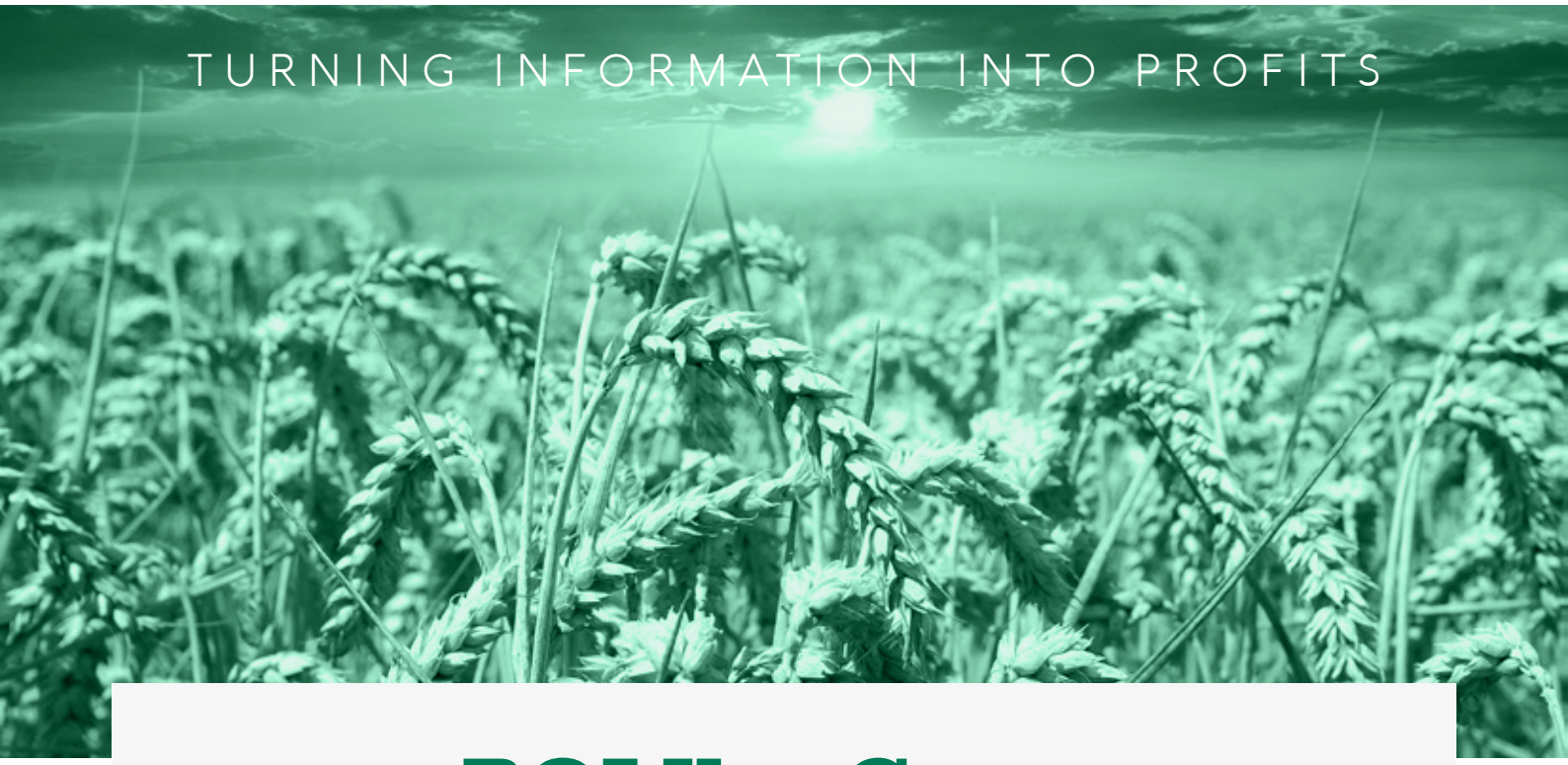

ROI Use Cases

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ROI Use Cases

CROP: Canola, Western Canada

AGRONOMIC ISSUE:

***Sclerotinia* Stem Rot**

- The fungus *Sclerotinia sclerotiorum*, which occurs in most to all the canola, soybean, and dry beans growing areas of Canada and the USA, causes stem rot of canola, soybeans and dry beans. The severity of sclerotinia stem rot can vary from year to year, region-to-region and even from field to field, with localized weather playing a significant role in its development.
- The incidence of *Sclerotinia* has intensified as canola production has increased, which is due to more acres of canola in rotations and management practices that increase yields, such as dense canopies, which produce better microclimate for disease development.
- Numerous studies in Western Canada have documented significant yield losses on canola with Sclerotinia stem root, so much so, that in high disease pressure regions spraying is wide spread.

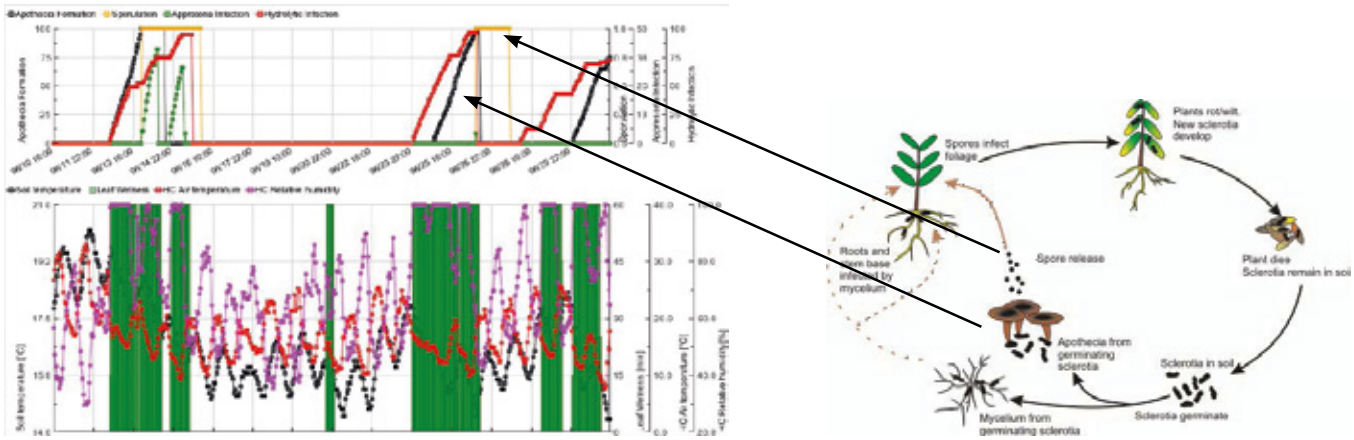
IoT SOLUTION:

Infield iMETOS 300 weather or ECO D3 soil moisture station(s) and *Sclerotinia* disease model

- With field specific weather solutions, know the modeled conditions for apothecia formation, sporulation, and sclerotinia risk
- Time fungicide applications based on growth stage and disease risk/pressure
- Preserve yield and grades based on well-timed fungicide applications


iMETOS® 3.3


iMETOS® ECO D3



- Apothecia formation and sporulation takes place if a rain of more than 8 mm is followed by a period of high relative humidity lasting longer than 20 hours at optimum temperature of 21°C to 26°C
- Direct Infection by Apothecia can be expected after a leaf wetness period followed by 16 hours of relative humidity higher than 90% under optimum 21°C to 26°C ("appressoria infection")

Cost Benefits:

It may be economical to apply fungicide when field scouting indicates that disease levels will reach 15 % in *Brassica napus* (Argentine canola) and over 30 % in *B. rapa* (Polish canola) by crop maturity.

