Dynamax Inc
10808 Fallstone, Suite 350
Houston, TX 77099
Tel. 281-564-5100

Dynamax

INSTALLATION OF SAP FLOW SENSOR ON MAIZE PLANTS

Over the last 3 years a considerable effort has been implemented to upgrade the corn sap flow installation. There are new SGEX sensors which make the installation on corn very efficient, to minimize and completely reduce adventitious roots. The ability to install and leave stems without maintenance can be increased from 2 weeks to 4 to 6 weeks, depending on the growth stage. Previously researchers applied the SGB and the SGC sensors to corn, and were damaged due to the squeeze on the sensors, and due to other moisture from the stem. Both adventitious roots and damage from the "squeeze" on the sensor is eliminated by going with the more flexible SGEX sensors.

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1 Preparation

1.1 The bottom two leaves should be removed form the stem leaving three segments with no leave between the three nodes. The sensor installation will be between the 2 and 3 node. The bottom 2 leaves will die out anyway, will not be a significant part of any transpiration, and they can clearly cause an interference of the sap flow sensor heat balance.

1.2 The objective is to have a clear stem, a) so that the thermocouples and heater will fit securely and enclose the securely to the stem; b) and to leave as much distance from the ground to the sap flow sensor.

1.3 Measure the stem and record the diameter size selection on the 2-3 node. The stem is oval shaped usually, so measure twice and take the average. If you wish the circumference may be measures, and the diameter estimated. Many well watered stems will be 19 mm diameter, up to 25 mm dimeter when fully grown.

1.4 Test by applying the sap flow sensor on the section of stem. The heater strip overlaps from 145% (at the most) around the circumference of the stem, or less. If the heater wraps too much it may buckle or crimp and a lower sized stem sensor need to be selected. If the heater does not wrap 100 % around the circumference of the stem and overlaps a bit, then the sensor is too small. You will need to go to the next higher sensor diameter.

Parts and Tools:

Caliper in metric (Or flexible measuring tape)

Scissors

Tape—office clear magic tape (1/2 in to 3/4 in. (13-19 mm))

Zip Tie Wraps— Some 12 " or 18 " to wrap the Reflectrix (aluminum bubble heat shield), and

Some 6 " tie wraps

Wrapping tape—2 inch packaging tape or flexible rubber tape.

Flexible electrical tape or stretch 1/2 or 3/4 in tape (13-19 mm)

G4 Grease (silicone electrical compound)

1.5 The trial fit of the sensor, showing that the Stretch Velcro starts at the middle. You will need to cut the stretch Velcro in half to do this. This is a trial fit ONLY. If the stem gage fits, remove it and proceed to the next step. After a few trials you can just check the fit very quickly.

2.0 Install "Food Wrap" stretchable plastic sheet (Saran Wrap).

2.0 Take a piece of food wrap, cut to the size of space between the two nodes #2 and # 3. The plastic wrap will prevent moisture from entering the stem section, and easily corrode the sensor or cause roots to grow. Roots will damage the sensor, and puncture the heater, or cause electronics to fail. The plastic wrap will be taped to the stem underneath the 3rd node, and above the 2nd node.

2.1 As shown DO NOT WRAP THE third node, as the moisture will cause the roots to grow out and damage sensors. Wrap only the purple marked part of the stem.

2.2 Stretchable food wrap is usually .25 X 10 –3 in. (.00025 in) will have insignificant delay in heat transfer of conduction.

3.0 Install sensor

3.1 Install G4 (electrical silicone compound) on the heater on the sensor and around the thermocouples. This will prevent sticking and corrosion. (Usualy 1/2 to 1 g)

Place the sensor onto the stem, about 1", (25 mm) below the 3rd node; and make sure the free end of the heater is wrapped underneath the opposite end of the sensor. Make sure that you do not crimp or fold the heater strip (and severe folding may be damage the heater and loose continuity).

3.2 Cut the Velcro Stretchable attachment (loop) into two pieces, and start by wrapping from the affixing hook strip around the heater, in the middle of the stem gage, and spiral clockwise upwards as you wrap around the stem. Only stretch the Velcro 25 % (pull hard to estimate 100 % first), then only stretch a little, since we want the plant to grow and not interfere with growth or constrict the stem.

