As we look into the future of agriculture and food production, we face a number of challenges that seem impossible to address on their own. The need to feed a rapidly growing global population is exacerbated by a decreasing mass of arable land for crop production and the negative impact production can have on our environment.

They say necessity is the mother of invention and we’ve seen many innovations that attempt to tackle the fine balance between agricultural productivity and environmental sustainability, but most come with significant trade-offs that do not achieve balance.
The only N-fixing bacteria that works from within the plant cells across crops to fix nitrogen all season long
THE OPPORTUNITY:
A solution without compromise

A new technology from Azotic, answers the need on both sides of the equation to meet the needs of our food supply and the environment. Envita™ is a naturally occurring food grade bacteria (Gluconacetobacter diazotrophicus) that enables plants of all types to fix nitrogen from the air and replace up to 50% of plants’ nitrogen needs, essentially turning plants into nitrogen-fixing machines.

Applied on seed, Envita enables every cell in the plant to fix its own nitrogen from the air which is 78% Nitrogen. Envita bacteria naturally metabolizes nitrogen directly from the air allowing farmers to reduce their nitrogen fertility program and still hit their yield goals.
How Envita colonizes plant roots

- Obligate endotroph
- Similar to Rhizobia
  - fixes atmospheric N
- Unlike Rhizobia
  - Fixes N within plant cells
  - Intra-cellular

Route of entry into the plant through root cells facilitated by bacterial enzymes β-expansin and an endo-1, 4-β-gluconase
Hypereye moves closer to commercialization

Developed by researchers at McGill University and supported by Egg Farmers of Ontario this technology will allow industry to determine the best use of an egg from the day it is laid.

The innovation not only saves hatcheries the cost of incubating eggs that will never hatch or be used in the layer industry, it displaces the controversial practice of destroying live male chicks shortly after they hatch.

In the past, before specialized fast-growing genetics were introduced to the broiler industry, the male chicks would be raised as meat birds, while the female chicks would be streamed into layer production. But once specialized egg and meat species were adopted, the use of males from the layer genetics for meat was no longer viable.

The Hypereye means that instead of newly hatched male chicks being gassed, asphyxiated or put through a grinder, they can be separated out before egg incubation starts and sold for commercial use in processing or table egg markets. That opens up a new revenue stream for roughly half of the eggs hatcheries produce.
Every day nearly 62,000 cockerels are culled in Canada. That’s 22.5 million birds each year. While the number sounds shocking, it is the harsh and unavoidable reality of Canada’s egg industry. In the developed world, that number reaches over a billion chicks. The birds that commercial egg farms purchase are bred specifically for egg, not meat, production, which means that while the females are highly coveted, male chicks have absolutely no value.

This is not only a serious animal welfare issue, but also an issue of waste. But technology developed by the Egg Research Development Foundation (ERDF) could change all that.

Hatcheries in Canada run a tough business. According to Tim Nelson, Chief Executive Officer of the Livestock Research Innovation Corporation (LRIC), when you take into consideration their losses, they run at 50 per cent efficiency. For one, some 10–15 per cent of all eggs are infertile, and hatcheries are forced to dispose of them as waste. Of those that do hatch, cockerels make up 50 per cent. The chick must then be identified, culled and disposed of by the hatchery. On top of the waste and animal welfare issues this raises, the hatchery must foot the bill for their incubation, as well as the labour and energy associated with raising them.
“We combine spectro-image data, so that’s why we call it the hyperspectral imaging. It’s a combination of broad spectral image signatures that we get from the egg. Then we put that through a fairly complex mathematical analysis where we are using some deep learning techniques to identify or relate those spectral and image data to the specific attributes that we are looking at – in this case, whether it is fertile or not and whether it is male or female.”

-Dr. Michael Ngadi, McGill University
Layer industry EU, N. America & Oceania:
• Incubate > 2.3 billion eggs per annum
• 50% of all layer breeder eggs hatched are ♂
• 1-3% infertile eggs also are incubated
• = 1,260,875,000 layer breeder eggs are incubated for 21 days with NO edible, saleable, useable output

International Broiler industry (not including China)
• Incubate >56 billion broiler breeder eggs per annum
• 10 – 15% of all broiler breeder eggs incubated are infertile
• = 6,000,000,000 broiler breeder eggs are incubated for 21 days with NO edible, saleable, useable output
## Resources used and waste produced from this system