- The estimated percent yield loss can be used to estimate the bushel loss due to sclerotinia infection if not treated using the following formula. **If the value is lower than the cost of a fungicide application/acre, then a fungicide application is not recommended:**

  Yield Loss/acre = % Potential Yield Loss * Estimated Yield * $/bu

- Cost of fungicide application $25/acre, $11 bu canola and yield of 40 bu/acre So 50% main Stem Infection

  (50% *.5 = 25%) = 25% yield loss:

  Yield Loss/acre/dollars = % Potential yield Loss* Estimated Yield * $ Bu

  Yield loss/acre/dollars = 25%*40*11 or $110

- On 1,000 acres, that's $110,000 lost in gross income. With an application cost of $25 acre, the cost is $25,000.
- **Potential gross income benefit with spraying = $110 - $25 = $85/acre and on 1,000 acres = $85,000**

Voice of the Grower

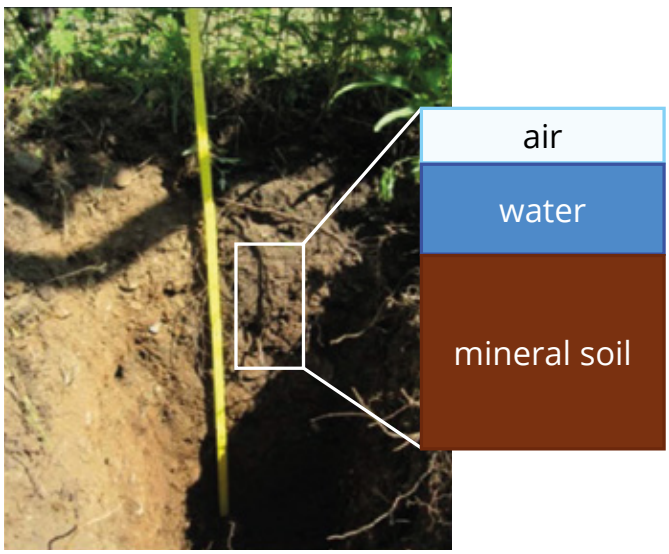
Sclerotinia stem rot robes my farm of yield, so much so, I have lost $55 acre on a 50 bushel crop for my 1,000 acres. I've had to change my management practices and use IoT solutions from Pessl to get a better handle on the environmental conditions for *Sclerotinia* disease risk so as to time fungicide applications. The IoT solutions cost my farm $6,000 a year, which translates into more than 8:1 return on investment.

CROP: Canola, Western Canada

AGRONOMIC ISSUE: ***Soil Moisture Management***

- Root zone soil moisture is the CROPS GAS GAUGE—Measure IT – Monitor IT – Manage IT
- Of all the parameters that effect crop production, water or soil moisture has the biggest impact on crop yield. So it's extremely important to measure and monitor root zone soil moisture to maximize yield and quality
- Numerous studies in Canada have clearly demonstrated that knowing root zone soil moisture through field and site specific soil moisture probes can maximize yields and in some cases lower input costs for a canola crop
- Each inch of soil moisture roughly equates to 5.7 bu of yield in canola, so maximize the genetic yield potential based on knowing actual root zone soil moisture

MEASURE » MONITOR » MANAGE



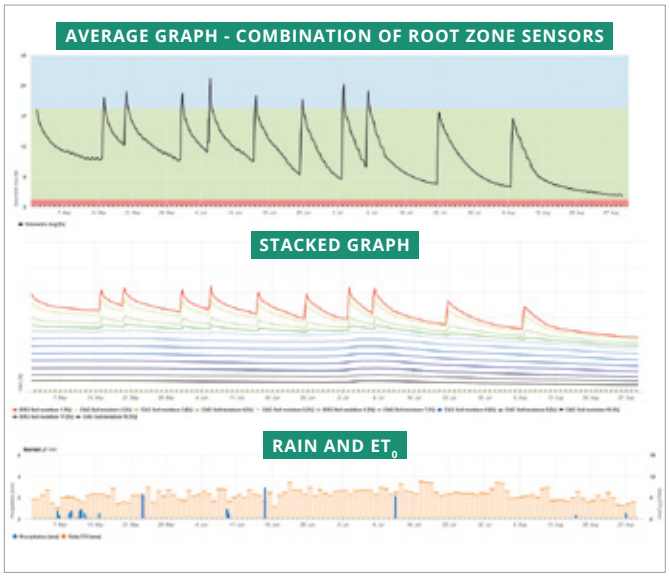
IoT SOLUTION:

Infield iMETOS 300 weather or ECO D3 soil moisture station(s) with iMETOS DDT soil moisture probes

- See the root system—with field specific stations and soil moisture probes, know real-time root zone soil moisture levels every 10 cm (4 inches) (second graph below)
- Improve yields based on applying the right amount of nitrogen for root zone soil moisture levels
- Time additional fertilizer applications based on growth stage and in-field root zone soil moisture levels
- Track individual soil moisture values for each sensor depth or the average root zone soil moisture based on the active root zone
- Set soil specific full and refill points for the active root zone (green zone in graph above)
- Know the volumetric water content of each sensor and the root zone


iMETOS® 3.3


iMETOS® ECO D3 - DDT



Cost Benefits:

Root zone soil moisture is the CROPS GAS GAUGE for yield potential.

Three case examples:

1. The grower purchased weather and soil moisture solutions and decided the season was too dry for late sea-son Nitrogen based on accurate root zone soil moisture and rainfall data (Good decision based on weather information). **Saved $18,500 in nitrogen costs (product and application) and returned about $480,000 on 1,000 acres (48 bu *$10 acre)**
2. The grower didn't purchase any weather or soil moisture solutions and went on gut feel and added extra Ni-trogen late season and didn't have enough subsoil moisture (Poor decision which was mostly yield limiting). **Extra $18,500 in nitrogen costs and returned about $490,000 on 1,000 acres (49 bu * $10 acre)**
3. The grower purchased weather and soil moisture solutions and the season was favorable based on rainfall da-ta and root zone soil moisture data so decided to apply late season Nitrogen (Yield increased markedly). **Extra $18,500 in nitrogen costs, but returned about $580,000 (58 bu *$10 acre) on**

Voice of the Grower

Targeting nitrogen fertilizer based on knowing the active root zone soil moisture in dry and wet years has earn my farm more dollars per acre than over the traditional method of a gut feel estimate.

We spent about $6,000 on our three Pessl IoT soil moisture solutions and earn money even in dry years by saving fertilizer costs, but in wet years maximized the return of $81.50 per acre by targeting the right amount of fertilizer for a 11 bu acre increase.

Our return on investment range from breaking even in dry years to over 15:1 in wet years.

CROP: Corn, USA Midwest

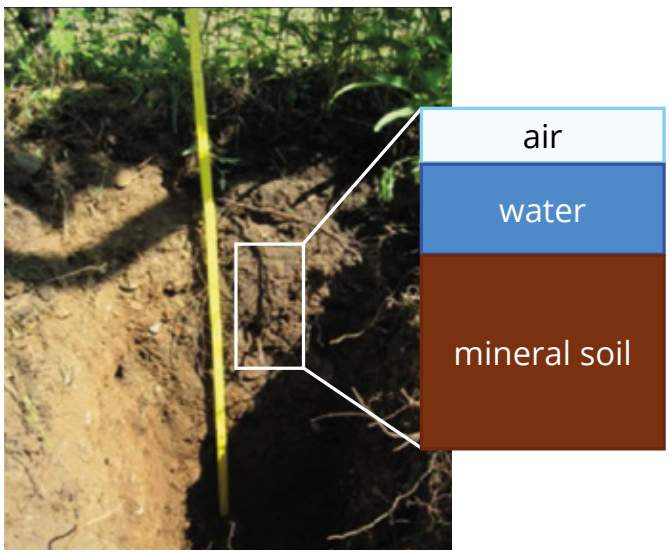
AGRONOMIC ISSUE:

Soil Moisture Management

Root zone soil moisture is the **CROPS GAS GAUGE**.

