Crop Scouting Using Aerial Imagery in Delaware Soybean Fields

Jarrod O. Miller, Mark VanGessel and Bill Cissel.
University of Delaware Extension

Final Report

Introduction and Objectives

Drones are the latest technology to be hailed as the future of precision agriculture, but their practical use still needs to be explored. For soybean production, drones have been used to estimate yields (Yu et al., 2016), detect disease (Tetila et al., 2017), and manage weeds (Huang et al., 2018). However, most of this research is performed with multispectral cameras and specialized software, which may not be practical for row crop farmers. Instead, with less advanced equipment, common tasks such as crop scouting, observing irrigation systems, or monitoring livestock can be performed. Crop scouting is already performed by trained agronomists and crop advisors, and drones may provide additional assistance in this field. However, most of these benefits are assumed, simply because a drone can take an aerial photo. There is a lack of information as to whether drones can increase the efficiency or effectiveness of a seasoned field scout.

With the focus on multispectral imagery and field mapping, scouting via drone has not received as much attention. As higher quality off-the-shelf drones are more available to farmers and consultants, scouting is an achievable task. The goal of this project was to compare traditional versus drone scouting methods to see if they could increase efficiency in either reduced time or increased issue discovery.

Methods

For this project three soybean fields (one from each county in Delaware) were selected and followed through the growing season. These fields were scouted by walking the rows as well as with aerially by drone. For walking methods, fields were covered in a zig-zag pattern at the beginning of the season, until full canopy reduced maneuverability. Following full canopy, walking could only be efficiently done along irrigation wheel tracks.

For aerial scouting, two drones were used, the Parrot Anafi (Paris, France) or the DJI Mavic Air quadcopter (Shenzhen, China), based on availability the day of the flight. Two aerial scouting methods were used in each soybean field. One was an automatic, pre-planned flight using free available software (Pix4DCapture, Switzerland) to setup a consistent scouting plan (Figure 1). The software was downloaded onto an Apple Ipad, which included celluar for global positioning (GPS) capabilities. Each field was selected by using the address and aerial photo with Pix4DCapture. The field boundary was drawn as a polygon to fit the exact outline and reduce the amount of battery used. Height above ground level (AGL) was set for 200 feet and overlap was initially set to 50%, before being reduced to 30% after the first flight. Camera angle can be set from 0 (straight ahead) to 90° (straight down) in Pix4DCapture. For this project, camera angle was set to 45° to capture more of the field in one image, also cutting down on flight time. Images were downloaded by Wi-Fi on the first flight, and then downloaded directly from the SD card onto a laptop for subsequent flights, due to time constraints.

