Belgium and Netherlands Study Tour

AIM Science and Technology Working Group

Nov 24th to Dec 1st, 2018

The AIM Science and Technology Working Group was able to travel to Belgium and the Netherlands in the late fall of 2018, with the primary goal of learning more about the precision agriculture tool and new production methods being employed in Western Europe. Group members Jason Webster, Kevin Schurman, and Evan MacDonald accompanied AIM Project Lead Ryan Barrett on the week-long tour.

Interpom Primeurs

The first two days of the tour focused on the Interpom Primeurs expo in Kortrijk, Belgium. The Interpom expo is the largest indoor potato-focused trade show in the world, featuring a mix of equipment manufacturers, processor and potato buyers, chemical companies, and various supply companies from across Europe. There was a major focus on harvesting equipment, potato handling equipment, technology for grading/processing potatoes, and new potato storage technology. Some highlights from the trade show included:

- Impressive 2-row and 4-row self-propelled potato harvesters. Major players include Grimme (industry leader), Dewulf, AVR, and Ploeger. In conversations with representatives and industry players, there is an industry trend toward 4 row harvesters as farm size grows. The majority of potato growers in Belgium do not own their own harvesting equipment and rely on contractors, who obviously have to cover a lot of acres in the fall for multiple growers. Towed harvesters are also common but self-propelled harvesters seemed to be getting the most attention. Most models of self-propelled harvesters have a storage box on them so that the harvester can continue to harvest without a truck/wagon alongside, and most models can unload and continue filling the storage box at the same time. The largest storage box we saw held 14 metric tons of potatoes (125 cwt). These self-propelled harvesters are almost always used without windowers but can travel faster in the field than a harvester in PEI (approx. two times as fast) and often under wetter conditions.

- A number of different crop wagons, including some with unloading booms at the front of the wagon. It is uncommon to have trucks in the field in Western Europe; instead, most potatoes are transported in bulk wagons driven by tractors. This is for several reasons: different highway regulations for truck drivers versus tractor drivers, inability to get trucks through often soft/wet soils at harvest, and lack of labour for multiple trucks. In most cases, two or three wagons would keep up with one harvester. Some new wagons we observed had unloading booms with dirt elimination rollers to allow wagons to unload directly into trucks that would be parked on the road instead of going into the field.

- There was a definite trend toward new dirt elimination technology. This included multiple potato handling systems with multiple dirt elimination methods employed, including a large mobile unit from Grimme including optical dirt clod detection. Many European fields are dug under wetter conditions than in PEI and with tighter chains than we would use, so getting dirt

Crop wagon with dirt elimination and unloading elevator for transloading potatoes in the field. Trucks are not commonly used in the field in Belgium.

Ploeger 4 row self-propelled harvester with 14 tonne holding capacity. There are versions of this harvester now in North America.

separated from the potatoes (in the field, where possible) is a high priority.

- Reglone (diquat) is scheduled for deregistration in the EU in the near future, so there were multiple technologies aimed at alternate forms of vine killing. This included mechanical chopping/mowing of vines, a new electric herbicide product from New Holland called X-Power, and variable rate sprayers with biomass mapping sensors so as to only spray desiccants where the crop wasn't already dead or dying.
- CIPC for sprout inhibition is also on the chopping block in the EU, so alternative sprout inhibition products were on display. There were multiple products and application methods using an extract/chemical from mint oil for sprout inhibition, as well as Restrain, the ethylene product.
- A range of self-propelled sprayers with new tank-cleaning technology and section/individual nozzle control were increasingly popular. Agrifac and Amazone are industry leaders. In Belgium, growers are able to access significant programs for equipment purchases, especially for those with sustainability technology.
- A ranger of planting equipment with variable-rate control for each row, with Grimme and Miedema as the industry leaders. This will be explored further on in our report. Belt planters are more commonly used for whole seed or long-type seed planted at less than 12 inches seed spacing. For wider spacing or cut seed/round seed, cup planters were more common.
- There are also multiple companies producing different equipment for sizing, both for seed grading and for sizing the commercial crop for different markets. This includes optical graders and shaker tables of multiple designs.

There was a limited series of speakers presenting in English on the Monday on a range of topics. In contrast to similar events in North America, the presentations were more "industry-focused" rather than dealing with agronomic questions that growers would normally have. Highlights from these presentations:

- The potential fallout from Brexit is still very uncertain, but if the UK has a "hard Brexit" it will have significant impacts on potato movement to and from the United Kingdom. Even with a "soft Brexit", there are potential impacts on seed movement for the UK.
- The WatchITGrow satellite crop monitoring platform was presented. It uses satellite images from the Sentinel-2 satellite combined with radar data, along with potato growth curves, to predict yield and monitor crop progress during the year in Belgium. This project was funded by Belgapom, the Belgian processor association. We heard feedback during the show and following the show that there are concerns about the validity of the growth models being used by the project, and there is concern from growers that the benefits of the tool will be much more to the benefit of the processors than to growers.
- A representative of Bayer in Belgium presented on advances in sustainable agriculture. EU farmers have lost access to about half of their pesticides since the 1990s, and must of the current research into crop protection products is in biopesticides.