Soil moisture is the more critical factor in determining crop health. The ability to measure, monitor and manage root zone soil moisture is crucial to maximize yield and quality. Numerous studies in the Midwest clearly demonstrated that managed soil moisture probes can increase yields and in some cases lower input costs for a corn crop.

MEASURE » **MONITOR** » **MANAGE**



IoT SOLUTION:

Infield iMETOS 300 weather and ECO D3 soil moisture station(s) with iMETOS DDT soil moisture probes

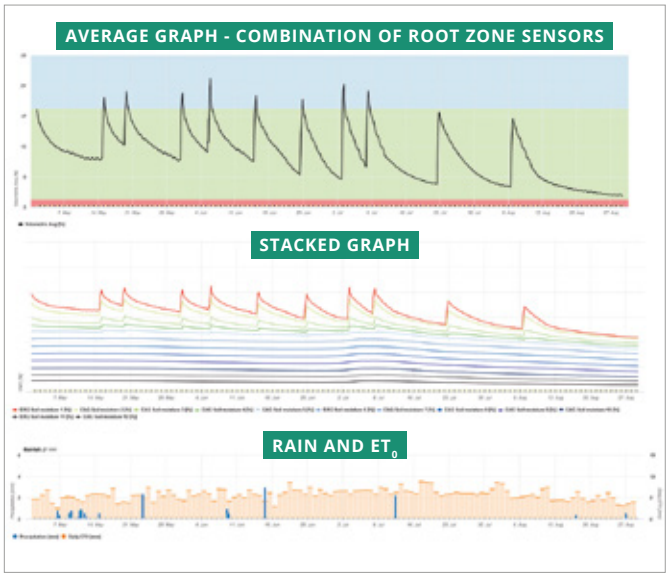
See the root system - with field specific stations and soil moisture probes, know realtime root zone soil moisture levels every 4 inches. (second graph below)

Irrigate on target - Identifying where roots zone is allows for proper on target irrigation. Encourage the roots to reach available soil moisture and reduce leaching or washing out of nutrients by the targeting root zone. Reduce input loses and over irrigation.

Fertigation - Application of water and nutrients in the active root zone, allows for increased nutrient absorption by the crop and reduces the chance of leaching chemicals into the water supply and improves yield.

Irrigation template - A template of average root zone soil moisture allows a user to both determine the timing and the amount of water required for each growth stage (green area on graph).

Finish the crop - Managing soil moisture with growth stage allows the user to reduce irrigation towards the end of development, but still allows the crop to tap store soil moisture (i.e. the gas tank) for final filling. Als reduces the risk of soil compaction during harvest.



Cost Benefits:

Root zone soil moisture is the CROPS GAS GAUGE for yield potential

- Soil moisture has the most significant impact on crop production
- Targeted irrigation can increase yield and quality, while saving water and nutrients costs
- Previous studies have shown that yields can increase by 10 to 25% and potentially more than a 4:1 return on investment
- Save resources and money by more efficient irrigation management

Example

20% increase in corn yields on a traditional 200 bu/acre crop = 40 bu/acre increase.

40 bu/acre *$3.0 corn * 640 acres = $76,800 gross profit.

This does not factor in that targeted water and nutrient costs could potentially be lower, further increasing the gross return.

Voice of the Grower

Ineffective soil moisture management robes my crop of yield. By using Pessl's field specific soil moisture probes I have benefited from reduced input costs and increased yields by 15% for my corn. I targeted irrigation water in the active root zone throughout the year, which reduced my irrigation and nutrient requirements. This resulted in more than a 4:1 return on my investment.

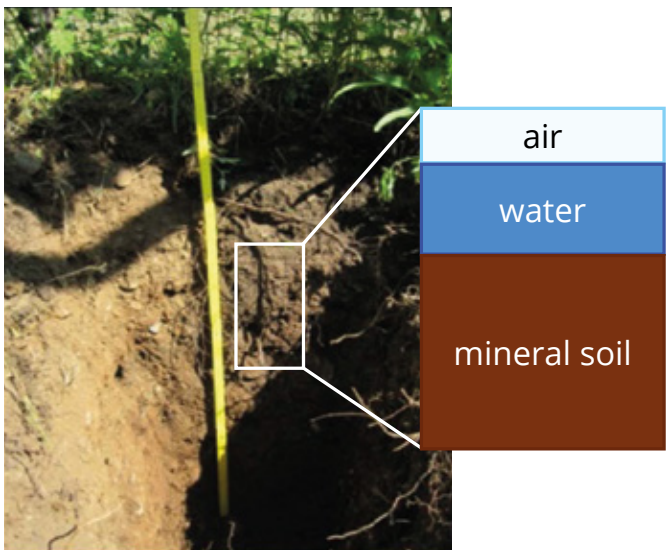
CROP: Potatoes

AGRONOMIC ISSUE:
Irrigation Management

Root zone soil moisture is the **CROPS GAS GAUGE**.

Soil moisture is the most critical factor in determining crop potential of potatoes. The ability to measure, monitor and manage root zone soil moisture is crucial to maximize yield and quality. Numerous studies have clearly demonstrated that managed soil moisture via soil moisture probes can increase marketable yields and in some cases lower input costs.

MEASURE » MONITOR » MANAGE



IoT SOLUTION:

Infield iMETOS 300 weather and ECO D3 soil moisture station(s) with iMETOS DDT soil moisture probes

See the root system - with field specific stations and soil moisture probes, know real-time root zone soil moisture levels every 4 inches (second graph below).

Irrigate on target - Identifying where roots zone is allows for proper on target irrigation. Encourage the roots to reach available soil moisture and reduce leaching or washing out of nutrients by the targeting root zone. Reduce input loses and over irrigation.

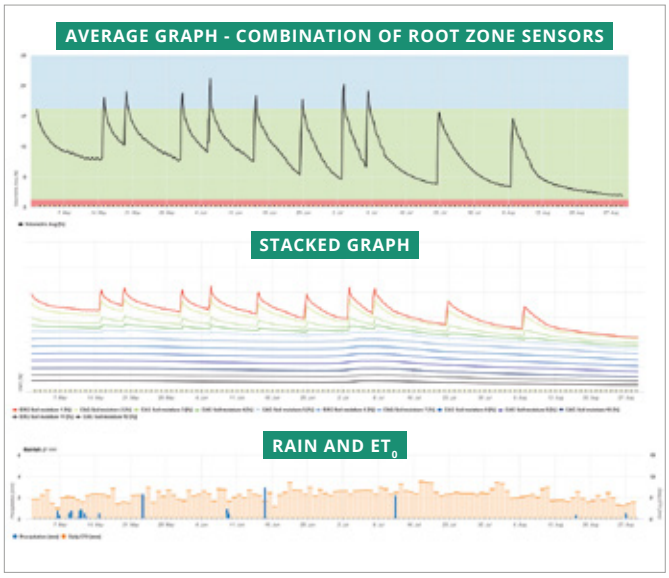
Irrigation template - A template of average root zone soil moisture allows a user to both determine the timing and the amount of water required for each growth stage (green area on graph).

