits that they have to adhere to. Most fields get 8 to 10 inches of water per season, an inch at a time. Will estimates that it costs them about £100 per hectare per inch of water, which equals approximately \$700/acre for 10 inches of water per year. They are one of the few farms that have center pivots for irrigation, but one of these systems is quite old and needs to be replaced. The rest are irrigated by reel and gun or boom.

The Jollys are trying to incorporate more cover crops into rotation where possible. Grass mixtures with common vetch and stubble turnips have been some of the successful mixes so far. However, they have to ensure that they match the cover crops to the needs of the resulting crop, so that they don't multiply diseases or pests in their other vegetable crops. Will would love to see some sort of guide or app that helps them choose and plan out their entire rotation that factors in the different pros and cons of different cover crops. They are trying to avoid nematicides as much as possible, but they also aren't big believers in biofumigant crops yet, in part because they take soil moisture to be effective. Due to the light nature of their soil they don't see much issue with compaction, but they subsoil to a depth of 14-16 inches before every vegetable crop. They are harvesting something 12 months of the year at their farm, and their potato crops average approximately 55 T/ha in marketable yield.



Meeting with Will Jolly at WO & PO Jolly Farms



Checking out one of the high capacity wells at Jolly Farms, 100 m deep.

Elveden Estate:

Our final farm visit was to the Elveden Estate near Thetford. Elveden is the largest hereditary estate in Britain, totaling 22,500 acres on the main estate. It is owned by the Guinness family of Guinness beer fame and they are very interested and involved in the success of the farm. We met with farm manager Andrew Francis, who gave us an overview of the farm and a tour of some nearby fields. In addition to the core estate (which includes quite a bit of forested or range rangeland), they have added another 18,000 acres of crop land in Lincolnshire and East Yorkshire. The Elveden Estate has very sandy land, much of which was only used for hunting and grazing for many years before investments in irrigation allowed them to bring land into arable farming production. In fact, they have over 100 miles of water mains to carry water to the many fields on their core estate. They employ 27 linear irrigation units as well as 35 reel and gun units. Soil moisture probes are employed in most fields, and they are also interested in trialing new soil nutrient sensors as well.

They do have a sheep flock that they use to graze many cover crops, as well as two cow-calf beef herds. 2000 acres of potatoes are grown, in addition to 2000 acres of onions, 700 carrots, 400 acres of parsnips, and a lot of combinable crops like wheat, barley and canola. Potatoes are grown primarily for fresh-pack to supermarkets through their private label Garden of Elveden branded business. They also grow 15,000 tonnes of processing potatoes each year primarily for McCain, with a large portion of this going to make McDonald fries. As such, they do grown varieties like Shepody and Russet Burbank for McCain.

Elveden employs a six year crop rotation, alternating between vegetable crops and cereals. They have been doing research in recent years on the value of green manure crops and cover crops to help improve soil health and soil organic matter, and they were an AHDB SPot farm for the past number of years. They are doing some work with brown mustard as a biofumigant for PCN but are still trying to assess how well it works, particularly under dry conditions. The farm assess not only the economic return of every crop but also the water and carbon footprint for each crop.

The farm employs 27 Fendt tractors in its equipment fleet, moving to owning their tractors rather than leasing in recent years. Their largest fields were 120 acres in size, which is rare for this region. The farm has also been experimenting with pollinator borders in some fields to benefit pollinator species as well as preventing spray drift and providing wildlife refuges. They are also employing some spray-on polymer products that are sprayed on the soil after onion planting to prevent soil erosion, as use of nurse crops is not possible in onions. These are quite expensive but are seen as necessary to prevent soil loss at the moment.



Pollinator-friendly barrier strip at Elveden Estate



Oilseed radish at Elveden, a very effective cover

Take Home Messages:

- UK potato producers are employing organic amendments as much as possible. While the UK has
 more animal agriculture and more population to PEI, it provides an example for finding
 opportunities to employ amendments as much as possible. This may require extension and
 research into how to best use the manure resources we currently have as well as gaining access
 to new sources.
- Most of the farms we visited are employing more cover crops to keep the ground covered as much as possible. Oilseed radish is widely employed, but there are a wide varieties of cover crops being used. Some are grazed by sheep or cattle, returning nutrients to the soil once again.

- 3. Cover crops are generally associated with improved potato yields. This has been borne out both in research and in field conditions. Use of biofumigant crops is targeted particularly at PCN.
- 4. On light sandy soils in East Anglia, irrigation is essential. Finding ways to access water in ways that keep the Dept of Environment happy is key. This may require exploration of water capture/storage from the winter in PEI where groundwater extraction is less feasible. However, any effort we can make to increase soil organic matter to improve water holding capacity should be undertaken.
- 5. There may be room to explore alternative seed production systems based on the UK example, with production of more whole seed or at the least, reduced cutting systems. This would require significant investment in sizing and handling equipment on PEI seed operations, as well as potentially a different pricing structure for seed to an acreage payment rather than cwt.
- 6. PCN is a terrible scourge that we much avoid at all costs! The cost of PCN to the UK potato industry each year is staggering.
- 7. Finding opportunities to reduce tillage where possible is worth exploring. In PEI, we may have more opportunity to do that than the UK because we don't have to destone ahead of potatoes. Reducing tillage in the non-potato years is particularly key.

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