Journal of Extension

Volume 59 | Number 2 Article 11

6-10-2021

Applying Drone-based Spatial Mapping to Help Growers Manage Crop Diseases

Qingren Wang
University of Florida, qrwang@ufl.edu

Shouan Zhang
szhang0007@ufl.edu

Recommended Citation
Wang, Q., & Zhang, S. (2021). Applying Drone-based Spatial Mapping to Help Growers Manage Crop Diseases. *Journal of Extension, 59*(2), Article 11. https://doi.org/10.34068/joe.59.02.11

Applying Drone-based Spatial Mapping to Help Growers Manage Crop Diseases

Cover Page Footnote

We gratefully thank Florida Department of Agriculture and Consumer Services for the financial supports with grants, Dr. Kelly Morgan, and Dr. James Fletcher from University of Florida for their coordination in conducting the statewide Best Management Practice program, and Torbert Farms for the agreement to carry out the survey from the field.

JOURNAL OF Extension

Research in Brief

Volume 59, Issue 2, 2021

Applying Drone-Based Spatial Mapping to Help Growers Manage Crop Diseases

Qingren Wang[1] and Shouan Zhang[1]

AUTHORS: [1]University of Florida.

Abstract. Phytophthora blight (*Phytophthora capsici*) is one of the major soilborne diseases threatening many vegetable crops including squash. The disease results in severe epidemics and yield losses due to a rapid spread of the pathogen associated with wet weather and soil waterlogging. Implementing drone-based spatial mapping with software elevation tools can assist growers in evaluating land levelling for uniform distribution of water to mitigate potential disease incidence. The technology has great advantages: rapid, precise, and labor-cost effective. Our result can implicate Extension professionals with application of spatial mapping to assist growers in managing their land and crops for disease control efficiently.

INTRODUCTION

An outbreak of the disease caused by the fungal-like pathogen *Phytophthora capsici* (*P. capsici*) is often a critical concern for vegetable growers. Growers are frustrated with this disease because a large number of plant species, especially many solanaceous crops and cucurbits, are hosts of this pathogen. The disease occurs and develops rapidly with excess rainfall or irrigation water, which can cause a massive yield loss (Roberts & Kucharek, 2018). This pathogen was reported on chili peppers in the United States as early as the 1920s, and its occurrence on cucumbers resulted in 100% of the fruit rotting (Kreutzer, 1937; Leonian, 1922). The pathogen has rapidly spread to other crops, including honeydew melon fruit, eggplant, summer squash, and tomato (Kreutzer, Bodine, & Durrell, 1940). The disease occurred in Florida prior to 1993 and it has become a chronic issue on summer squash and pepper since 1997 (Roberts & Kucharek, 2018).

Phytophthora blight may occur during any stage of host crop development. The pathogen can infect seeds causing seed rot or seedling damping-off. The rot of crown, root, or fruit may cause a severe yield loss (Roberts & Kucharek, 2018). Both summer (yellow crookneck and zucchini) and winter (acorn and butternut) squash varieties are highly susceptible to phytophthora blight and fruit rot. Excessive rainfall is the most influential environmental factor affecting the incidence and distribution of the disease. Timely field surveying to detect the disease, evaluate its severity, and predict the potential for yield loss is challenging for growers because of the pathogen's rapid occurrence and spread. The conventional survey technique of walking through fields is time-consuming, labor-intensive, and a difficult way to obtain real-time information.

Implementing drone technology in field surveying has provided great advantages in flexible manipulation, timely detection, and labor-cost saving as compared to prior methods, such as the use of satellites or piloted aircraft. The use of spatial mapping techniques based on super high spatial resolution airborne orthoimages can help growers identify the infected locations, prioritize plant inspection, and evaluate the potential yield loss (Johansen et al., 2014). Therefore, the information derived from a drone system can help growers make decisions, change practices, and optimize resources, thus promoting agricultural production (Candiago, Remondino, Giglio, Dubbini, & Gattelli, 2015). Drone technology has been widely used in the agricultural industry, especially in precision farming and detection of plant diseases (Johansen et al., 2014; Primicerio et al., 2012; Wang, Liu, & Zhang, 2020).