Control physiological disorders - Maintaining optimal soil moisture levels (between FC and WP) limits a number of physiological disorders throughout the growing season, such as: hollow heart, late blight, open lenticels in excessive moisture situations, while yield loss, sugar ends, scab and tuber malformations happen under deficit situations.

Finish the crop - Managing soil moisture with growth stage allows the user to reduce irrigation towards the end of development, but still allows the crop to tap store soil moisture (i.e. the gas tank) for final filling. Reduced irrigation near harvest diminishes the chances of rots (pink, water and soft) by limiting conditions conducive for development.


iMETOS® 3.3


iMETOS® ECO D3 - DDT



Cost Benefits:

Root zone soil moisture is the CROPS GAS GAUGE for yield potential

- Soil moisture has the most significant impact on potato yields, more so than on many other crops
- Targeted irrigation can increase yield and quality, while saving water and nutrients costs
- Previous studies have shown that yields can increase by 10 to 12% by improving soil moisture levels from 55 to 75% of FC, which is potentially more than a 8:1 return on investment
- Save resources and money by more efficient irrigation management

Example: 10% increase in potato yields on a 300 acre crop

Price per CWT: $11.70. This resulted in a $375 increase per acre or $112,500 gross return on a IoT solution investment of $10,000 or a 10:1 return of investment.

Voice of the Grower

Ineffective root soil moisture management robes my crop of yield. By using Pessl Instruments' field specific soil moisture probes I have increased my yields by 9% in my potato fields. I targeted irrigation water in the active root zone and maintained it at predetermined thresholds throughout the year, which increased my yields and improved the quality of the tubers. This resulted in more than a 7:1 return on investment on my 300 acre crop.

CROP: Potatoes

AGRONOMIC ISSUE:
Late Blight

- **Potato Late Blight** caused by *Phytophtora infestans* is one of the most devastating plant diseases worldwide.
- This fungal disease affects both the foliage and tubers. Potato late blight spreads by continuous leaf and stem infection when inoculum is present and favorable environmental conditions exist.
- Late blight thrives the most when moderate temperatures (15 to 26°C or 59 to 79°F) are combined with high humidity in the canopy or leaf wetness, caused by high dew levels and/or rainfall and prolong periods of high humidity (> 80%).

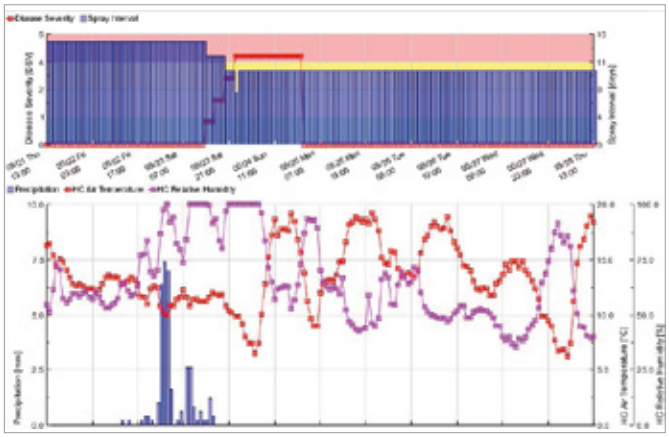
IoT SOLUTION:

Infield iMETOS IMT300 weather or iMETOS ECO D3 disease management station and potato disease model by Pessl Instruments

- Choose from one of the 7 late blight models that is most appropriate for your region
- With field specific weather solutions, know the modeled conditions for sporulation, variety sensitivity and late blight risk
- Modify the spray interval based on changes in disease risk/pressure
- Preserve yield and grades based on well-timed fungicide applications
- Control secondary and storage infections through well timed applications


iMETOS® 3.3


iMETOS® ECO D3



Cost Benefits:

Root zone soil moisture is the CROPS GAS GAUGE for yield potential

- Field specific weather solutions are required for proper disease modelling and assessing changing risk levels
- The number of spray applications is dependent on the levels of inoculum, vari-ety susceptibility, type of product and environmental conditions
- The spray interval can vary substantially based on field level weather condi-tions and can vary from 6 to 15 days, with the worst conditions occurring with moderate temperatures and high humidity levels.
- Shorten or stretch your spray interval based on field specific conditions, which either protects the plant or reduces the amount of product and application cost

Example: reduce one spray for a 300 acre crop. Price per application/acre $19. This results in a $5,700 savings on 300 acres. IoT solution investment of $1,500 or a 4:1 return of investment.

Voice of the Grower

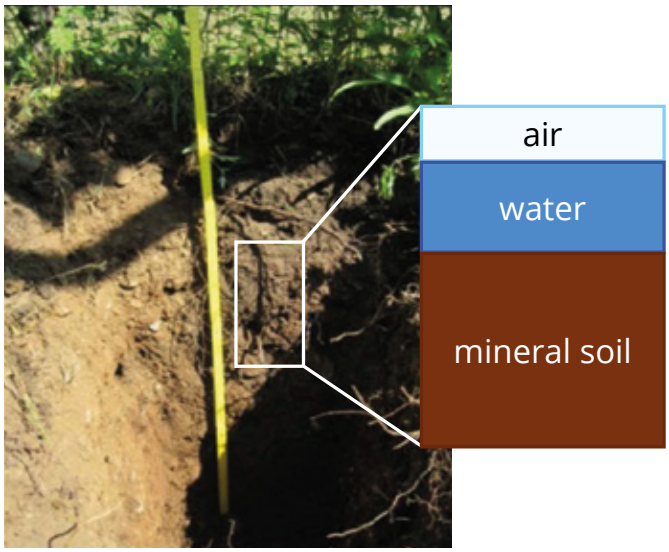
Ineffective late blight management robes my crop of yield and grade. By using Pessl's field specific ECO D3 weather monitoring solu-tion I have either maintained my yields/grade or saved spray applications. With a 10% loss in yields I can lose over $300 per acre or over $240,000 for my 800 acre crop. With my IoT solution investment of $10,000 my ROI is well over 10:1

CROP: Sorghum, Australia

NITROGEN FERTILITY

- Root zone soil moisture is the **CROPS GAS GAUGE.**
- Of all the parameters that effect crop production, water or soil moisture has the biggest impact on crop health. So it's extremely important to measure, monitor and manage root zone soil moisture to maximize yield and quality.
- Numerous studies in Australia have shown the relationship of soil moisture levels and nitrogen use to targeted yield. With additional soil moisture and nitrogen available to the crop, yield general increases in a linear trend to a maximum based on the genetic potential of the variety.

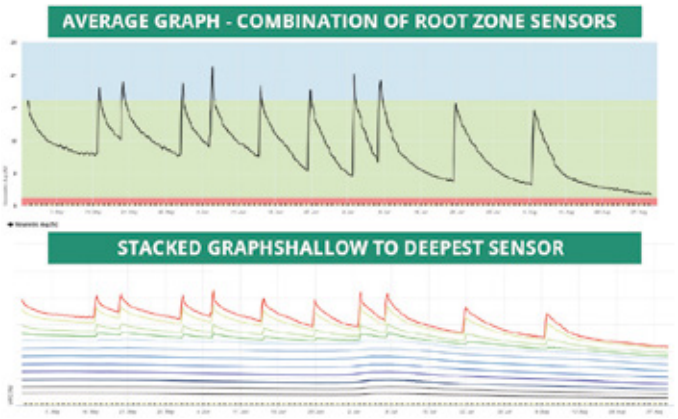
MEASURE » MONITOR » MANAGE



IoT SOLUTION:

Infield iMETOS 300 weather and iMETOS ECO D3 soil moisture station(s) with iMETOS DDT soil moisture probes with field specific stations

- With field specific stations and soil moisture probes, know real-time root zone soil moisture levels.
- Improve yields based on applying the right amount of nitrogen for root zone soil moisture levels.
- Time additional fertiliser applications based on growth stage and in-field root zone soil moisture levels.
- Track individual soil moisture values for each sensor depth or the average root zone soil moisture based on the active root zone.
- Set soil specific full and refill points for the active root zone (green zone in graph on the right).
- Know the volumetric water content of each sensor and the root zone.