One of the key messages of this presentation was that integrated pest management (IPM) has to be integrated field management, incorporating all possible mitigation options to control pests and diseases with a holistic approach.

- There was a presentation by ILVO (Flanders Agricultural Research Institute) on the use of drone based imagery for detection of early blight. While they were successful in detecting early blight damage on the leaves, it required very low flight heights (less than 1 m above canopy) and a huge amount of imaging data. So while technically feasible… not yet at a level approaching commercial viability. Might have more success as a tractor/sprayer mounted imaging system.

Factory Tours

On the day following Interpom, we visited two equipment manufacturers: Dewulf and Case New Holland. Dewulf is a family-owned equipment manufacturer which has specialized in harvesting equipment for potatoes, sugar beets, onions, carrots, and other root vegetables. Dewulf acquired Miedema in 2014, adding expertise in planting equipment. Dewulf has primarily focused on 2 row harvesters (both self-propelled and towed) but added a 4 row harvester in 2010. Their company's four core values are being Innovative, Economical, Reliable, and Enjoyable.

They operate three factories (Belgium, Netherlands, Romania), with 290 employees. They produce 1600 machines per year across their total product line. 24% of their production is domestically used (Belgium/Netherlands), with the remaining 76% exported around the world.

Dewulf recently invested in a new Smart Logistics Center to for storage and distribution of parts, both for machine manufacturing as well as parts replacement. Most parts are stored in this sole location and then expedited around the world on request. A commitment to efficiency, safety, and reliable engineering was evident from this company. They have a relationship in PEI with Allan Equipment, particularly for their Miedema planting equipment. They also have a cutting table for single-cutting seed that might be of interest for Island growers interested in cutting smaller volumes of seed lots without much oversized tubers (8 oz and down).

We concluded Tuesday was a visit to the Case New Holland plant at Zedelgem (near Bruges). This factory had been in operation for many years (predating acquisition by New Holland) and was where the world's first self-propelled grain combine was developed. New Holland has 66 plants and 63,000 employees around the world, with over $27 billion USD in annual revenue. The plant in Zedelgem employs more than 2500 people and is the world-wide Centre for Excellence in harvesting equipment. This plant specializes in manufacturing combines, producing 13 combines per day along with 4 large balers and 3 forage harvesters per day. We did a tour of the factory, including the part manufacturing areas and the combine assembly line.

We then had a presentation by Jack Varekamp on New Holland's advancements in precision agriculture technology. Some highlights included:

- New Holland has been partnering with Trimble for after-market sales, independent of brand of tractors.
- Their new Intellistar system has GPS integrated into the tractor and is capable of creating data maps simply from data captured by the tractor

Dewulf self-propeller potato harvester under construction at the Dewulf factory in Roeselare, Belgium.

X-Power "electric herbicide" implement, a collaboration between Case New Holland and Zasso of Switzerland.

such as speed, fuel consumption, traction control, etc. Their new forage harvesters have the capability of testing both yield and moisture on-board, and they are also incorporating Near Infrared (NIR) to measure crude protein, ADF, NDF, etc.

- They have also recently formed a partnership with Precision Hawk for incorporating drone data.
- They have developed a new tool called Soil Xplorer to be mounted on the front of the tractor for measuring compaction, soil textures, and water content through use of electroconductivity (EC). This is similar technology to the research AIM is doing with UPEI. These maps would then be used to create variable rate maps for fertilizer or seeding. In the Netherlands, they have shown a 3% yield increase from variable rate seeding.
- They have developed a new technology with Zasso from Switzerland called X-Power which they call an electrical herbicide. It is a non-selective tool that runs an electrical current through green plants to kill them. This could be used on pre-emerged potato fields for weed suppression or to desiccate potato plants as a Reglone alternative.
- The next stage in precision agriculture is their Crop Xplorer system, which can be used to measure plant populations, calculated optimum N rates from "green indices", and control spraying/fertilizer application with high precision. This program is still in development/testing.