There have been some reports about using drone technology to spark participant interest in Extension programming, and about implementing a drone system in a tomato tospovirus survey (De Koff, 2017; Villegas, 2016; Wang et al., 2020). However, publications about drone implementation in Extension programming to help agricultural producers manage their land and crops are scarce. The objective of this study was to explore spatial mapping conducted by a commercial drone to help growers identify the specific plant disease and its incidence, severity, and field distribution. In this article, we elucidate our findings to help agricultural Extension professionals better understand drone technology in order to provide timely information to producers about land preparation and crop management.

MATERIALS AND METHODS

The study area was located in south Florida in a 23-acre yellow summer squash (*Cucurbit pepo*) field seeded in early April 2019. It was the final crop of the season in the subtropical region of Florida, because summer is an off season for vegetables. A parallel-moving overhead irrigation system was used with normal fertilization and pest management practices according to the owner's farm plan. The plants were initially healthy and vigorous through the flowering and early fruiting stages. In early May, however, it rained for several days with light precipitation occurring continuously. This resulted in a severe outbreak of phytophthora blight in this and other nearby squash fields.

To investigate the distribution of the disease, we employed a DJI Phantom 4 Pro drone (Shenzhen, China) with a high definition camera and a multispectral sensor (Double 4k), specifically designed for agriculture applications (Sentera, Minneapolis, MN). The drone was used to collect data on May 13, 2019. Using a flight app downloaded to an iPhone, we used the autonomous flight setup with the parameters set to 80% overlap, 200 ft above ground altitude, a speed of 20 miles/hr, and an east to west orientation against and in line with the ambient wind direction for smoother photographing (Wang, 2019, Wang et al., 2020).

The flight data was transferred and stored to micro secure digital cards and uploaded to a data processing agency website, FieldAgent (Sentera, Minneapolis, MN), for picture stitching and an orthomosaic image creation. With FieldAgent software, we generated a series of mosaic images, including red-green-blue (RGB), near-infrared (NIR), normalized difference vegetation index (NDVI), and normalized difference red edge (NDRE). Using specific features of this software, an image of management zones was derived based on plant health and NDVI values. The distributions could then be displayed in various colors with estimates of acreages of healthy and unhealthy plants.

RESULTS AND DISCUSSION

We obtained a series of orthomosaic images after stitching together the 1,200 individual spatial photos taken by the drone system. From the RGB mosaic image (Figure 1, left), it was easy to visualize that plants died in irregular shaped patches across the field. The FieldAgent software was used to create management zone images using NDVI values that ranged from +1 to -1 ("healthy" to "unhealthy"). The image indicated that in the surveyed field, excluding driveways within and around the field, there were 10.12 ac (54%) healthy plants (green area) with NDVI value 0.43-0.67, 2.72 ac (14%) less healthy plants (yellow area) with NDVI value 0.31-0.43, and 4.15 ac (22%) unhealthy or dead plants (red area) with NDVI value -0.15-0.31 (Figure 1, right).

When the details of a severely infested spot were examined by increasing the magnification of the corresponding area, it appeared that nearly all of the plants died from *P. capsici* infection. The image was viewable in different layers (i.e., RGB, NIR, NDVI, and NDRE as highlighted on the top of each image) with a flipping over feature, which showed the same result (Figure 2).

Field sampling and diagnosis confirmed that the phytophthora blight-like symptoms were caused by *P. capsici* (Figure 3). The symptoms included sudden plant wilting and brown, water-soaked, constricted lesions near the soil surface.