Cost Benefits:

Root zone soil moisture is the CROPS GAS GAUGE for yield potential

Three examples:

1. The grower purchased weather and soil moisture solutions and decided the season was too dry for late season Nitrogen based on accurate root zone soil moisture and rainfall data (good decision based on weather information). Saved $90,000 in nitrogen costs and returned about $513,000 on 1,000 hectares
2. The grower didn't purchase any weather or soil moisture solutions and went on gut feel and added extra Nitrogen late season and didn't have enough subsoil moisture (poor decision which was mostly yield limiting). Extra $90,000 in nitrogen costs and returned about $503,000 on 1,000 hectares.
3. The grower purchased weather and soil moisture solutions and the season was favorable based on rainfall data and root zone soil moisture data so decided to apply late season Nitrogen (yield increased markedly). Extra $90,000 in nitrogen costs, but returned about $930,000 on 1,000 hectares.

Voice of the Grower

Targeting nitrogen fertiliser based on knowing the active root zone soil moisture in dry and wet years has earn my farm more dollars per hectare than over the traditional method of a gut feel estimate. We spent about $12,200 on our three Pessl IoT soil moisture solutions and earn money even in dry years by saving fertilser costs, but in wet years maximized the return per hectare by over $440 by targeting the right amount of fertilser. Our return on investment range from breaking even in dry years to over 30:1 in wet years.

CROP: Soybeans, Midwest USA

AGRONOMIC ISSUE:

***Sclerotinia* Stem Rot**

- The fungus *Sclerotinia sclerotiorum*, which occurs in most to all the soybean, canola, and dry beans growing areas of USA and the Canada, causes stem rot of soybeans, canola and dry beans. The severity of sclerotinia stem rot can vary from year to year, region-to-region and even from field to field, with localized weather playing a significant role in its development.
- The incidence of *Sclerotinia* has intensified as soybean production has increased, which is due to more acres of soybean and other effected crops in rotations and management practices that increase yields, such as dense canopies, which produce better microclimate for disease development.
- Numerous studies in the Midwest have documented significant yield losses on soybeans with sclerotinia stem root, so much so, that in high disease pressure regions spraying is common.

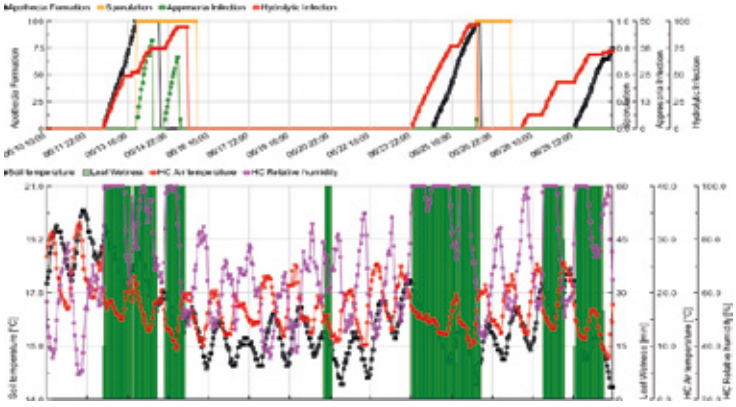
IoT SOLUTION:

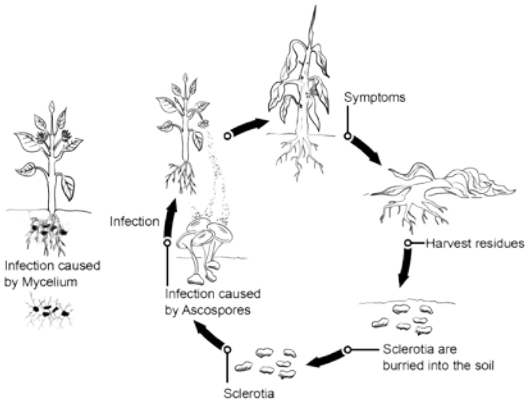
Infield iMETOS 300 weather or ECO D3 disease management station and sclerotinia disease model by Pessl Instruments

- With field specific weather solutions, know the modeled conditions for apothecia formation, sporulation, and sclerotinia risk.
- Time fungicide applications based on growth stage and disease risk/pressure.
- Preserve yield and grades based on well-timed fungicide applications.


iMETOS® 3.3


iMETOS® ECO D3





- Apothecia formation and sporulation takes place if a rain of more than 0.31" is followed by a period of high relative humidity lasting longer than 20 hours at optimum temperature of 70°F to 79°F.
- Direct Infection by Apothecia can be expected after a leaf wetness period followed by 16 hours of relative humidity higher than 90% under optimum 70°F to 79°F ("appressoria infection").

Cost Benefits:

Disease incidence is defined as the number of plants that have symptoms of white mold (sclerotinia) divided by the total number of plants assessed. If 100 plants are examined and 45 had symptoms, then the incidence is 45 percent. Every 10% increase in the disease incidence at the R7 soybean growth stage, results in a yield reduction of about 2 to 5 bu/acre.

- The estimated percent yield loss can be used to estimate the bushel loss due to sclerotinia infection if not treated using the following formula. If this value is lower than the cost of a fungicide application/acre, then a fungicide application is not recommended.

  Yield Loss/acre = Potential Yield Loss * $/bu

- Cost of fungicide application $25/acre, $9 bu soybean and yield of 40 bu/acre:

  So 20% incidence = 4 to 10 bu/acre yield loss:

  Yield Loss/acre/dollars = Potential yield Loss * $/Bu

  Yield loss/acre/dollars = 7 bu/acre * $9 = $63

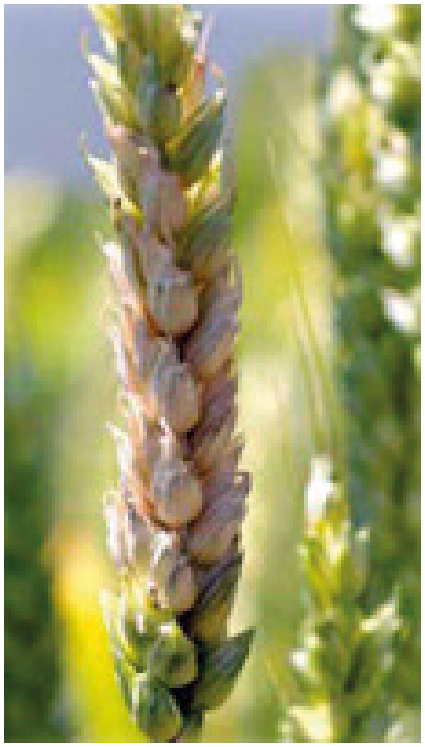
- On 1,000 acres, that's $63,000 lost in gross income. With an application cost of $25 acre, the cost is $25,000.
- Potential gross income benefit with spraying = $63 - $25 = $38/acre and on 1,000 acres = $38,000.

