Pocket Sensor Evaluation

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Our assessment of the pocket sensor (PS) doesn't deviate much from what was reported by Mariana. There appears to be three concerns with the PSs that we have noticed through using them throughout the winter wheat growing season. First, it does not deliver a 1:1 relationship with the original Greenseeker (GS). Second, there is not a great deal of PS to PS reliability. Lastly, we recently noticed error message issues due to canopy height over sparsely vegetated areas.

Issue #1--1:1 Relationship with the Greenseeker

To test if there was an acceptable relationship between the PS and the GS, we combined all the sensor data which had been collected on winter wheat thus far this growing season. A highly significant relationship was observed between both sensors (Fig. 1). Similar to Mariana's report, we did not observe a 1:1 relationship between the PS and the GS. The slope of the linear regression between the PS and the GS was statistically lower than 1.0 and our intercept was statistically higher than zero. Furthermore, we observed a change in slope with PS NDVI values greater than 0.50 (Table 1). This results in the GS delivering higher NDVI values compared to the PS in situations with more dense and green vegetation. Similar results were also observed in Mariana's data set.

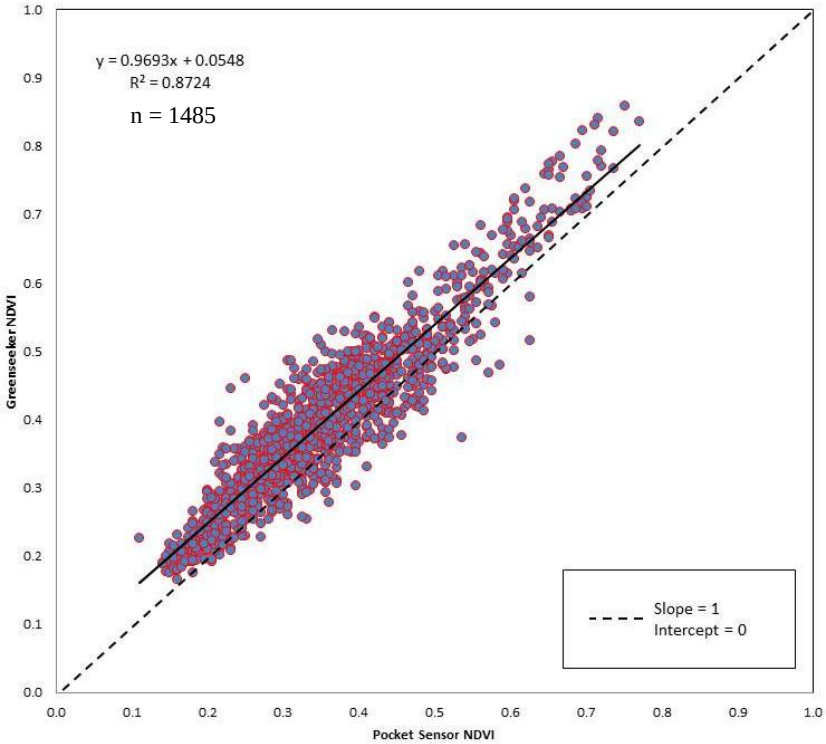

Figure 1. Linear regression of the pocket sensor NDVI values versus Greenseeker NDVI values.

Table 1. Parameters of the linear regression model for pocket sensor and Greenseeker sensor reading relationships and determination of significance for parameter estimates equal to 0 and 1.0 for intercept and slope, respectively.