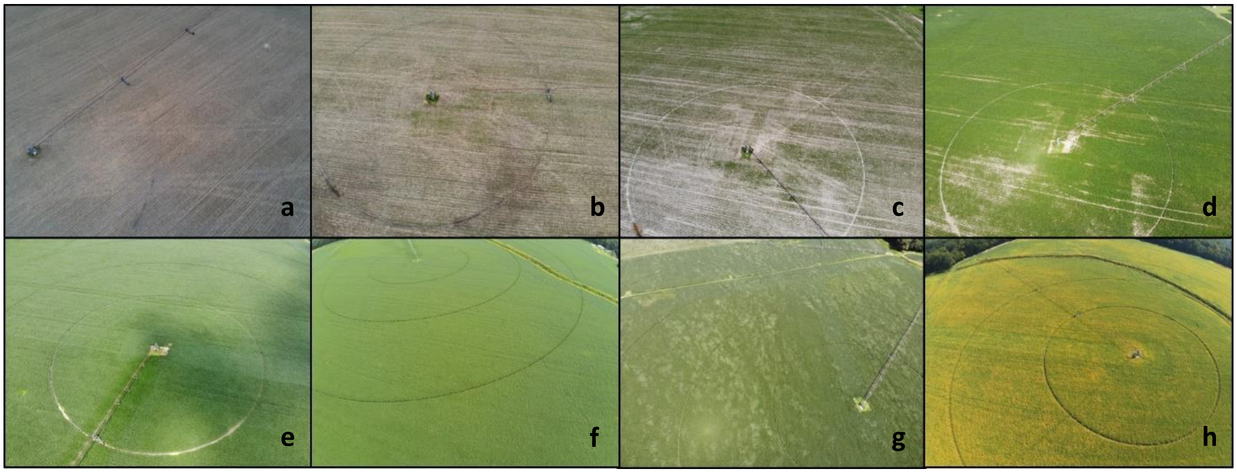

Figure 1: Automated (pre-planned) flight from June 4 (a), June 19 (b), July 2 (c), July 17 (d), Aug 1 (e), Aug 21 (f), Sept 9 (g), and Sept 26 (h) in a soybean field at 200 feet AGL.

The second scouting method using a drone was a manual flight using the software associated with each drone. The Parrot Anafi was flown with Parrot FreeFlight6 (Paris, France) and the DJI Mavic Air was flown using the DJI GO 4 app (Shenzhen, China). Each app was downloaded onto an Ipad tablet for a larger screen. The drone was initially taken up to 400 feet to get an overall view of the field, before flying to problem areas and performing lower height scouting (Figure 2). All images were downloaded and stored on a 1TB external hard-drive.

Figure 2: Season long images from 400 feet AGL give a quick overview of the field, which can be followed up by closer inspection through the drone or walking.

Results and Discussion

Time in the Field

This simple experiment was revealing when evaluating the use of drones in soybean scouting, so that outreach to farmers and consultants could be clear on the expected uses. Most of the outcomes of this project are expected; including less time spent scouting fields with a drone (Table 1). At each field, walking accumulated the most time (17-34 mins), with an average of 25 minutes across all sites over the entire season. Typically, longer walking times were associated with full canopy soybeans later in the season (Figure 1f), when irrigation wheel tracks were the best option to get across the field. Early in the season, any zig-zag or "w" pattern could be employed, particularly when soybeans were in early vegetative stages. The longest average walking time was at the largest field (Kent County, 34 minutes), which would be expected due to acreage. Using a drone to scout the field *initially* cuts down on the time-spent scouting but may also miss some issues. For example, in Figure 3, deer feeding is clearer at ground level when walking the field (Figure 3c). This initial scouting time (by drone) also does not include any subsequent time spent walking the field to investigate or obtain actual samples. The major benefit in time when using a drone would be pinpointing specific issues to check, rather than spending 34 minutes crisscrossing the field. There was not much difference between a pre-planned flight (Figure 1) and manually scouting the field in total time (Figure 2), even though the automated flight took more pictures.

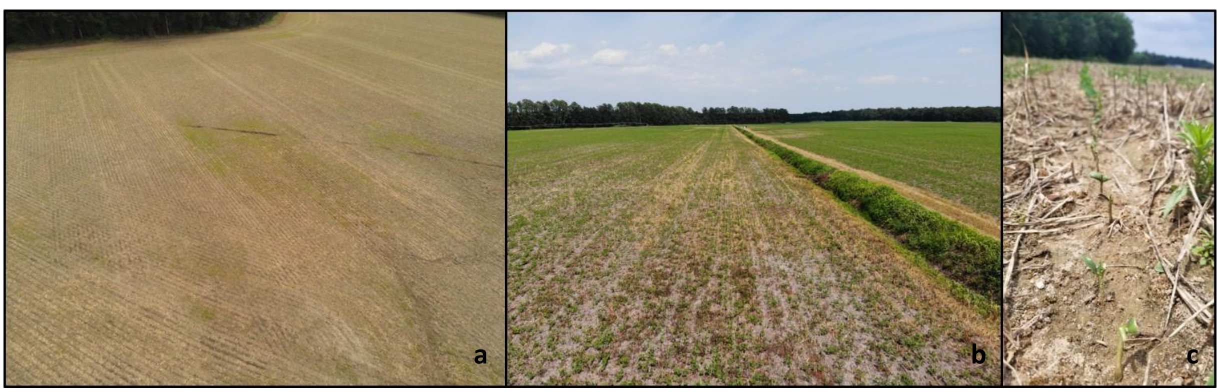

Figure 3: A drone view of soybeans at a) 400 feet AGL, b) 30 feet AGL, and c) deer damage when walking the field at ground level.