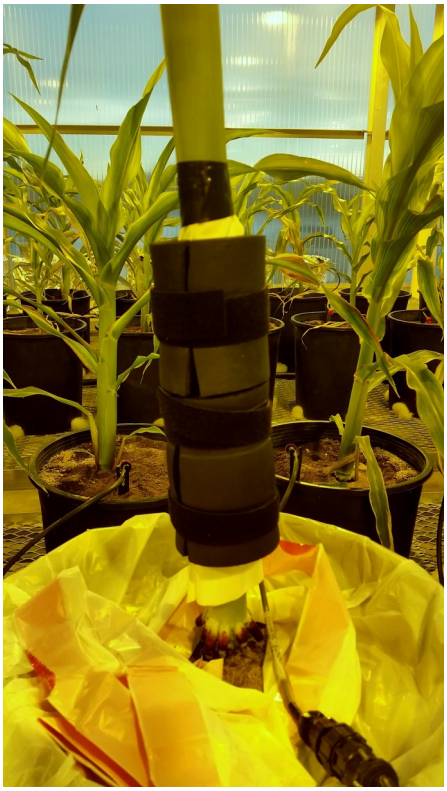
Trim any excess Velcro at the top to the stem wrap.

Start at the middle, and wrap the bottom part in the same direction, clockwise, as the top. The sensor will **not move** very easily with a twisting motion.

4.0 Install Goretex (moisture micro-pore barrier)

4.1 A white moisture barrier shield is wrapped around the sap flow gage, and is taped on the top of the stem and once above the second node. Liquid Water will not penetrate the moisture barrier, however any water vapor from the stem will pass through the barrier and be evaporated or excluded from the sensor affixing section.

4.2 Goretex may be left open at the bottom, to allow any moisture drop to shed below to the ground.



5.0 Install Insulation

4.1 Add at least the two insulation shields to prevent rapid temperature changes to the stem test section. There are three provided with each sap flow sensors.

4.2 The bottom insulation is left off to allow the sap temperature to stabilize .

6.0 Install Heat Shield

6.1 Trim and wrap the reflector bubble shield at least 1.5 times around the insulation, and leave the bottom open.

6.2 Put tie wrap at the top, to make sure the heat shields secure. Please do not secure too tightly to restrict growth.

6.3 Wrap elastic tape or packing tape around the top layer of the stem, to ensure there will be no water or irrigation running into the plant—sap flow sensor junction. Any minimal leakage will be shed by the water micro pore protections.

7.0 Install and secure water protection on connector

7.1 Please secure the connection to a nearby plant, or stake that secures the cable to a wire-tie and prevents an accident from pulling on the connection.

7.1 As the connection is low to the ground, please verify the connector has a grey ring inside the male part, and that both the male has at least 1 g of G4 Electrical grease inside the connection to protect the contacts, and prevent moisture.

7.3 For longer exposure in very wet conditions, wrap an electric tape around the connector or in severe cases, you will need to wrap a rescue tape and layers of electrical tape.to secure the connector from flooding. The MEC connectors are reliable and rated for splash protections, thus if flooding or swamping over 30 minutes is expected, please refer to ftp.dynamax.com/sapip-support/Weather-Proofing-Connectors.pdf

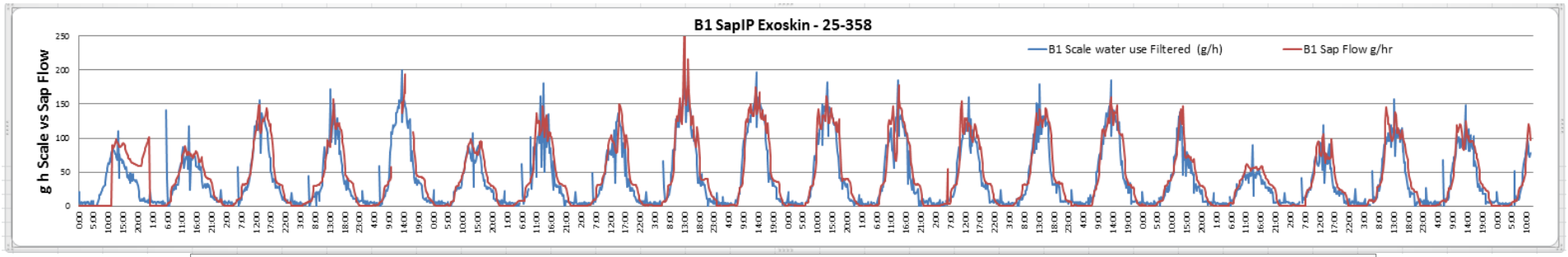
8.0 Conditions with Exo-Skin sealing method compared to Dynagage Sap Flow sensor.