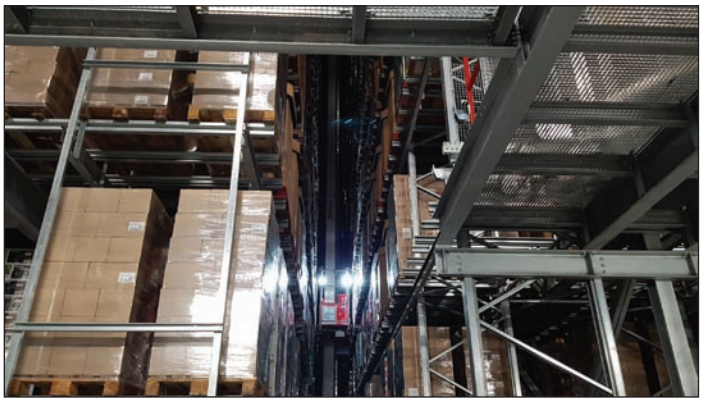
Agristo – Processing Plant Tour

In between our visits to Dewulf and Case New Holland, we were fortunate to get a visit to the Agristo processing plant in Wielsbeke. Agristo is an independent processor with four plants in Belgium, three which make French fries and a fourth that makes formed product. We were fortunate to get a tour from the owned, Mr. Antoon Wallays, who has been to PEI in the past and has many North American connections and partnerships.

Agristo is family owned and was started 32 years ago. They produce more than 650,000 kgs of finished product per year and ship to 115 countries and more than 500 customers. More than 1000 growers deliver potatoes to Agristo, and 70% of their raw potatoes are contracted. They contract four main varieties (Fontane, Challenger, Markies, and Innovator), with Bintje volume next to zero now. 50% of business goes to retail, with 35% to food service and 15% to QSR customers. Almost all of their production is in third-party packaging. Contracts are based on base price with fixed quality parameters, not having the bonus structures our growers are used to. This was an extra-ordinary year for lowered yield and quality, so quality specs from main customers have been adjusted to reflect this.

The Wielsbeke plant is the newest plant, completed in late 2017 after taking only 15 months to build from ground breaking to completion. The striking feature of the plant is an automatic, robotic cold storage that is 45m tall and can hold 55,000 pallets. 10 robot cranes stack the pallets and retrieve them to fill orders. Pallets of finished product are never on a skid steer until right before they are loaded on a truck, and they can load 10 trucks of finished product per hour.

What was striking to us was how few people worked in this plant. The plant has a 30 metric ton per hour line in full operation and a 15 metric ton line soon to be completed next to it. From grading to cleaning/peeling to cutting and all the way to packaging, there were very few people on the line. Antoon told us that only about 30 people are working in the entire plant at any one time, and about



One of ten robotic cranes transporting pallets of finished product in the Agristo cold storage in Wielsbeke, Belgium.

French fries coming off the cutters at the Agristo plant, headed for optical sorters to divert those requiring additional trimming.

120 people total work in this plant across five shifts. They have chosen to embrace high efficiency equipment and technology to reduce labour needs, and it has proven difficult to get good labour for processing facilities.

Another benefit of the plant is its close location to a nearby canal. Containers are driving no more than 2 miles away to meet a barge on the canal, where they can then be shipped to ports at Antwerp, Zeebrugge, or Rotterdam. This greatly reduces transportation costs per pound of finished product.

PCA

On Wednesday morning (Nov 28th), we paid an early visit to PCA, the potato research centre for the Flanders (Dutch) region of Belgium. We met with Kurt Cornelissen, who was instrumental in helping us with our tour agenda in Belgium. PCA is a research institute that specializes in potato research and collaborates with a similar organization in the Walloon (French) region. There are more than 7000 potato growers in Flanders, and PCA has membership that represents about 55-60% of Flemish potato acreage. PCA produces a weekly price quotation for producers in partnership with FIWAP in Wallonia, while the processor association (Belgapom) also produces another price quotation. Interestingly, there is no over-arching potato producer association in Belgium.

Belgian producers have "tonne contracts," and can be responsible for fines or supplying additional potatoes if they are under their contract in challenging years. This contrast to the Netherlands, which generally has acreage contracts instead. The current average price in Belgium for processing potatoes is around 125 euros per tonne, which equates to about $8.50 CDN per cwt.

In Belgium, the majority of seed is purchased through the processors, with the exception of public varieties like Bintje. However, use of these varieties has decreased noticeably. The average yield of the most widely grown variety – Fontane – is between 45-50 MT/ha (400-400 cwt/ac). Production in Belgium is down almost 30% in 2018 due to severe drought during the growing season.

Most growers grow only a small amount of potatoes (less than 20 ha) as part of a mixed farm with livestock and other crops. Farmers need to grow three different crops to be a legal farm with the government, so potatoes are often grown in small amount by livestock farms with all planting and harvesting done by contractors and potatoes sold direct out of the field to brokers or processors. 95% of Belgian production is in the processing industry, with only 5% for fresh market.

We had a good discussion about challenges facing the industry and research priorities, including:

- Development/testing of new varieties. PCA is responsible for third-party evaluation of new private varieties, including fertility trials, disease resistance, and pest resistance.

- **Storage.** Only one in ten producers in Flanders have storage facilities, and many existing storages are rudimentary. There is a need for new storage facilities and improvements in ventilation/refrigeration.