Number of Photos and Storage

For each flight, the most photos were taken during the automatic method at 30% overlap (Table 1). The number of photos ranged from 26-60 with a pre-planned flight, and reduced to 12-22 with a manual flight (Table 1). An automated flight will be consistent every time, and manually taken photos will depend on what the user sees or is interested in. Some individuals may take twice as many photos as the researchers of this project, so it will be possible that pre-planned flights could end up with less photos depending on the user. Additionally, for the pre-planned flight, 30% overlap may also be excessive and could possibly be reduced to 20% or less. Walking the field typically took the least photos, but this will still be scout based, as cell phones make it easy to take multiple photos (Figure 4). The value in walking the field is the better detail, and slower pace that allows the scout to observe more issues (Figure 4).

The storage space needed for these photos quickly rises upon from an overall average of 51 MB for walking, to 136 and 349 MB for manual and automatic flights, respectively (Table 1). This gives rise to additional questions, such as whether these photos will be stored permanently, or selectively deleted. Another question scouts may have to consider is what imagery to send to a farmer, as 349 MB is an excessive amount, and also represents at least 44 photos, which is more than any land owner will want to look through. Photos sent will have to be culled and selected, if they are sent at all. The time spent in deleting and managing photos should be considered as a storage and streamline portion of this type of work. This consideration will probably change, as consultants and agronomists come up with a plan for drone scouting timelines, including data management and storage.

Table 1: Average characteristics across all counties from each scouting trip across soybean fields.

	New Castle	**Kent**	**Sussex**	**All Sites**
Time Spent (min)				
Auto	3	6	6	5
Manual	5	8	7	7
Walking	17	34	19	25
Photos (#)				
Auto	26	60	38	44
Manual	12	22	14	18
Walking	10	14	5	13
Storage Size (MB)				
Auto	187	477	329	349
Manual	89	23	103	136
Walking	35	14	25	51
Issues ID'd (#)				
Auto	6	11	10	N/A
Manual	7	11	6	N/A
Walking	9	27	12	N/A
Field Size (acres)	10	43	22	N/A

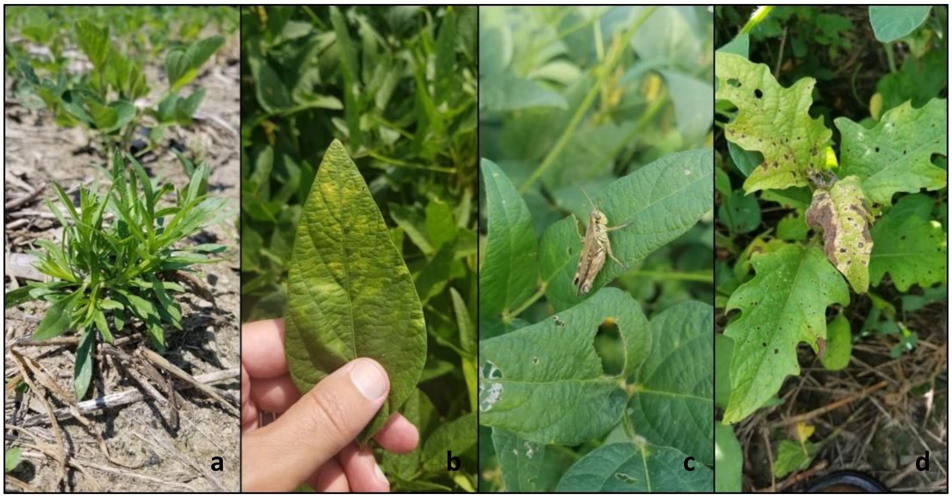

Figure 4: Walking the field with a camera/smartphone allows for closer inspection of field issues, although not necessarily at any economic threshold for management.