The sudden outbreak of this phytophthora disease resulted from the pre-existing pathogen in the soil and the corresponding weather change in the area. According to the Florida Agriculture Weather Network (University of Florida, 2019), there were two continuous rainfall events prior to the outbreak. The first occurred on May 5 and 6 with rainfall amounts of 0.16 and 0.90 in., respectively, and the second on May 10 through May 12, with rainfall amounts of 0.07 to 0.15 in., respectively. The patchy distribution of infected squash plants implied that the infested areas might be related to certain geomorphological characteristics. When analyzing the NDVI data by applying an elevation tool (Drone Deploy software) (Figure 4, left), we derived a well-correlated image in various elevations with the incidence and the distribution of the disease in the field, except the top left corner with structures and a driveway (Figure 4, right). For instance, the blue color in the image represented a lower area in elevation, which corresponded well with the *P. capsici* distribution.

The results imply that the soil had been infested by *P. capsici* and that yellow squash was a highly susceptible host. The continuous rainfall created an ideal condition for disease advancement, especially in waterlogged patches. As reported, excess water is critical to the infection and dispersal of the pathogen. The worst incidence of the disease occurred during wet weather and in low, waterlogged spots of the fields (Roberts & Kucharek, 2018). The disease incidence and severity were heightened even when elevation was only a few inches lower, such as in this field (Figure 4).

Based on our results, we suggest that laser leveling of the land to avoid low areas will provide a more uniform distribution of water for growing squash and other susceptible

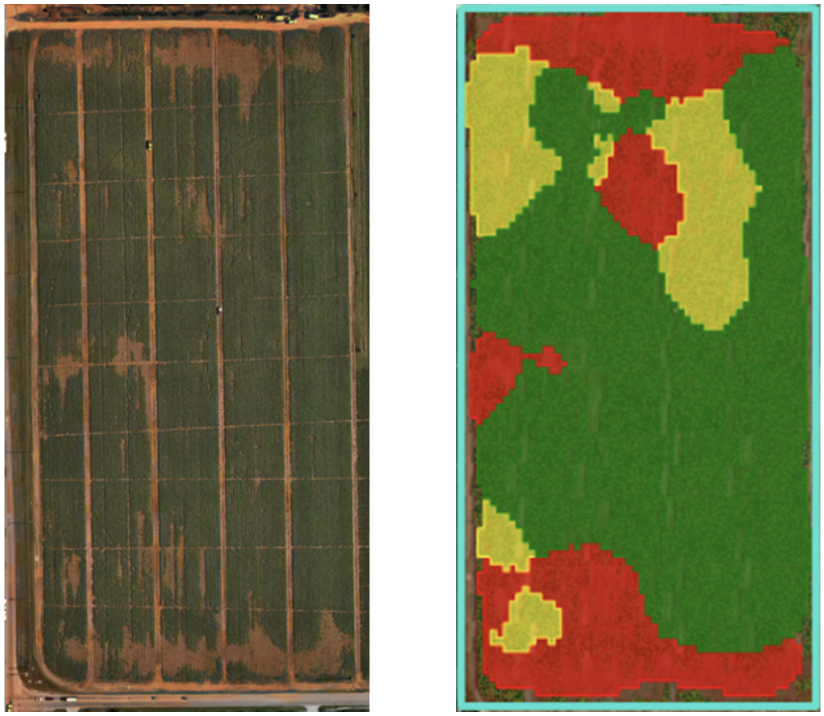

Figure 1. Orthomosaic images of (left) red, green, and blue (RGB), and (right) normalized difference vegetation Index (NDVI) with management zones from the yellow squash field (green: healthy, yellow: unhealthy, and red: dead spots).