- **Restrictions on pesticides.** Reglone is scheduled to be eliminated in 2020, and CIPC is also on the chopping block. Most neonic insecticides are already banned, and there aren't many insecticide options for certain pests. The last two years has seen increasing Colorado potato beetle pressure, and aphids are also an increasing issue. CIPC alternatives like Biox or 1,4 Sight can be up to 8 times more expensive than CIPC and more work/applications.

- **Fungal diseases.** Late blight (Phytophera) and early blight/brown spot (Alternaria spp.) are the two biggest disease issues. Growers generally spray 12 to 20 times per year for late blight with fewer products than available in Canada. Due to their high density of production and mild winters, they are seeing rapid mutations in late blight strains. PCA is working with others to develop early blight prediction/decision tools to reduce the amount to sprays necessary and improving timing of spraying. They have determined that a lot of observed Alternaria damage is actually something else. As well, they have been able to show that it is not necessary to treat for Alternaria until late July or August given the life cycle of the fungus and the recent climactic conditions. This will enable growers to save a spray or two each season. PCA provides weekly pest updates for their members and tracks harvest progress.

- **Cover Crops.** There is a legal requirement to have a 1 in 3 crop rotation, and 1 in 4 rotations are very common. There are some at 1 in 2 years that get

short term exemptions. Acreage has increased from 70,000 ha (175,000 acres) to 95,000 ha (238,000 ha) in just ten years. It is becoming increasingly common to plant cover crops after potatoes, primarily to prevent nitrate leaching. There is a lot of pressure from the government and environmental lobbyists to reduce nitrate concentrations in groundwater and surface water, and there have been rumors of requiring "catch crops" for early harvested crops. We observed substantial acreage of fall brassica species like yellow mustard or oilseed radish which are used as green manures/N catch crops but are also used to combat nematodes.

Grimme

We then paid a visit to the Grimme Belgium headquarters in Roeselare, meeting with Cord-Heinrich Fustenau, who is normally based in Germany and who is responsible for North America sales. Here, we discussed the Grimme product line and advancements in precision agriculture and new technology.

Grimme is a German, family-owned company now incorporating the 4th generation of the Grimme family. It has been in business for 150 years and has €450 million in annual sales. Grimme also owns Spudnik in North America.

Highlights of our discussion:

- There has been a trend in Western Europe toward 4 row harvesters instead of 2 row harvesters, and a trend toward self-propelled harvesters.
- New planters are equipped with the ability for variable rate planting. This allows for wider plant spacing in areas of low soil organic matter or sandy soil texture, or closer spacing in better parts of the field. They have also developed a system for tighter plant spacing in rows adjacent to tramlines to lessen the impact of sacrificing land for tramlines.
- Controlled traffic farming: using GPS/GIS and software to calculate placement of tramlines. Then most traffic (sprayers, wagons) take place only in those tramlines. Grimme has been working with a grower in Alberta on this approach, aimed at reducing soil compaction.
- Grimme is working on yield monitoring technology in the Netherlands at the moment
- The myGrimme portal is seeing continued development with new applications and a central database of field data, and includes a new isobus terminal.
- Use of "microdams" on hillers mounted on the planter. These perform a similar role to the dammer-dikers that are common in North America but with smaller size and requiring less horsepower. There may be an opportunity to incorporate similar microdams on various types of hillers here in PEI.

ILVO

On Thursday morning (Nov 29th), we visited ILVO near Ghent. ILVO is the Flanders agricultural research institute, conducting research across all commodities. It is primarily government funded, with some private industry funding. They have core funding of approximately €50 million per year with approx. 600 staff, half of which are researchers. Research is divided into four streams: plant

Large Grimme system for potato receiving, dirt elimination, optical sorting of dirt clods/rocks, and sizing of potatoes into multiple size groups.

Drones under evaluation at ILVO near Ghent, including a drone (left) with a 12 litre tank for direct pesticide application.

science, animal science, social/economic studies, and technology and food. ILVO collaborates extensively with the University of Ghent, and is leading a national cluster on Smart Farming.

Dr. Nicole Viaene gave a presentation on research and diagnostics for plant health. One project of particular interest for us was work on wireworm. Belgium is dealing with the same Agrioties species of wireworm as we have in PEI, and they are also seeing increasing wireworm damage. They have develop and online tool for producers to predict risk and degree of wireworm damage, incorporating five years of crop history, pH, soil organic matter, soil type, and historical wireworm presence. They have been able to show 70% accuracy for damage level thus far after just launching the tool recently.