Number of Potential Issues Observed

In each field, more *potential* issues were observed with walking, which ranged from a low of 9 to a high of 27 over the season (Table 1). These are only potential issues, because many were not necessarily at economic thresholds, just field observations. Both drone scouting methods found less issues, mostly due to the heights and speeds flown (Table 1). Walking a field restricts the how quickly a scout can cover a field, while a quadcopters move quickly causing a scout to miss potential issues. As already mentioned, some of the issues noted when walking includes minimal insect damage, or finding just one weed, not economic thresholds to take action (Figure 4). When issues do become large enough to spot by aerial imagery, they may be more likely to respond to rescue treatments to fix the issue. Patterns are much clearer in soybeans as the season progresses and canopy coverage occurs (Figure 1, Figure 5). The drone may provide a clearer picture of the problem's extent, and whether any rescue treatments are necessary or will benefit. In Figure 5c, with canopy closure, stressed areas are apparent in the outlined region (black circle).

Figure 5: Early season differences are difficult to discern (a), but as canopy closes (b), patterns and variation emerges, such as the color differences (c).

Drone Benefits and Effectiveness for Crop Production Issues

Of the potential problems that may reduce yield, drones are effective at spotting weeds early in the season (Figure 6a). Most soybean production will include a post-emergence herbicide that will reduce or eliminate weed pressure prior to soybean canopy. In that case, the drone will not be more effective than following herbicide schedules. On the other hand, as can be seen in Figure 6, the drone can alert the grower to weed growth in harder to reach parts of the field and may induce an earlier spray date. With the onset of herbicide resistant weeds, such as palmer amaranth, in need of timely applications, the drone may help detect these issues earlier. Later in the season, as soybeans canopy, weeds will blend into the field better, and will require slower, more careful inspection via drone imagery (Figure 6b,c).

Figure 6: One early season issue that is easy to spot is weed pressure (a), which becomes more difficult without careful inspection during canopy (b, c)

One of the greatest benefits of a drone as a scouting tool is following the crop through the season. Due to the ease at which a drone can examine larger field issues, the progression can be followed to determine the potential relationship to grain yield. In some cases, those problems could be fixed in the current season or next. For example, lighter colored beans were recognized in one of the fields (Figure 7a), easily standing out from the adjacent health soybeans. Upon closer inspection and using the zoom feature of the drone (Figure 7b, 7c), the issue appears to be manganese (Mn) deficiency, a common issue on sandy soils. This cannot be verified without a tissue test but could indicate a portion of this field where Mn concentrations are too low, or pH is too high, and could be rectified in the following season. In this case, the affected area is also small enough that the grower may decide to ignore the issue and keep monitoring the field over subsequent seasons.

Figure 7: Potential manganese deficiency can be spotted later in the season, following canopy (a,b). The drone can allow closer inspection (c) without walking the field, although tissue tests are still recommended.

Issues with plant diseases can also be tracked through the season by drone, providing information on the overall extent, rate of growth, and final effects on yield (where yield monitors are used). In Figure 8, soybean sudden death syndrome (SDS) appears in August (Figure 8a), with increasing effects but minimal additional spread in September (Figure 8b). In this case, the SDS was close to a field road, and could have been seen from any vehicle. If this had occurred in a less accessible portion of the field, these drone images could have provided the reason for lower yields. In addition, actual symptoms can be observed by the drone (Figure 8d) like those seen when walking the field (Figure 8c). When the pilot has comfort in flying a drone (within line of sight) it is quite possible to hover several feet over the canopy and retrieve high resolution photos of disease symptoms, such as SDS. As with the Mn issue (Figure 7), proper diagnosis of SDS should be done by a diagnostic lab, and not based on drone photos.