<table>
<thead>
<tr>
<th></th>
<th>Layers</th>
<th>Broilers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure produced equivalent in Olympic swimming pools. (1 pool = 2500 Cu Metres = 2500 tonnes liquid manure)</td>
<td>48</td>
<td>228</td>
<td>276</td>
</tr>
<tr>
<td></td>
<td>≈ 120,000 metric tonnes manure</td>
<td>≈ 570,000 metric tonnes manure</td>
<td>≈ 690,000 metric tonnes manure</td>
</tr>
<tr>
<td>KWH of energy used</td>
<td>169,052,000</td>
<td>802,997,000</td>
<td>972,049,000</td>
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<tr>
<td>Equivalent in homes powered (US av. 2017)</td>
<td>16,255</td>
<td>77,211</td>
<td>93,466</td>
</tr>
<tr>
<td>Water (L) used</td>
<td>719,069,346</td>
<td>3,415,579,393</td>
<td>4,134,648,739</td>
</tr>
<tr>
<td>Tonnes of corn wasted used</td>
<td>4200</td>
<td>19,900</td>
<td>24,100</td>
</tr>
<tr>
<td>750g boxes of cornflakes equivalents produced from the corn used (Assumes feed intake of 105g per day per breeder hen over its life)</td>
<td>5,552,140</td>
<td>26,372,665</td>
<td>31,924,805</td>
</tr>
<tr>
<td>Co2 Equivalents</td>
<td>64,914,395</td>
<td>308,343,376</td>
<td>373,257,771</td>
</tr>
</tbody>
</table>
Farmer driven & funded solution

• Egg Farmer’s of Ontario (EFO) Funding Canadian Research @ McGill University
• Initial research 2007
• Moving into commercial production in 2020
Major Plant Growth Factors

- Genetics – billion $ industry
- Water – billion $ industry
- Nutrients – billion $ industry
- Temperature – control of, driving the greenhouse industry
- Lighting – hundreds of millions $
- Pesticides – billion $ industry
- CO2 – dissolved CO2 works best to maximize use of the above
CO2 Delivery Use Cuts CO2 Gassing Use in Half

CO2 gas dissolved at 1300 ppm stays in water with little off-gassing. At 1300 ppm gassed, 60% of CO2 gassing is lost (OMAFRA Greenhouse Study).

A 1M sq. ft greenhouse uses 3,000 MT of CO2/year for 33% added plant growth at a cost of $300K-$600K/y.

60% CO2 gassing losses cost $180K - $360K/y

- CO2 Delivery use yields 20%+ more plant value than CO2 gassing (proven on peppers, lettuce, algae), is safer for workers AND cuts CO2 gas use by 50%
Our cannabis sativa and hybrid strain trials both had 20% more bud biomass and 20% more THC and CBD per unit of weight. They grew 33% faster to pre-flowering maturity during CO2 Delivery Solutions. Our leafier indica strain trial had the same 20% bud biomass and 33% growth increases but with 75% THC and 89% CBD per unit of weight.
Powdery Mildew – All plants were covered with a known dried powdery mildew pathogen and grown for a further 21 days. Results were scored visually at these commercial sites. All six plants in the control group developed powdery mildew disease while none of the CO2 Foliar Sprayed cannabis plants developed powdery
2018 CO2 Delivery Trial Results

- CO2 DELIVERY VALUE LIFTS VERSUS NO CO2 GASSING:
  - **Cannabis** – three strains (sativa, indica and a hybrid) had minimum 45% value lifts plus 20%-75% more THC and 16%-89% more CBD
  - **Flowers** – 25%-33% value lifts for periwinkles and chrysanthemums
  - **Peppers** – 50% value lifts at both Michigan and Minnesota grow trials

- CO2 DELIVERY VALUE LIFTS VS 800 PPM CO2 GASSING – Lettuce up to 100%, Micro Greens 8%-35%, Peppers 20% (used half the CO2 gas)
CO2 Delivery Analytics At SCSU

- **Demonstrated 800% More CO2 Conductance** – dissolved CO2 enters the entire leaf surface; CO2 gas can only enter leaf stoma (pores)
- **Demonstrated 400% More Chlorophyll A** – dissolved CO2 in a leaf immediately creates sharply higher chlorophyll A growth
- **Demonstrated Top of Leaves are 90% as Effective as Bottom of Leaves for dissolved CO2 conductance**
- **Demonstrated 50% Less CO2 Usage** – CO2 Delivery added 20% more pepper value over CO2 gassed peppers using only half the CO2 gas
September 3 harvest of 5-week-old-plants. Controls on left, treated on right with C02GRO.
Plant response of *Nicotiana benthamiana*, grown for production of tratuzmab (anti-cancer pharmaceutical)

C02GRO treatment at 5 weeks, trials for PlantForm Corporation with University of Guelph

September 2019

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percentage Increase/Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>+ 48.9 % *</td>
</tr>
<tr>
<td>Wet Weight</td>
<td>+ 112% *</td>
</tr>
<tr>
<td>Dry Weight</td>
<td>+ 133% *</td>
</tr>
<tr>
<td>Leaf Area</td>
<td>+ 147% *</td>
</tr>
</tbody>
</table>

* statistically significant