A major concern for Belgian producers are nematodes of multiple types. Meloidogyne species (root-knot) of nematodes are a quarantined pest and are hosted in multiple crops. Managing soil to avoid spread of root-knot nematodes is a major effort, as well as breeding resistant varieties. Potato cyst nematodes (PCN) is also a major issue, particularly with the discovery of particularly virulent populations that will multiply despite the use of resistant varieties. They are investigating methods to treat waste soils to kill nematodes, including water inundation and heat treatments. ILVO has also developed some laboratory methods to quantify root-lesion nematodes using qPCR equipment; we will be exploring how these methods might be used back home in PEI in the future to improve nematode testing.

Dr. Johan van Vaerenburgh presented on recent research by ILVO and partners on bacteria causing blackleg, including Dickeya species and Pectobacterium species. In recent years, Belgium has been making blackleg tolerance levels more restrictive in seed certification. Now, all seed imported to Flanders must be tested for all bacterial species causing blackleg. Dickeya is only present on about 10 to 20% of lots, with some newer species of Pectobacterium now being of greater concern.

Pectobacterium carotovorum brasilense is now the greater concern in Belgium, as it can develop symptoms in both cool and warm field conditions. Symptoms of blackleg are more likely to develop under wet soil conditions and in clay soils as opposed to sandy soils. Different varieties are showing different susceptibility to blackleg, and there are huge differences in virulence between variants of blackleg.

Dr. Simon Cool then provided us with an overview of some of the precision agriculture research being conducted at ILVO. In recent months, they have been doing significant work on variable rate spraying, either for crop protectants, foliar fertilizer, or vine desiccants. They have a sprayer with individual nozzle control, including an assembly with four different types of nozzles which can be controlled individually. Other current priorities for research include using drones for disease detection, experimenting with a drone that can deliver site-specific pesticide applications, thermal imaging for heat stress, using in-field sensors for soil moisture, using digital imaging for weed identification, and developing farm management software that incorporates various precision agriculture technologies and data sources.

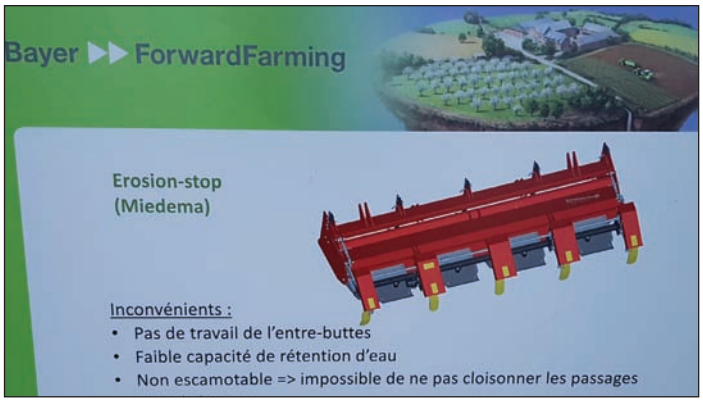
Bayer Forward Farm

Following our visit to ILVO, we travelled to the farm of Jan and Josse Peeters near Brussels, a functioning potato farm that is also designated as a Bayer Forward Farm. Using this Forward Farm concept, Bayer is showcasing sustainable agriculture practices for both the grower community as well as politicians and regulatory officials.

Phytobac system at the Bayer Forward Farm for pesticide residue remediation for sprayer wash water.

Multiple nozzle assembly on Amazone sprayer at ILVO. Each nozzle can be controlled individually across the entire sprayer for variable rate application.

Demonstration of aggregate stability of soil at Bayer Forward Farm. Soil on left from min-till field, soil on right from moldboard ploughing.



Discussion of "micro-dams" on planters/hillers for erosion prevention and better water infiltration. Available on both Grimme and Miedema.

The Peeters brothers own 100 ha and rent another 40 ha. They are the fourth generation of their family on this farm, but the farm house and several barns date from the mid 1700's. Potatoes are the primary crop, but they also grow wheat, sugar beets, corn, and oilseed rape in rotation. They also have a small pear orchard. They grow 55 ha (137 acres) of chip stock destined for Frito-Lay, and they store potatoes until June. They have a deep top-soil (up to 2 m) on well drained, rolling land so they are able to achieve very high yields of up to 60 T/ha (530 cwt/ac). They also attain wheat yields up to 10 T/ha (4 T/acre) and sugar beet yields of 90 T/ha (36 T/ac).

Among some of the sustainable practices employed and demonstrated at the Forward Farm:

- 7% of total arable land is green area, including buffer zones, hedges, bird feeding areas, and permanent grass borders.
- Cover crops are used after most crops, particularly potatoes and wheat. Yellow mustard is used as a green manure cover crop, and winter wheat is often planted after potatoes.
- Reduced tillage practices have been adopted, with very little use of moldboard ploughing.
- They have adopted a special mowing regimen for grassed areas to protect bird habitat.
- They have installed two "bee hotels."
- Installation of a Phytobac pesticide remediation system. A washing/drainage area for their sprayer has been installed, draining to an underground tank. That water with pesticide residue is then applied to an above ground compost pack that breaks down the pesticides, eliminating source point pesticide contamination.
- Use of a Bayer Ecoflow system for precise measurement of pesticides that also eliminates the risk of operator exposure to concentrated pesticides.
- Use of low drift nozzles and section control on their sprayer.
- Use of "microdams" on their Miedema planter to improve water infiltration in the field.
- Use of variable rate planting according to soil electroconductivity and soil texture maps.