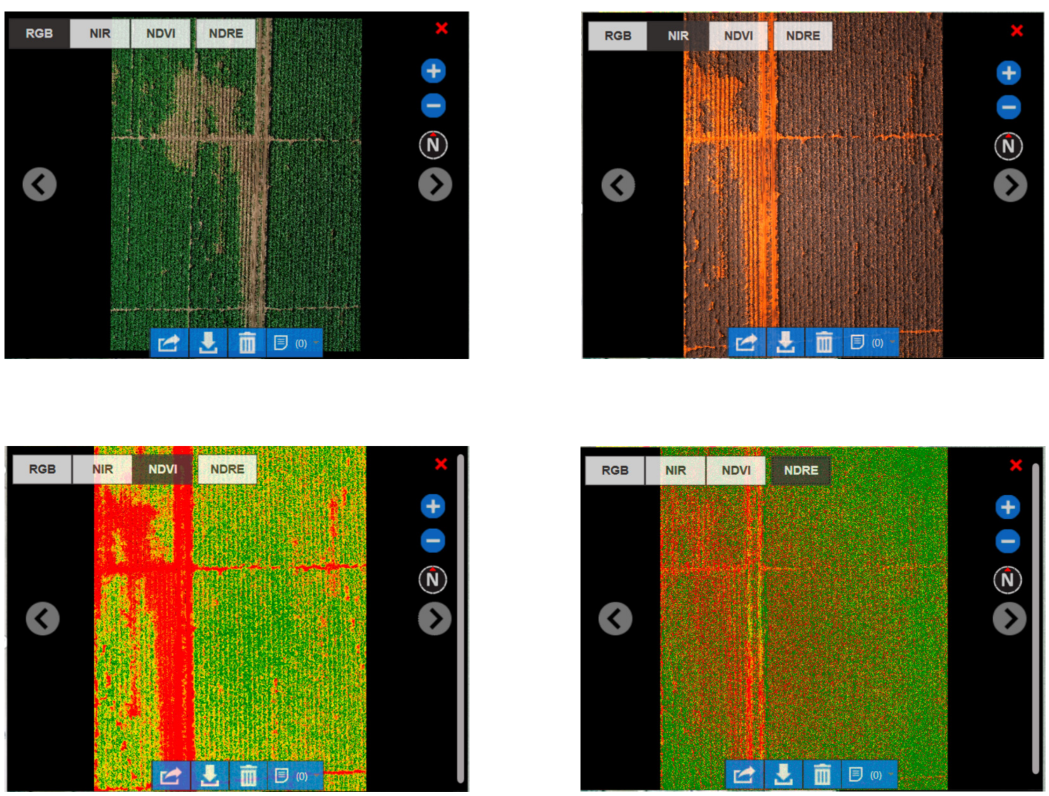

Figure 2. Detailed view of *Phytophthora capisici* infested area with different layers of the image (RGB, NIR, NDVI, and NDRE). (RGB: Red, green and blue, NIR: Near infrared, NDVI: Normalized difference vegetation index, and NDRE: Normalized difference red edge.)

Figure 3. Comparation of a ground photo (left) with a spatial photo (right) in a severely infected area.