Sensor Readings	Parameter of the model†		R^2	n	Significance‡	
NDVI	a	b			Slope	Intercept
All	0.05	0.97	0.88	1485	*	*
Greater than 0.50	-0.08	1.21	0.72	160	*	*
Less than 0.50	0.07	0.93	0.78	1325	*	*

† a = intercept, b = slope
‡ Level of significance determined at α=0.05
* Denotes significant differences

Issue #2--Pocket Sensor to Pocket Sensor Reliability

During the field testing process, we began to notice that different PSs were reporting different NDVI values for the same exact plot with approximately the same height and pass above the plot (Fig. 2). To complement the sensor data which was collected from winter wheat, an indoor, controlled assessment was conducted to negate environmental and user error. Sensor data was collected from nine solid colored 1x1 m pieces of fabric with NDVI values ranging from 0.0 to 0.9. Three PSs and a GS sensor were held 0.91 m above the fabric and sensor data was collected for five seconds (Fig. 3). From this point forward this assessment will be referred to as the blanket evaluation. In this assessment, not only were the PSs evaluated against each other, but once again we tested the ability of each PS to predict GS NDVI values.

Figure 2. Pocket sensor to pocket sensor differences.


Figure 3. Technique used during the blanket evaluation.

Highly significant relationships were observed among the three PSs and GS (Fig. 4). When comparing the PS NDVI values to the GS NDVI values, all of the sensors displayed a statistically different slope of 1.0 and an intercept of 0 (Table 2). When each PS was compared to the other two PSs, again significant relationships were observed, however, like the comparison to the GS, no individual PS had a 1:1 relationship with any of the other PSs (Table 2). Stability analysis revealed that when an individual PS was compared to the average of all PSs, only one sensor (PS #7) had a significantly lower slope compared to the other two PSs (Fig. 5).

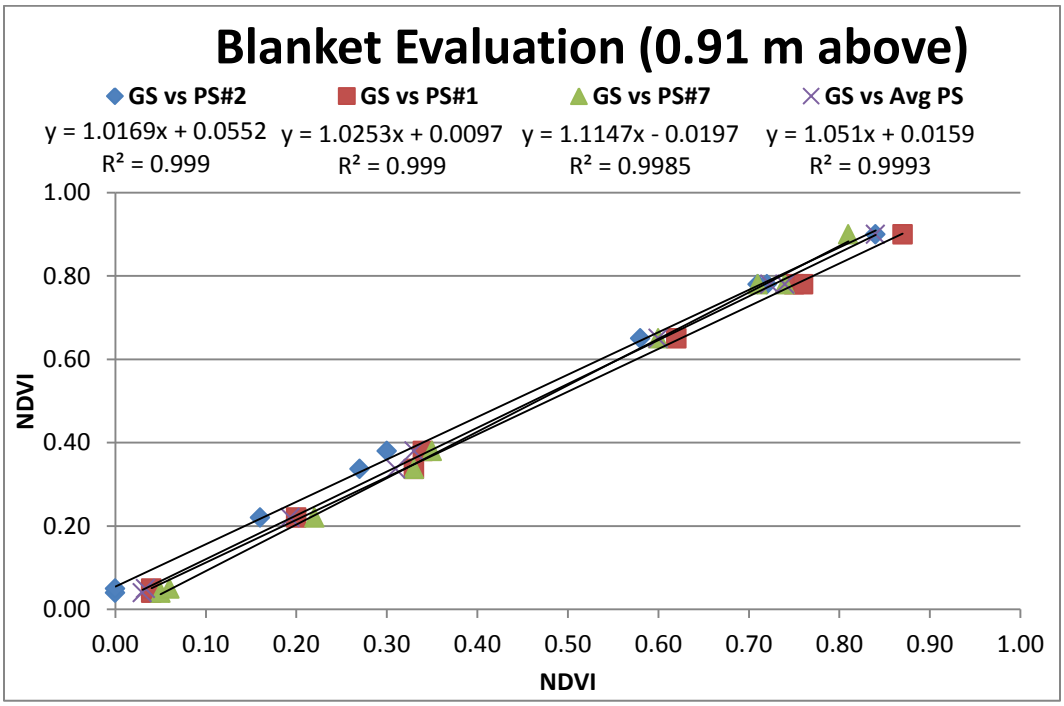

Figure 4. Linear regression from the blanket evaluation for three different pocket sensors (PS) and a Greenseeker sensor (GS).