Voice of the Grower

Sclerotinia stem rot robes my farm of yield, so much so, I have lost $45 acre on a 50 bushel crop for my 1,000 acres. I've had to change my management practices and use IoT solutions from Pessl to get a better handle on the environmental conditions for sclerotinia disease risk so as to time fungicide applications at the critical reproductive stages. The IoT solutions cost my farm $6,000 a year, which translate into more than 6:1 return on investment.

CROP: Spring and winter wheat

AGRONOMIC ISSUE:
Fusarium Head Blight



- Is a fungal disease that effects cereals crops such as wheat and barley but also impacts corn and oats
- The main species that causes the greatest concern is Fusarium graminearum. This species produces significant economic damage from both grade and yield losses, but with most significant loss through downgrading. It also produces toxins that are harmful to humans and animals
- Numerous studies in Western Canada have documented significant grade and some yield losses on CWRS

MEASURE » MONITOR » MANAGE

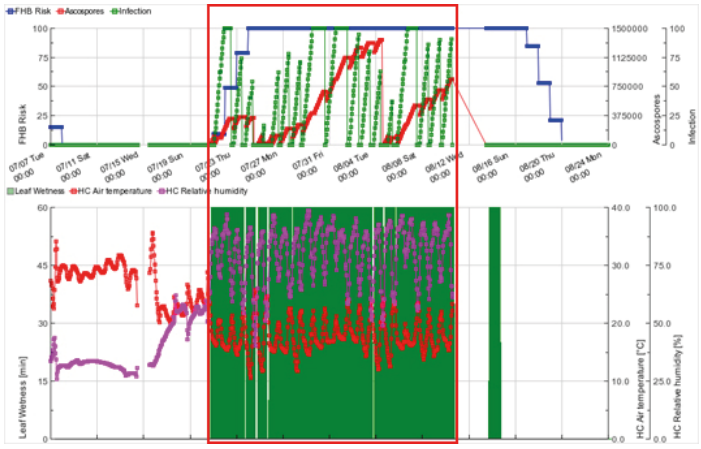
IoT SOLUTION:

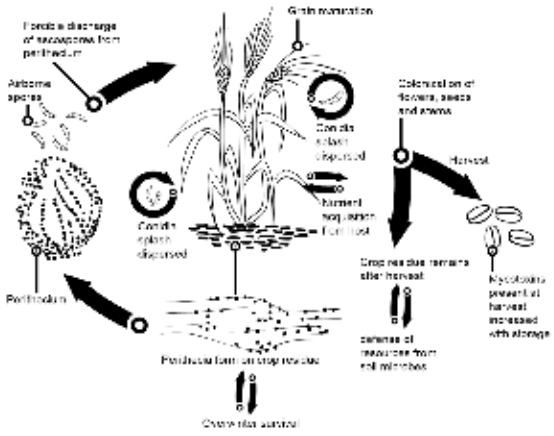
Infield iMETOS 300 weather or ECO D3 disease management station and fusarium disease model by Pessl Instruments.

- With field specific weather solutions, know the modeled conditions for spore infection, mycotoxins and FHB Risk.
- Time fungicide applications based on growth stage and disease risk/pressure.
- Preserve grades and yield based on well-timed fungicide applications.


iMETOS® 3.3


iMETOS® ECO D3





- Fusarium Head Blight Risk model points out risky time periods for an infection. Whenever 100% infection (green line) is reached the risk (blue line) is very high and conditions for the fungus have been favourable for infection.
- Fungicide application (curative, preventive) should take place during the risky time period shown by the blue line.

Cost Benefits:

Fusarium head blight is an extremely destructive disease on grade and yield, but more so on grade.

- Damage from fusarium head blight is quantified by the number of Fusarium Damaged Kernels (FDK) in a sample measured on the percentage of weight.
- Tolerance levels for #1 is <0.25%, #2 <1.0%, #3 <2.0% and feed <5 % of FDK in the sample by weight.
- There has been documented a small decrease in yield, but the main economic impact has been lower grade.

Example

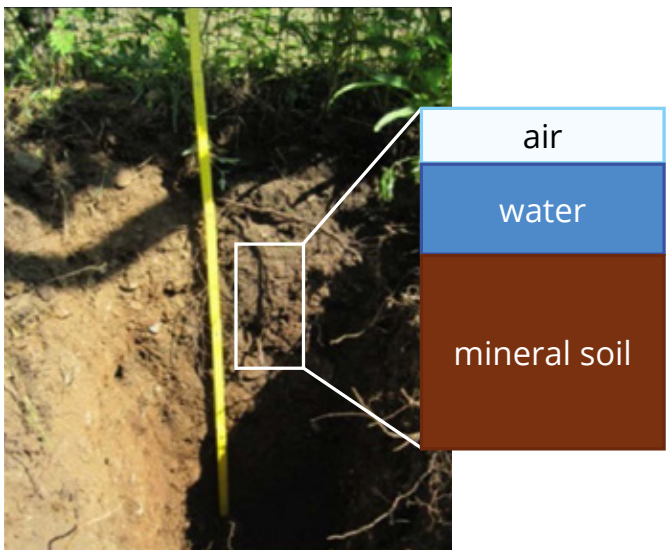
With disease severity levels varying between 0.5%, 1.2% and 2.2% , downgrading of Canadian Western Red Spring (CWRS) from #1 to #2 or #1 to #3 or #1 to feed on a 55 bushel acre crop has resulted in **$12, $35 and $100 of lost farm income per acre**.

Voice of the Grower

Fusarium head blight robes my farm of grade and yield, so much so, I have lost $45 acre on a 50 bushel crop for my 1,000 acres. I've had to change my management practices and use IoT solutions from Pessl to get a better handle on the envi-ronmental conditions for FHB disease risk so as to time fungicide ap-plications. The IoT solutions cost my farm $3,000 a year, which trans-late into more than 10:1 return on investment.

AGRONOMIC ISSUE:
Fall Soil Moisture Levels

- Fall soil moisture levels are the CROPS GAS TANK for next year's production on the Northern Great Plains
- Soil water serves as a solvent and carrier of food nutrients for plant growth. The yield of a crop is more often determined by the amount of water available rather than the deficiency of other food nutrients. Soil water acts as a nutrient for photosynthesis.
- Therefore, of all the parameters that effect crop production, water or soil moisture has the biggest impact on crop yield. So it's extremely important to measure and monitor fall soil moisture levels to plan for next year's crop



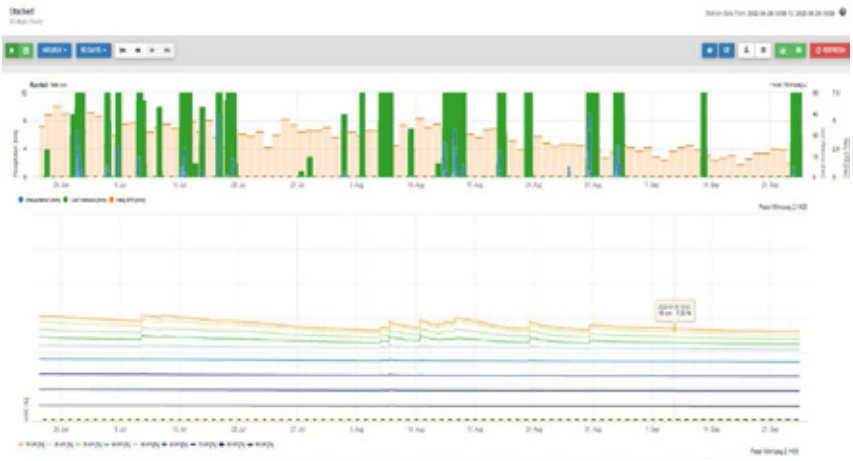
- Each inch of soil moisture or water used roughly equates to 5.5 bu of canola, 7.5 bu of wheat and 10 to 11 bu of corn yield, so knowing actual fall soil moisture amounts allows preplanning on next years fertility requirements for targeted yields
- Knowing the spatial variability of soils and fall moisture levels is crucial for understanding trafficability and compaction, which also impacts both yield and operational costs