Sprayer mounted NDVI sensors for measurement of crop canopy biomass and N-response at Bayer Forward Farm.

Imants "spader" tillage implement for land preparation in advance of potato production or for incorporation of biofumigant crops.

Imants

On Friday (Nov 30th), we started the day with a visit to Imants in Reusel, NL. Imants produces a line of tillage equipment called spaders, which dig deep into the top soil (as deep as 35 cm) through a series of spades on a rotary cylinder. The majority of their machines are 3m wide, but they make a 4.5m version for North America. These machines do not invert the soil profile like a plough, but they thoroughly mix the soil in preparation for planting primarily vegetable crops. They have different versions that require different horsepowers to travel at different speeds, and they also have versions that are combined with added attachments, including subsoiling shanks or a roller for use in biofumigation (ie. incorporation/rolling of mustard). They make all of their equipment at their factory in Reusel and sell equipment all around the world, including Canada. They also have a line of turf management equipment that is used by golf courses and soccer stadiums, including some high-profile clients.

Wageningen University

We then travelled north to Wageningen to meet with a team of researchers at Wageningen University who have developed a software platform for management of different precision agriculture tools and apps. Dr. Frits van Evert provided and overview of Akkerweb, which was developed in partnership with a Dutch farmer association to directly meet the needs of producers.

The Akkerweb platform works by providing a common database for multiple precision agriculture tools, avoiding duplication of data entry and creating errors in data. All of the tools pull from the same core databases but can be used individually like apps on your phone. Private companies can develop apps on the Akkerweb platform, but the majority of apps have so far been developed by the team at Wageningen. Four of the best regarded apps so far include:

1. A mapping program for applying variable rate herbicides by using soil EC and soil organic matter
2. A mapping program for variable rate sidedress N using NDVI
3. A decision tool for late blight, aimed at matching fungicide protection to times of risk of infection using weather data and crop growth models
4. Direct measurement of green index of potato vines for variable rate vine desiccation

There was also a core app in Akkerweb which records field boundaries, crop rotation history, and all crop management activities. More apps are in development, including managing soil sample information, a decision tool for nematodes, and an early blight decision tool similar to the late blight tool. Our team felt that there would be the potential for testing the Akkerweb platform right away in PEI, and we plan to follow up with the team this winter to investigate further.

Emmeloord Visits

On Saturday morning, we visited two seed potato farms in the Emmeloord area of the Netherlands. Emmeloord is the primary seed producing area of the Netherlands. The land in this area is all reclaimed land from the sea after World War II, and as such, is very flat, with larger fields than we saw in Belgium and southern Netherlands. Every farm was surveyed to 300 m wide by 800 m long with rectangular fields. Land in this area is very productive and very expensive, with land prices up to €120,000 per ha! Most growers in the area grow much smaller acreages of potatoes than in Prince Edward Island but with strong yields of primarily seed potatoes. Most other crops in rotation

Discussing the Akkerweb precision agriculture platform at Wageningen University.

Chatting with Thys Smits and Eise Timmerman about seed production in the Netherlands in their box storage.

(sugar beet, onions, chicory, carrots) are also high-value crops. Wheat was generally the only non-vegetable crop grown in this area. Our two visits were to growers for HZPC, coordinated by local fieldman Eise Timmerman of HZPC.

Our first visit was to the Smits seed farm, and we were hosted by Thys Smits. Thys farms with his father, two uncles, and two first cousins. He is the third generation on this farm, started in the 1950s. The soil is 80 cm deep with clay, followed by a layer of deep sand. They grow 100 ha (250 ac) of potatoes, with most of these being seed potatoes for both large seed companies in the Netherlands, HZPC and Agrico.

They store 4500 boxes of seed in three locations. Their primary storage uses an air bag system designed by Tolsma to assist with rapid drying of seed, which is a priority following harvest. It is not uncommon to have more than 10% shrink within two months of harvest in an effort to get seed dried down. This air bag system can both suck air out of the storage as well as blow air into the storage to manage humidity and carbon dioxide. Boxes are stacked six high, with 1250 kg of potatoes in each box. The Smits family grows 12 varieties, including varieties such as Innovator, Challenger, Sifra, and Colomba. Seed is stored at 8 degrees Celsius in the storage we viewed, which also included some table potatoes as well as onions. Some limited irrigation from well water is used, primarily to prevent common scab at tuber initiation. They are currently on a four year rotation, but are considering moving to a three year rotation in an effort to better control nematodes with resistant varieties like Innovator.