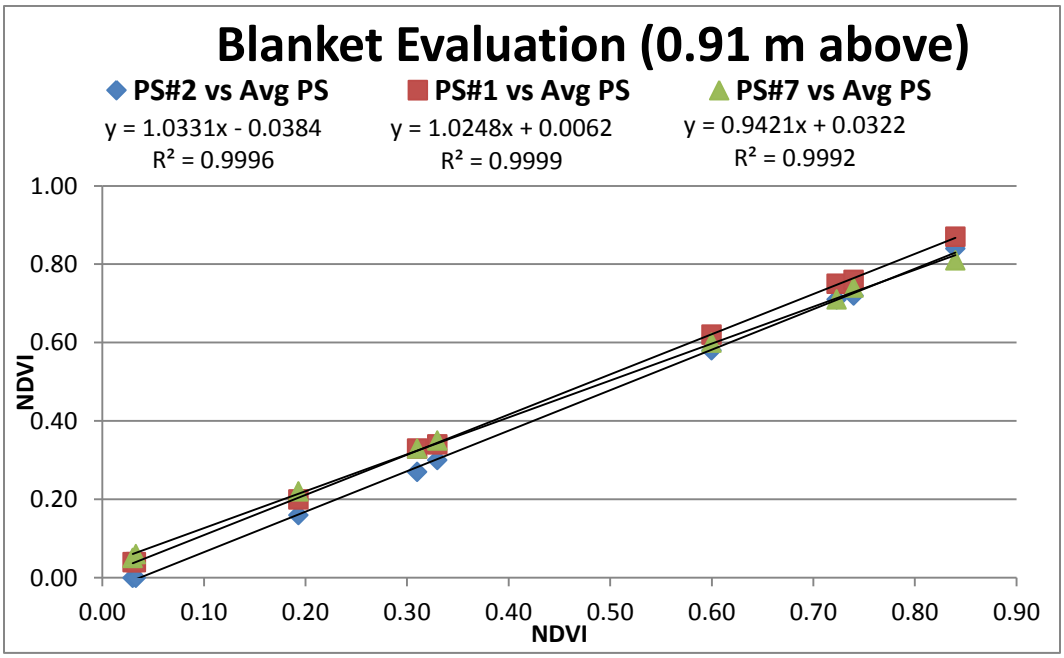

Figure 5. Stability analysis from the blanket evaluation for three different pocket sensors (PS) across nine different fabric colors.

Table 2. Determination of significance for parameter estimates equal to 0 and 1.0 for intercept and slope, respectively when comparing Greenseeker (GS) and pocket sensor (PS) NDVI values.

	GS†		Avg PS		PS#7		PS#1	
	Slope	Intercept	Slope	Intercept	Slope	Intercept	Slope	Intercept
PS#2	ns	*	*	*	*	*	ns	*
PS#1	*	ns	*	*	*	*		
PS#7	*	*	*	*				
Avg PS	*	*						

† Level of significance determined at α=0.05

* Denotes significant differences

Issue #3—Error Messages Associated with Sparse Vegetation

Collecting sensor data from winter wheat which has reached growth stage Feekes 10.5 (heading), has proven to be very difficult using the PSs. The internal error system consistently displays the error far message (E_F) when holding the sensor at the appropriate height (0.6 to 1.0 m). The error message typically goes away when the PS is moved closer to the crop canopy (~0.2 m). However, as the operator proceeds to sense along the plot, the error message will intermittently appear. We have noticed this issue to be more prevalent in winter wheat with sparse vegetation and little tillering. It is unknown how these error messages affect and average NDVI value for a particular plot. We have not investigated this issue thoroughly in corn, but presumably will become an issue as the corn plants increase in size.

Conclusion

If the PS is unable to deliver a 1:1 relationship with the GS, a new algorithm will need to be developed. Also, each sensor appears to be slightly different. The biggest issue is without reliability between sensors, the development of an algorithm is a minute problem. From one PS to the next, NDVI has been observed to be 0.06 different in a controlled environment and as much as 0.1 in field conditions.