IoT SOLUTION:

In-field µMETOS Soil or iMETOS ECO D3 station(s) with iMETOS DDT soil moisture probes and Work Planning Tools

- **See the root profile** - with field specific stations and soil moisture probes, know real-time soil moisture levels every 10 cm (4 inches)
- Plan fall fertilizer applications based on in-field soil moisture levels and temperature
- Improve yields based on applying the right amount of nitrogen for actual field level soil moisture values
- Track individual soil moisture values for each sensor depth or the average profile soil moisture based on the root zone
- Use site specific forecast and work planning tools for tillage and field accessibility (hourly updated)

µMETOS SOIL



iMETOS ECO DDT PROBE

Cost Benefits:

Fall soil moisture is the CROPS GAS TANK for next years yield

Three case examples:

1. The grower purchased weather and soil moisture solutions and decided the fall soil moisture levels were too dry (4 inches of stored water) for a full application of nitrogen based on accurate profile soil moisture and rainfall data (Good decision based on weather information). Saved in nitrogen costs (product and application). Wait to see if spring moisture conditions.
2. The grower didn't purchase any weather or soil moisture solutions and went on gut feel and added a full application of nitrogen, but didn't have enough subsoil moisture (4 inches of stored water, poor decision based on current soil moisture levels). Extra nitrogen costs (product and application). Wait to see if spring moisture improves.
3. The grower purchased weather and soil moisture solutions and the fall soil moisture levels were favorable based on rainfall data and profile soil moisture data (8 inches of stored water) so decided to apply full application of nitrogen (Higher yield potential next year). Extra nitrogen costs, but has a higher yield potential due to the additional 4 inches of water 1,000.

Voice of the Grower

Applying fall nitrogen fertilizer based on actual measured field soil moisture levels in dry and wet years has earned my farm more dollars per acre than over the traditional method of a gut feel estimate.

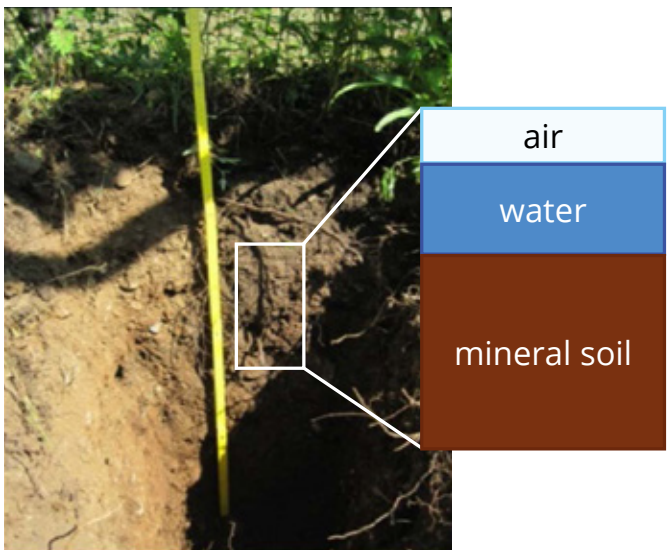
We spent about $6,000 on our three Pessl Instruments IoT soil moisture solutions and earn money even in dry years by saving fertilizer and application costs, but in wet years maximized the return by increasing our chances of increase yields in the next growing season

Our return on investment range from breaking even in dry years to over 10:1 in wet years.

SOILS: All soils

AGRONOMIC ISSUE:
Soil Trafficability & Compaction

- Knowing the spatial variability of soils and moisture levels is crucial for understanding trafficability and compaction, which impact both yield and operational costs.
- Two main factors determine the rates of compaction and traction: the physical strengths of the soil are determined by texture and bulk density and don't change over short periods of time. Clay soils with a higher bulk density resist higher pressure, before undergoing compaction. These soil characteristics define the spatial or geographic field variations of compaction and traction.



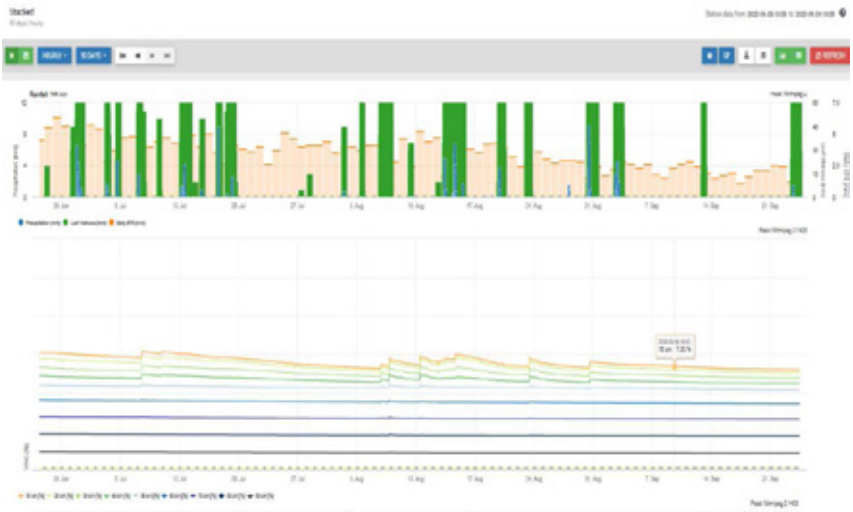
- A very important external and temporal factor effecting grain to grain strength of soil is soil moisture. As soil moisture increases the strength of the soil decreases, which then influences trafficability and compaction.
- Other factors that control trafficability and compaction are based on tractor options. Soil–vehicle interaction focus on the influence of types of traction (tires, track), tire inflation pressure, wheel and axle load on soil deformation and slippage.

IoT SOLUTION:

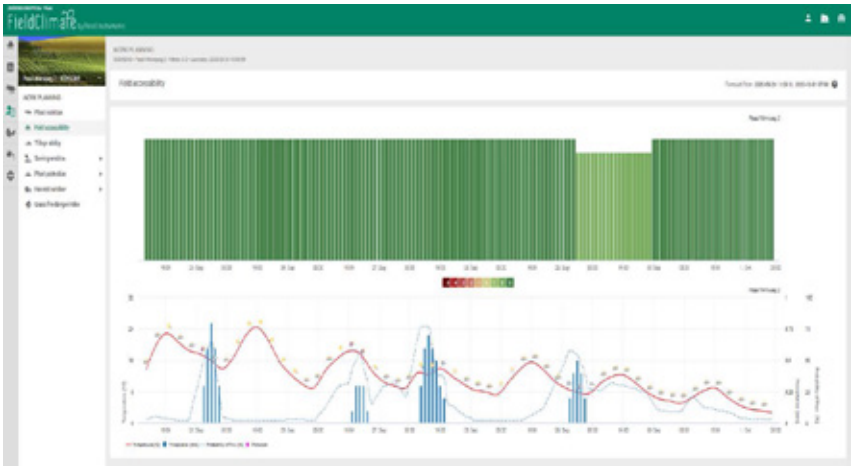
In-field µMETOS SOIL or iMETOS ECO D3 station(s) with iMETOS DDT soil moisture probes and Work Planning Tools

