**Pocket Sensor Questions**

1. Charging
   1. Will the device charge properly without installing the Hardware - CP2102 USB to UART Bridge Controller?

I connected a sensor, that was completely drained of battery power, to a computer that did not have the driver (CP2102 USB to UART bridge controller). Within a few seconds the sensor began to give readings. Before I connected the sensor, it would not even display numbers when pressed. It appears that you don’t need the driver; however, without the driver you cannot change the calibration coefficients etc. While the battery charges the computer and sensor won’t “talk” to each other.

* + 1. 
  1. The manual states to charge the device every night and it also states to charge the device for 3-4 hours.
     1. Can the device be charged for more than 3-4 hours? If so, how much longer?

If the battery is completely drained, I would recommend charging for 8 hours. In Mexico, when I used the sensors daily, I would charge the sensors 3-4 hours everyday. I didn’t leave the sensors charging all night because the electricity in Mexico seemed to be a bit more variable, and not charging them overnight kept reduced the possibility of surges etc; however, in the United States I think charging overnight and longer is okay.

I’m not sure which sensors you have, but the newer prototypes should have a low battery display.

1. Operating
   1. The manual states not to use the device in “extreme heat or cold.” Can you define extreme heat and extreme cold?

We took readings at 100-104 degrees F, and the data still looked good. I believe that Dr. Raun had some information about using the GreenSeeker on his website and temperature. I didn’t find it, but any variation to temperature is minimal from 32-100. I think that the temperature that the operator can withstand will be more of an factor than what temperature the sensor can operate under.

* 1. **It may be difficult to hold the Pocket Sensor perfectly parallel to the ground when it is above eye level. So, how much are the reading affected if the device is not perfectly level to the sensing area?**

This is a great question. What we observed in corn was that when the canopy was taller than 1 meter (39 inches) that are data became variable. For corn we were measuring 24 inches (60 cm) above the whorl of the corn plant. This meant that there were some leaves that were much closer to the sensor than 60 cm; however, are results were very good. Once we began trying to hold the sensor over 160 cm tall (height of crop canopy + distance above canopy) are data was not as good. For corn, this always allowed us to capture between V10-V12 with no problems. It could be a problem for capturing late season data, but it should allow a nitrogen rate recommendation to be developed. I have included two graphs, one that shows data with readings over 1 meter and the other removing plots that were tall, over 1 meter and tall enough we could not verify the PS orientation from the bubble level. This was from a nitrogen study with 12 different rates so height was affected by plot treatment.

Height will affect readings if you cannot see the level to orient the sensor. However, you should be aware that this is a problem associated with tall plant canopies. Canopies that are smaller, and allow you to maintain the sensor above the canopy and see the level to orient the sensor will not show this effect.

Figure 1. Graph showing all data readings from Exp. 250 C2.

Figure 2. Exp. 250 C2 removing plots that had average whorl height above 1 meter.

* 1. **While holding the pocket sensor 24 to 30 inches above the crop canopy, I understand the target area is circular with a diameter of 6.3 to 7.9 inches. By comparison, the Hand Held GreenSeeker can ‘see’ a 24 inch width 60 inches from the sensor.** 
     1. **How far into the canopy can the Pocket Sensor ‘see’?**

This highlights some of the difference between the Pocket Sensor and GreenSeeker, and also some of the differences associated with costs of the instrument. The PS was designed to measure the same thing as the GS but for less than 10% of the cost of the GreenSeeker. This means that some sacrifices had to be made with respect to parts. Both sensors are active sensors; however, the Pocket Sensor has LED lights for the light source. While the LED allows the sensor to be more affordable, they are not as powerful as the light source on the GreenSeeker and is part of the reason that measurements are taken closer to the plant canopy with the Pocket Sensor. If the PS is used within 24-30 inches of the plant canopy it is capable of obtaining very similar results to the GreenSeeker. At this distance it will “see” the available plant canopy that reflects the light emitted by the sensor. At distances outside this area the PS will either become flooded with light (usually at very close range from the plant canopy) or be washed out and have low readings. The graph below shows how sensor readings and standard deviation change with changing the distance above the canopy. This sensor was calibrated to use at 60 cm. This trend was very common over any NDVI as the sensor height moved away from the calibrate region of 60-70 cm the NDVI value did not reflect the GS value and the standard deviation became more variable.

* + 1. **Can one use the Pocket Sensor to mimic the results of the Hand Held GreenSeeker by taking three reading: one in the middle and one on each side of the row of plants? Total diameter ~18.9 to ~23.7 (6.3 x 3 and 7.9 x 3) inches?**

At the current time, we have had excellent results from just measuring directly over the row of the plants. (I do have some data over wheat planted in beds, where we measured similar to this—row, middle, and row of wheat, the data hasn’t been analyzed.) While I wouldn’t rule this possibility out in the future to refine PS measurements, our current work only taking over the center has been extremely accurate in both wheat and corn.

The key to obtaining these results is knowing the limitations of the sensor and good sensing practice, ie. not covering the LED’s or blocking the lens with your fingers, and maintaining the sensor at a good height and angle. With sensor limitation the PS only collects one data reading every second, thus the graphs below have all been made from taking an average of three readings over the same plot. The GS takes ten readings per second with an area of 60 cm2 per reading for an area of 600 cm2 per second. At 24 inches above the canopy the PS takes one reading per second with an area of 200 cm2 . Thus an average of three readings with the Pocket Sensor compared to one reading with the GreenSeeker is roughly comparing the same area sensed.

Taking an average of three readings with the PS is critical in corn, because of the way the corn plant grows up and is spaced from the next plant. It is likely that when you take a measurement one reading will be in a hole between plants and very low, so by averaging three readings there is a better representation of the entire row that has been sensed. In wheat, I took three readings and the average; however, the canopy is much more closed than corn so it may be possible to only use one reading in wheat. I suspect soybeans may also be similar if the canopy is closed in and uniform.

Figure Experiment Y250C2. Corn nitrogen study.

These results show that the PS is reading very close to the GreenSeeker. While not exactly the same, we would expect this based on factors such as sensors (even two GreenSeekers won’t give the exact same results) as well the reduction in price of the sensor resulting in some loss in precision.

Figure . Nitrogen experiment in wheat. Experiemnt Y 226

1. Transporting
   1. The soybean fields where our soybean samples are located can be many miles apart and a soybean sample may be several hundred paces into a field. Many of these samples are enumerated during the early morning hours when dew may be present on the plants. To protect the device from moisture (and dirt), it will be wrapped in a cloth and placed in a ziplock bag. Additionally, the device - wrapped by cloth in a ziplock bag – will be in a vehicle all day long.
      1. Do you see any issues with the intended packaging, transportation and storage of the device?
         1. For example, can the devise be placed in a car with the windows rolled up parked under the hot summer sun?

I think that sounds really good. In Mexico, I only used a cardboard box which allowed the sensors to be exposed to dust etc. When leaving the sensor in a vehicle, I would just try to leave it out of direct sunlight, not on the dashboard. If the lens or LED gets dirty just use a soft cloth to clean any dirt off. The sensors are fairly durable and should handle normal use of transportation and field use well. I would handle them with care like any other instrument, but I would not be overly concerned that transport or field use would damage them. (Maybe think of it like a large graphing calculator or blackberry cell phone, you wouldn’t handle it extremely rough but not like it was fragile glass)

Remember that both the GreenSeekers and Pocket Sensors are susceptible to dew. The dew will make the readings appear lower than they really are.