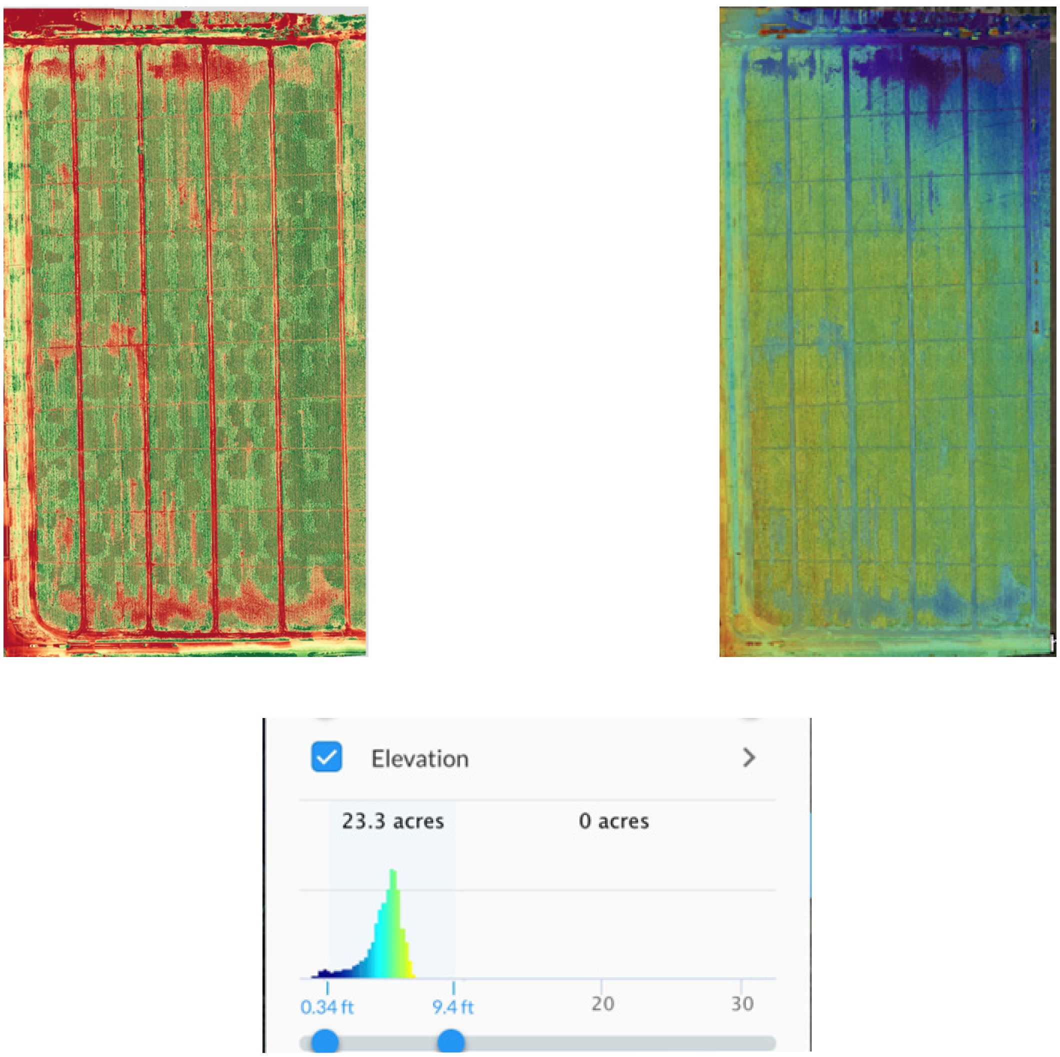

Figure 4. Correlation between *Phytophthora* disease infection areas in the normalized difference vegetation index (NDVI) orthomosaic image (top left) and the land elevation image (top right) associated with an elevation legend (bottom).

crops and thereby decrease the disease caused by *P. capsici*. This would be true even in this experimental field that was characterized by a very porous, rock-rich soil (Krome gravelly loam), which is prevalent in south Florida. A short period of standing water in the field creates an ideal environment for phytophthora blight. Another important environmental variable for the disease occurrence is temperature. This disease may occur at any temperature between 46 and 99°F, but the optimum temperature for producing zoospores and initiating infection by the pathogen is from 80–90°F (Roberts & Kucharek, 2018). The average temperature during a winter vegetable growing season in this area is about 75°F.

Focus group discussions with relevant growers indicated that the preferred best management practice is to eliminate soil pathogens via soil fumigation. This is very costly, however, and unfeasible under the current production system for squash. Application of preventive fungicides labeled for squash may help reduce the infection to some extent, but chemical control is ineffective when continuous rainfall occurs for several days. Growing phytophthora-resistant varieties or cultivars is another potential option, but currently no such varieties or cultivars are commercially available (Thabuis et al., 2013). Therefore, improvement of environmental conditions for crop growth through cultural control practices during the land preparation procedure, especially implementing laser leveling to make water uniformly distributed prior to planting squash, is an optimal choice.

Spatial field mapping using elevation may facilitate a platform for agricultural Extension professionals to help growers determine the quality of their land levelling to mitigate crop damage. The results of an assessment from an on-site demonstration of the drone technology associated with a grower's workshop indicated a strong willingness by vegetable growers to accept such an approach. On a scale of 1–5 ("low" to "high"), all 30 participants at the field demonstration and workshop indicated a knowledge gain with a weighted average rating of 4.8, and 100% were willing to change their practices by adopting the drone technology with a weighted average rating of 4.5.