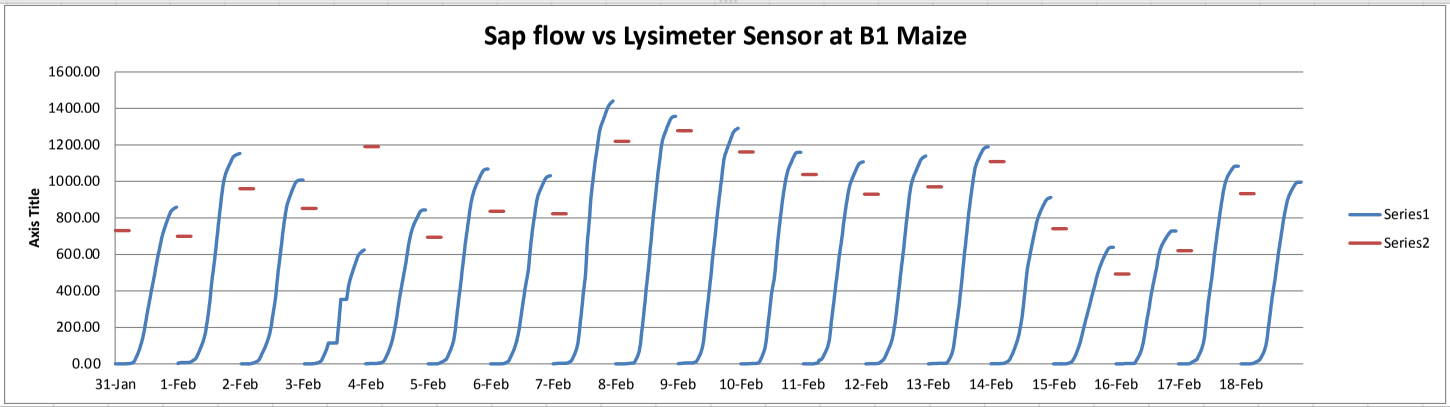
During the consultation and testing with USDA in Ft Collins, Dr. Louise Comas, and with USDA in Bushland TX, Judy Tolk, we were able to confirm various aspects of the performance. The results were able to determine that the sap flow sensors, when applied at this protocol were very accurate, and sap sensors can last in the filed for 4 to 5 weeks without damage or interruption of data set. Continuous operation of the data set was due to exclusion of moisture, and maintenance of the sensors.

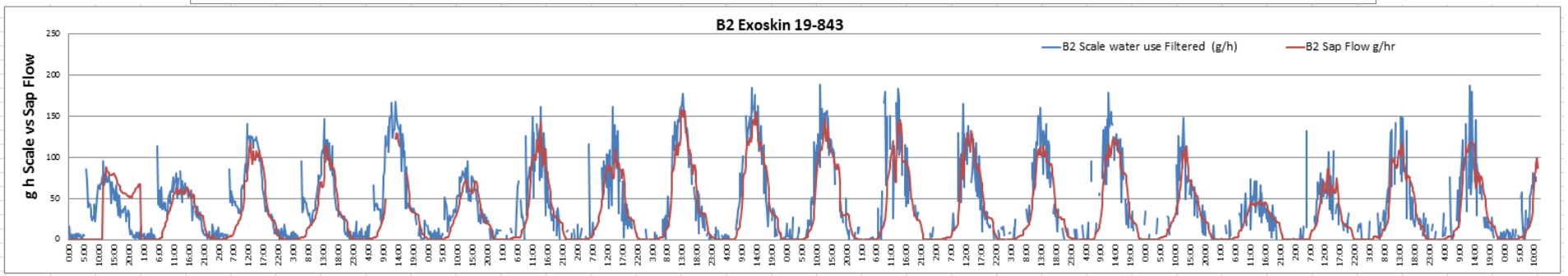
USDA in Ft Collins provided the data set on 5 Exo Skin sensors, and compared to six Dynagage sensor using a foil wrap around only the "Dynagage SGC" version of installation. In this condition the Dynagage did not have a micro-pore barrier (Gore-Tex), the insulation was not applied (only the sensor insulation), and aluminum foil was substituted for the Aluminized bubble shield. The testing in the greenhouse from Jan 30 to Feb 18, 2015, showed that the Dynagage had water collection after 4 to 5 days, and could interfere with heat distribution or shorting out the thermocouples inside the sensors.