A stronger example of the seasonal progression of plant disease can be observed in Figure 9. In mid-July (Figure 9a) disease is not immediately apparent in the image. By August 6 (Figure 9b) there is an obvious separation between stressed and normal soybean growth. Samples taken at this time revealed infection by charcoal rot and diaprothe longicolla in the lighter colored beans (Figure 9b). Another pattern later in the season is the darker green beans on September 10th (Figure 9c), which had slower maturity and senescence (Figure 9d) than the surrounding beans. While these soybeans adjoin the area suffering from infection, the later senesce may actually have been due to soil moisture. Across this and the adjacent field (not shown), these soybeans showed a clear pattern following drainage from an adjacent field. The higher available moisture during drought conditions allowed for greater growth, and possibly higher yield, than the adjacent soybeans, which were also infected by the previously mentioned plant diseases.

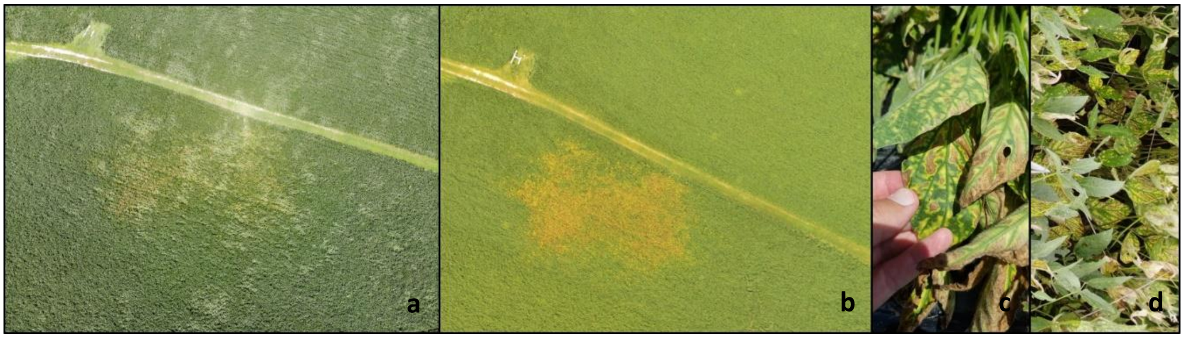

Figure 8: The effects of soybean sudden death syndrome from August (a) to September (b) 2019 are apparent from the air. Both walking the field (c) and drone imagery (d) can provide closer inspection of visual symptoms prior to submitting to a plant diagnostic lab.

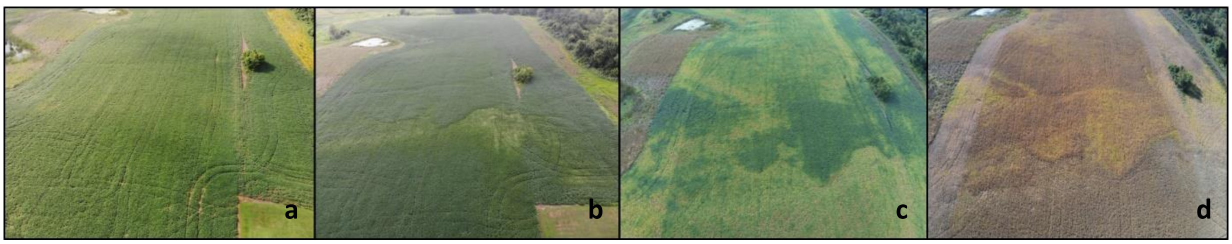

Figure 9: One of the biggest benefits of aerial photography is following an issue through the season to yield. In this case disease pressure is not apparent in mid-July (a), but shows up Aug 6 (b), and becomes steadily worse from Sept 10 (c) to Sept 26 (d).