- **See the whole soil profile**—with field specific stations and soil moisture probes, know real-time soil moisture levels every 10 cm (4 inches) for field work conditions
- Know the volumetric water content of each sensor for soil compaction and trafficability
- Use **site specific forecast** and **work planning tools** for tillage and field accessibility (Hourly updated)

iMETOS ECO D3



µMETOS SOIL



Cost Benefits:

Soil compaction and trafficability losses and costs

Compaction and field trafficability impacts on soil are well know, but are one of the most poorly look at factors for yield loss and higher operational costs. Recent studies have shown that the impact on yield can vary widely based on soil type, type of tires and of course soil moisture content. For corn and soybeans on the northern great plains this translates into on average 20% yield loss for not one but two years. The values vary greatly from location to location or different soils, but generally 10% to 50% yield losses have been reported. When looking at the operational impact for deep tillage to improve soil structure, the cost varies between $7 to $17 per acre.

The summary:

- a 20% yield loss on 200 acres of effected corn or soybeans soils is a significant amount of lost income. For corn, using the following assumptions $3.15 corn, 165 bu/acre yield, this translate into 165*20%*$3.15*200 acres =$20,790 in lost income. For soybeans, using the following assumptions $8.00 soybean, 42 bu/acre yield, this trans-lates into 42*20%*$8.00*200 acres = $13,440 in lost income.

The economic loss from deep tillage operations to improve soil structure on 200 acres would range from $1,700 to $3,400. When combined, yield loss and operational costs ranges from $15,140 to $24,190 on 200 acres of corn or soy-bean.

Voice of the Grower

We use a full weather station with a site specific forecast and work planning tools for field accessibility and tillage along with two soil moisture stations with 90 cm or 3 foot probes to determine the risk for compaction and trafficability. On our 1,000 acre farm this costs us $6,000 a year, but has returned us a high ROI in wet years and break even in dry years. When we combine the soil compaction solution with the other IoT solutions we use - disease forecasts, fertility, spraying, etc., the ROI is even higher each year. Holistic solutions for the entire crop year.

AGRONOMIC ISSUE:

SNOW - Pro's and Con's

- Snow is a two edged sword, at the right time it has tremendous benefits, but at the wrong time and amount it can cause significant management issues.
- Another important fact to note, is that all snow is not created equal. Most people use the 10:1 rule, that is 10 cm of snow equals 1 cm of liquid water, but this is just not the case. We can have very wet snow, with an extremely high water content, or very dry snow, that is light and fluffy, which is loved for skiing. This impacts the value of the commodity in different situations.
- **Snow Benefits:** Each inch of snow acts as an insulating blanket, protecting fall seeded crops from winterkill, which stops frost penetration into the soil and protects the soil from erosion. On the other hand, when there is little snow, frost penetration into soil is deep helping reduce soil compaction.

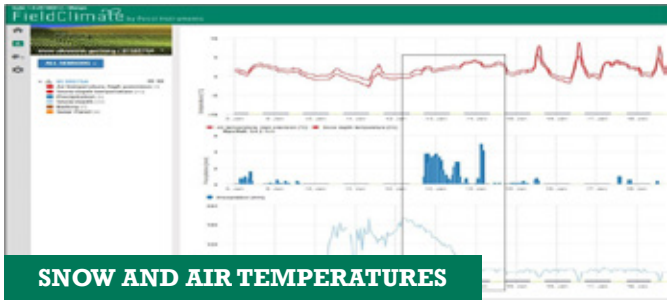
- **Snow Benefits:** Light fluffy snow has little in the way of snow equivalent water, while heavy wet snow can add significant moisture to the soil, improving yield potential. The lack of snow can also aid in reducing insect populations, allowing cold temperatures to penetrates deeply. Snow can also trap nitrogen, nitrate and ammonium from the atmosphere, free of charge, although amounts are not large.
- **Snow Risks:** Obviously snow can delay harvest operations, reduce quality and grade of crops. The lack of snow can cause deep frost penetration into soils, which can freeze soils and reduce infiltration in the early spring and cause winter kill in fall seeded crops or forages. Early snow in the season can be lost due to sublimation over the winter, meaning less water infiltrating the soil. Lack of snowmelt in the spring can cause shortages in dugouts and seed bed moisture for germination. Heavy snow and cold temperatures can also increase livestock feeding requirements.

IoT SOLUTION:

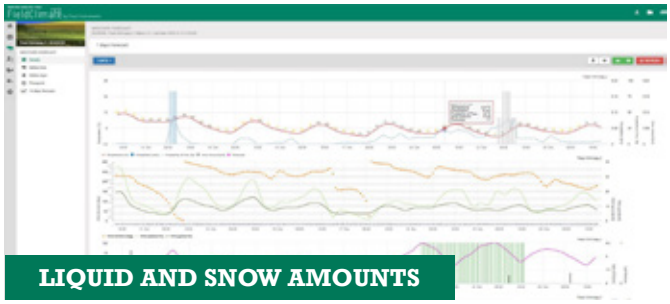
In-field iMETOS ECO D3 station with Ultrasonic Snow Height Sensor and Site Specific Weather Forecast

- Track snow depth on the field with the ultrasonic snow height senor and combine with a rain bucket to capture both liquid and frozen precipitation
- Know the air and snow temperatures for freezing and thawing periods (graph below)
- Use site specific forecast for both liquid and snow amounts and probabilities (Hourly updated) (second graph) for work planning

iMETOS ECO D3 ULTRASONIC SNOW



SNOW AND AIR TEMPERATURES



LIQUID AND SNOW AMOUNTS

Cost Benefits:
Not all SNOW is created equal

As discussed snow can have both benefits and risk to agricultural production: too little snow and the concern for fall seed or perennial crops is winterkill. The lack of snow amount is also a concern for recharge in the spring of both dugouts and seedbed moisture. Overall, soil moisture is the crops gas tank and knowing total soil moisture allows for selection of crops and fertility plans.

The timing and amount water held in the snow can really hamper or enhance on-farm production. Late season, heavy snow can significantly delay field operations in spring. With a late season, high water content snowfall, field operations can be delayed 7 to 14 days. The water held in this type of snow is not the 10 to 1 ratio, but more in the range of 3 to 5:1 (3 or 5 cm of snow to 1 cm of liquid water), which can dramatically improve seed bed and subsurface soil moisture if the soils thawed. For livestock, heavy snow and cold temperatures drive up food rations and put further pressure on the calving season.

What does all this mean: Even though the bulk of farm operations have slowed during the winter, the importance of snow for agronomic and animal welfare remains very important. Lack of snow cover can result in major winterkill and poor meltwater for spring soil moisture recharge, which reduces the potential for income. Heavy snow can adversely impact livestock and calving season, while the snowmelt is welcome for spring soil moisture and improved yield potential. This can translate into thousands of dollars of lost or improved income on a farm today.

Voice of the Grower

Knowing snow cover and the total water balance on my farm has allowed us to select our crops and plan fertility options.

We spent about $7,000 on our three METOS IoT snow solutions and earn money even in dry Winters by saving fertilizer and application costs on winterkilled crops, but in snowy years maximized the return by increasing our chances of increase yields based on knowing the total water balance on the farm.

Our return on investment range from breaking even in dry years to over 6:1 in wet years.

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