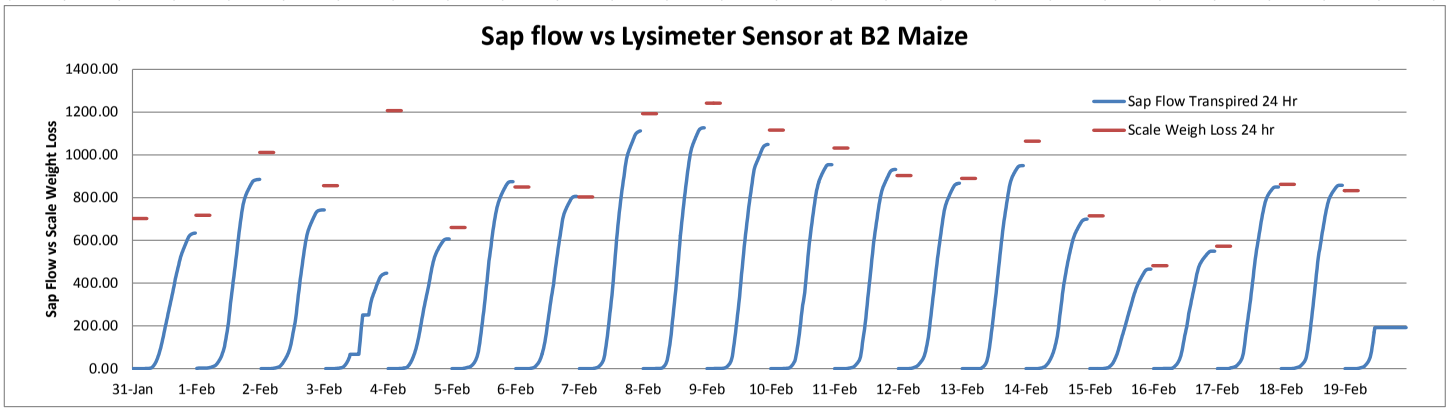
On the next page are the results of three of the Exo-skin sensors, over a three week test. One day Jan 30 is the "Ksh" setting day, and thus is excluded. All the results are downloaded exactly as the SAPIP recorded, and uploaded signals into the Agrisensors.net web site. There were no recalculation of the data set, only the typical Agrisensors.NET heat balance equations were then downloaded for each 15 minutes. That process allowed the data to be combined with the scale data very simply. The scale data reported its approximately 5 minute data, but did not always have a scheduled reporting interval. The lysimeter scale is also affected by the irrigated watering interval from 5 am to 6:30 when the drained excess water was complete and thus the scale data is excluded from the data set. The lysimeter is also affected by fans putting wind pressure on the leaves, and thus there are plenty of "noise" in the quarter hourly comparison. At the end of the day, the most important detail is the daily loss comparing the two methods. On the average there is very little difference, some sensors read a bit higher, and some are lower within 100 g / day than the scale. Note that on Feb 3, all the sensors were shut down for maintenance.