Additional Functionality for Production Agriculture

Two additional functions of drone imagery for soybean production can be seen in Figure 10 and Figure 11. While the value of irrigation on sandy soils is accepted in Delaware, imagery from the summer of 2019 (Figure 10a) clearly show the benefits of irrigation, as the edge of the center pivot shows a clear distinction in soybean growth and senescence. Scouts may also notice the deer paths through the soybeans, leading from the woods towards the field center (Figure 10a). Also, drone pilots with practice and good eye site can check irrigation equipment without crossing the field or climbing on the pivot (Figure 10b).

Farmers and consultants who plant different varieties may also use a drone to follow progress through the summer. In two fields, different soybean varieties are obvious (Figure 11), particularly when observing the straight lines from different planter passes. The soybeans in Figure 11b are particularly striking, as they obviously have a later maturity and senescence than the adjacent variety. For anyone following variety trials through the season, imagery may provide ancillary information.

Figure 10: Scouting irrigation and deer paths (a) and checking on irrigation equipment (b).

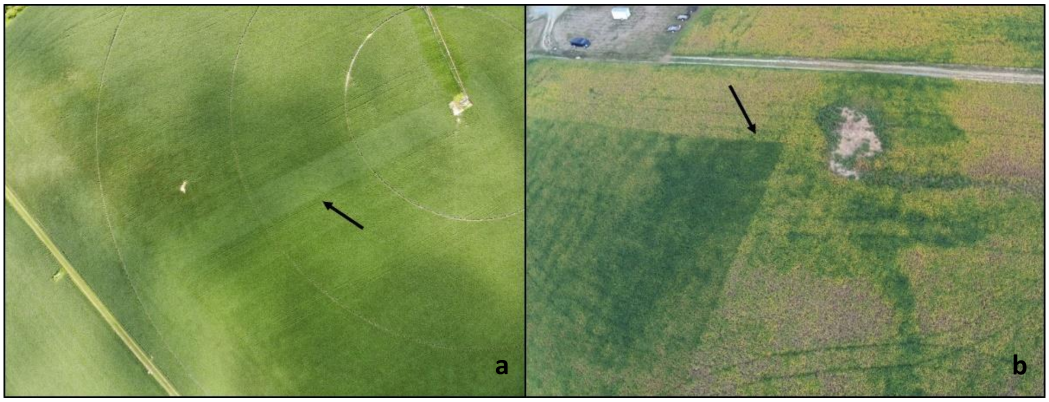

Figure 11: The growth of different soybean varieties is very clear in both photos (edge marked by black arrow).

Drone Cost

There is an overall cost associated with each drone, which typically cost between $600-$2000 depending on the quality of the camera and stability of the drone. It is not recommended to scout fields with anything cheaper, as they may not have good range, stability in the wind, or capture higher resolution photos. Other considerations in the cost of the drone include backup batteries, which can cost anywhere from $50-$150, also depending on the drone. One field can easily drain a battery power, with quadcopter flight times ranging from 15-25 minutes. All scouts should consider additional batteries when making a drone purchase, particularly as models go out of production within 1-3 years in the current market. For each scout or farmer, the investment in time and issue management should be compared when purchasing a drone. This can include the cost of the drone pilot exam ($150) or additional insurance and regulatory restrictions.

Conclusions

While there are benefits to scouting a field by drone, there are also limitations. Scouting earlier in the season is still best done by walking the field or using a 4-wheeler. Although the drone can be flown low to the ground at a slower pace, it is still difficult and would be limited by battery life. One issue that is obvious early in the season is weeds, which will grow in between rows and fill out the area. There greatest benefits from scouting by drone come later in the season with full canopy, where soil colors are not present. With full canopy patterns of disease and nutrient deficiencies become obvious, even at 400 feet AGL. Still, for proper diagnoses the scout will have to walk to that portion of the field and obtain a tissue sample, but the drone will have allowed for more precise targeting of field issues.

References

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