Fertility in the potato crop consists of a liquid NPK product in furrow at planting, as well as CAN applied at hilling. A majority of N and P needs are met by use of liquid manure, which they have easy access to. They use a 4 row planter and harvest with a 3 row towed Grimme harvester. Mustard or winter wheat is planted after potatoes, and soil organic matter ranges between 2 and 3%.

The next farm we visited was owned by Jeender Bonnema. He and his wife grow 70 ha (175 ac) of seed of multiple generations in a three year rotation with a combination of wheat, sugar beets, chicory, and onions. They grow 13 different varieties, including several varieties destined for starch production. Innovator is a primary variety, as is a variety called Fortus that was developed by Jeender's father-in-law. The starch varieties they grow are largely resistant to nematodes, and one variety is largely resistant to late blight, only requiring two sprays per growing season.

The flat, rich soil of Emmeloord, Netherlands.

Seed storage at Thys Farms near Emmeloord.

View from the top of the box storage at Thys Farms.

Seed grading facility at Bonnema Farm near Emmeloord.

At this farm, they do two stage potato harvesting. They have a "lifter" which dig out potatoes, and then follow with a harvester to pick up the potatoes. This process isn't common in the Netherlands, but helps to eliminate soil more effectively. Planting is done with a 4 row belt planter with a box tipper. The crop is largely planted in April, with harvest starting in late August, with the starch varieties harvested last in early October. Liquid phosphorus is applied on the planter, while nitrogen is broadcast pre-plant. Potassium is largely applied the fall before as a liquid product that is a waste product from the starch plant that they work with. Some manure is applied after winter wheat to help break down straw and build organic matter. Fertilizer rates were between 80-100 kg/ha N, a maximum of 60 kg/ha of P, and up to 300 kg/ha of K. They have a 50 T/ha yield goal, but usually produce around 45 T/ha in an average year. In 2018, they only had 400 mm of rain, about half of their average rainfall. They have the ability to irrigate from wells, but once again, this is usually done just early in the season and is done using reel and gun equipment.

Van den Borne Potatoes

Following our Emmeloord visits, we headed back down to the Netherlands/Belgium border to visit with Jacob Van den Borne, a leader in precision agriculture in the potato industry. Jacob and his brother Jan grow 600 ha (1500 acres) of potatoes, making them one of the largest potato growers in the region. Their farm is located right on the Netherlands side of the border with Belgium, but 80% of their fields are in Belgium. They only own 200 ha of land, renting the remaining land needed for potatoes. Last year, they grew potatoes in 180 fields, with an average field size of around 3 ha (7.5 acres)! In fact, they have land rental agreements with 138 different farmers and land owners…in itself a strong argument for accurate data management tools.

Jacob provided a professional presentation describing their journey in introducing precision agriculture tools to the farm. When GPS was adopted, they reduced overlap of spraying and fertilization from 13% to 1%, already a significant savings. From there, they adopted a wide array of tools and software to track field operations and make management decisions on every field. Whenever an operator takes a tractor across a field boundary, they automatically receive a notification on their cell phone requesting information on what action is being done in that field. Another notification is received when they leave the field!

All fields are scanned using a DualEM sensor for electroconductivity, the same sensor that UPEI is using in their project with AIM. Jacob was convinced that this was the best EC sensor available. Using soil EC maps, he is able to assess the variability of his fields, identifying zones with higher and lower potential for yield based on soil texture and soil organic matter. He describes this as measuring the "battery potential" of his field. He also assesses fields for soil compaction and top soil depth, and these maps are used for variable rate fertilization and planting. He noted that percent organic matter is not as important as tonnes of organic matter…measuring the thickness of topsoil is as important as knowing the organic matter percentage.

Jacob uses tramlines in all fields, and these tramlines are established in the winter for each field using software from 365 Farm Net. Tramlines are zones for controlled traffic in the field, where sprayers and potato wagons travel to reduce incremental soil compaction across the field. It has been shown that controlled traffic farming can increase yield in their production system but at least 7%. Reducing surface compaction allows for larger pore spaces in the soil, allowing for more oxygen in the soil, which fosters microbial activity. He currently uses self-propelled harvesters, but is interested in adding window-

Jacob Van den Borne's "drone hangar" in his lecture room on the farm. Jacob employs a number of drone-based sensors for crop management.

The view from the top of the bulk storage at Van den Borne Aardappelen, piled with telescopic, swinging bin piler.

ers to his harvest system to reduce the weight of equipment on the field.

Variable rate planting has been incorporated in multiple ways. Zones of higher EC/soil OM are planted thicker, while sandier areas are more spaced out. Rows adjacent to tramlines are planted with 30% more seed than average rows to compensate for land area lost to tramlines. In addition, shadow maps from drones can be used to adjust seeding rate in areas with higher degrees of shade (near forests/hedgerows).