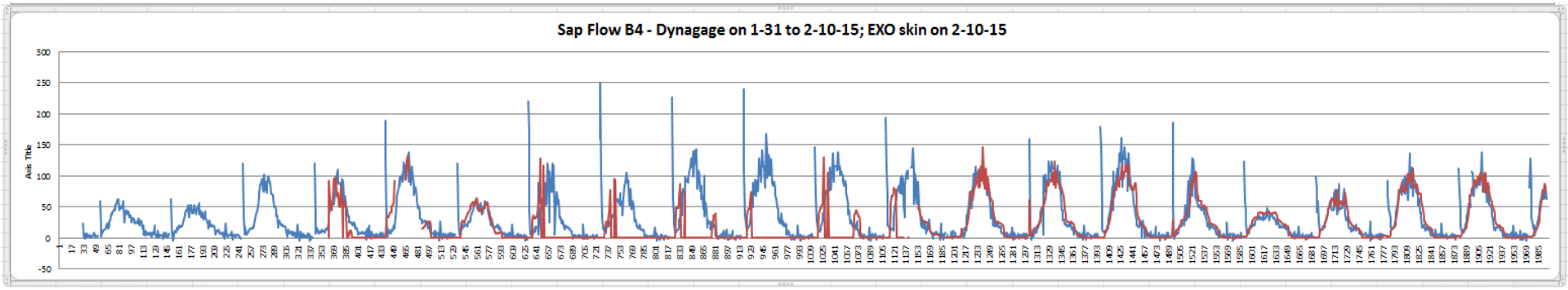
Overall the Exo Skin data was within +/- 10 % range of the scale data set.

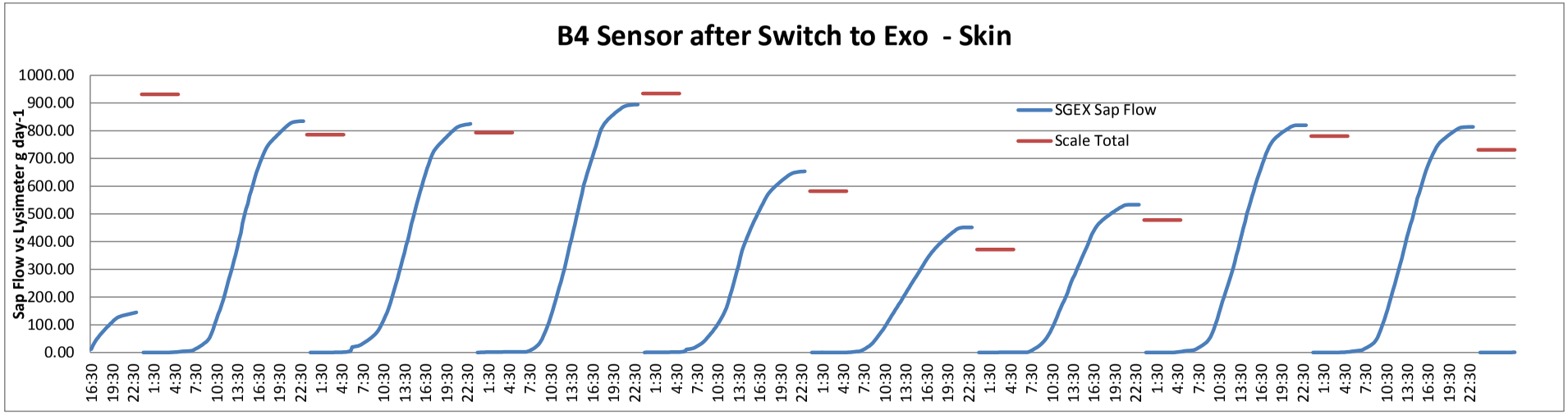

B1 SapIP Exoskin - 25-358
g h Scale vs Sap Flow
B1 Scale water use Filtered (g/h)
B1 Sap Flow g/hr


Sap flow vs Lysimeter Sensor at B1 Maize
Axis Title
Series1
Series2


B2 Exoskin 19-843
g h Scale vs Sap Flow
B2 Scale water use Filtered (g/h)
B2 Sap Flow g/hr


Sap flow vs Lysimeter Sensor at B2 Maize
Sap Flow vs Scale Weight Loss
Sap Flow Transpired 24 Hr
Scale Weigh Loss 24 hr


Sap Flow B4 - Dynagage on 1-31 to 2-10-15; EXO skin on 2-10-15
Axis Title


B4 Sensor after Switch to Exo - Skin
Sap Flow vs Lysimeter g day-1
SGEX Sap Flow
Scale Total