CONCLUSION AND IMPLICATION

Phytophthora blight is a fatal disease in cucurbits, especially yellow squash. The outbreak and rapid spread of the disease is highly correlated with wet weather and waterlogged spots in the field. Compared to conventional approaches, implementation of a field survey using spatial mapping with drone technology can provide reliable and real-time information in a rapid and labor-cost effective solution. The application of an elevation tool with spatial mapping allows visualization of lower land areas where the potential occurrence of the plant disease is higher. This can aid producers in better land preparation by use of laser levelling to mitigate the crop yield loss caused by *P. capsici*. With the rapid development of drone technologies for agricultural producers, we believe that more growers will take the advantage of drone-based systems in their farming management. It has the potential to become an essential tool for autonomous farming practices in land and crop management. Extension educators and agricultural professionals will have to be ready to assist growers with their challenges in implementing the technology.

ACKNOWLEDGMENTS

We gratefully thank Florida Department of Agriculture and Consumer Services for the financial support with grants, Dr. Kelly Morgan and Dr. James Fletcher from University of Florida for their coordination in conducting the statewide Best Management Practice program, and Torbert Farms for the agreement to carry out the survey from the field.

REFERENCES

Candiago, S., Remondino, F., Giglio, De G. M., Dubbini, M., & Gattelli, M. (2015). Evaluating multispectral images and vegetation indices for precision farming application from UAV images. *Remote Sensing, 7*, 4026–4047.

De Koff, J. P. (2017). Drones in extension programming: implementation of adult and youth activities. *Journal of Extension, 55*(6). https://tigerprints.clemson.edu/joe/vol55/iss6/49/

Johansen, K., Sohlbach, M., Sullivan, B., Stringer, S., Peasley, D., & Phinn, S. (2014). Mapping banana plants from high spatial resolution orthophotos to facilitate plant health assessment. *Remote Sensing*, *6*, 8261–8286.

Kreutzer, W. A. (1937). A *Phytophthora* rot of cucumber fruit. *Phytopathology, 27*, 955.

Kreutzer, W. A., Bodine, E. W., & Durrell, L. W. (1940). Cucurbit diseases and rot of tomato fruit caused by *Phytophthora capsici. Phytopathology, 30*, 972–976.

Leonian, L. H. (1922). Stem and fruit blight of peppers caused by *Phytophthora capsici sp. Nov. Phytopathology, 12*, 401-408.

Primicerio, J., Di Gennaro, S. F., Fiorillo, E., Genesio, L., Lugato, E., Matese, A., & Vaccari, F. P. (2012). A flexible unmanned aerial vehicle for precision agriculture. *Precision Agriculture, 13*, 517–523.

Roberts, P. D., & Kucharek, T. A. (2018). Vegetable Diseases caused by Phytophthora capsici in Florida. *University of Florida Institute of Food and Agricultural Science, electronic data information source (EDIS)*. http://edis.ifas.ufl/vh045

Thabuis, A., Palloix, A., Pflieger, S., Daubeze, A. M., Cafanta, C., & Lefebvre, V. (2013). Comparative mapping of *Phytophthora* resistance loci across Solanaceae and for a large genetic diversity. *Theoretical and Applied Genetics*, *106*, 1473–1485.

University of Florida. (2019). *Florida Automated Weather Network (FAWN)*. https://fawn.ufl.edu

Villegas, V. (2016). Drones in agriculture for STEM/STEAM education. http://blogs.oregonstate.edu/agdrones4steam/2016/06/25/drones-agriculture-steam-workshop

Wang, Q. (2019). Demonstration of drone technology to improve crop management in vegetable production. *Proceedings of Florida Society of Horticultural Science, 132,* 125-127.

Wang, Q., Liu, Q., & Zhang, S. (2020). Implementation of drone system in survey for tomato chlorotic spot virus. *Journal of Extension, 58*(2). https://tigerprints.clemson.edu/joe/vol58/iss2/20/