Jacob has also been incredibly innovative in development of new tools or software solutions when there was not an adequate tool on the market ready to use. He developed his own yield monitor, as he found existing equipment inadequate. He also developed a dashboard for climate data, organizing data from a number of weather stations in his fields. At the same time, he is also making use of software from Dacom which incorporates sensor data, application data, and remote sensing (drone/satellite) data in one platform. Drones are definitely a passion for Jacob, as evidenced by his "hangar" of various drones with various sensors/cameras.

Jacob also doesn't put blind trust in the output of remote sensors…he backs this up with in-field soil and plant sampling. In the summer, he has a group of students doing in-field sampling to correlate with the information coming from sensors and drones. He is then storing all of this data and hopes to be able to offer this database to companies looking toward machine learning.

Some additional notes from our visit:

- Jacob uses digital tubers which are planted in the soil with the crop, measuring moisture and temperature during the growing season. These then go into storage and measure temperature in the storage pile. These are used for assessing physiological age of the seed crop.
- He employs a split-tank sprayer with section control, enabling him to do variable rate fertilizer while applying consistent rates of fungicides.
- He has seen up to 60 T/ha difference in yield within field. However, he maintains that the lower averaging areas of the field only have so much potential…better to maximize the yield from the best areas of the field, as they have the biggest "battery" or potential to produce.
- His yield monitoring system tracks not only yield by spot in the field but tracks those potatoes to placement in the storage….similar to the Greentronics system.
- Irrigation is done early in the season but not all season long. Work with Dacom on irrigation scheduling, using soil moisture monitors. Has become a fan of applying no more than 15-20 mm in an application to avoid leaching of N.
- Talked about the "rule of 10%" – have to do a 10% change in rate (fertility, spacing, etc) to see whether there is a change in yield/quality.
- Became a MacDonald's Flagship Farm in 2017. Grows Ivory Russet for MacDonalds. Majority of acreage is Fontane.
- Has a system to make his own liquid fertilizer on farm.
- Potatoes are stored until early summer. 80% goes to Farm Frites, 20% to Agristo.
- All cleaning/sizing/grading done on farm, only washed potatoes leave the farm.
- Average yield this year was 45 T/ha, normal yield around 55 T/ha.

Take Home Messages:

This study tour was very full, with visits to a variety of different parts of the Belgian/Dutch potato industry. One of the key observations from everyone on the trip was that the majority of challenges faced by Belgian/Dutch potato farmers (diseases, pests, sustainability, precision agriculture) are very similar to the challenges faced here in PEI. There are some approaches that are less applicable to Canada, but there are some definite take home messages and projects to investigate immediately, including:

1. The average grower in Belgium/Netherlands is likely at a similar stage of precision agriculture adoption as a Canadian grower; however, the early adopters are likely at a higher level than the early adopters here in terms of access to precision agriculture tools.
2. The trend toward self-propelled harvesters in these countries is unlikely to be replicated in Prince Edward Island. However, these companies are also developing new towed harvesters for the North American market that are interesting, particularly with the inclusion of dirt elimination technology.

3. Equipment in Belgium/Netherlands appears to be more ready for variable rate mapping/application than here in PEI. In part, this is due to government programs to assist with purchase of new equipment.

4. Variable rate planting has moved from theory to practice and can be implemented with simple management zone maps or EC maps. Could be investigated in Prince Edward Island with enabled planters.

5. Akkerweb platform would be worth immediate investigation in Prince Edward Island, particularly for the field management and late blight apps. Apps could then also be built for variable rate lime and K application.

6. Variable rate/split application N before row closure could be trialed in PEI this summer, with adequate equipment.

7. Tech WG should investigate opportunities for use of "micro-dams" on planters/hillers in 2019 growing season. Also investigate possibility of simple decompaction teeth on hillers for better water infiltration (Grimme-HJV)

8. Investigate trial of Miedama single cut set cutting table (Allan Equipment)

9. Work with Aitazaz Farooque at UPEI to do DualEM EC maps of more fields prior to planting for a number of research projects. Continuing research into soil EC for PEI growers is essential.

10. Follow up with ILVO on wireworm online risk tool and qPCR protocols for root lesion nematodes.

11. Investigate use of 365 Farm Net software for creating optimum A-B lines in fields.

12. Investigate bringing Bayer Ecoflow pesticide technology to Canada.

13. If pursuing further research on Alternaria (early blight), coordinate with PCA and ILVO to learn more from their previous research and forecasting.

Demonstration of the EasyFlow pesticide pouring and measurement system at the Bayer Forward Farm near Brussels, Belgium.

Downtown Bruges, one of the most historic cities in Belgium.