The Potential of Precision Agriculture Technology in Potato Pest Management in the Pacific Northwest

Silvia I. Rondon, Extension Entomologist Specialist
Oregon State University, Hermiston Agricultural Research and Extension Center, Hermiston, OR, USA

The potato is one of the world's most important food crops that arrived from Peru to Europe in the late 1500s and in North America in the 1600s. Since then, potatoes have been cultivated throughout the world. Insects, both as pests and beneficials, have been studied since the beginnings of agriculture, but of the millions of insects on the planet, only a fraction impact crops. A number of pests are important to all western U.S. potato regions including aphids, beet leafhoppers, potato tuberworm, Colorado potato beetle and more recently, Lygus, mites, and thrips.

Monitoring insects

Monitoring insect attack and overall plant health is an important aspect of successful agricultural operations. Traditionally this has been carried out by visual examination, which is time consuming, and is limited by the ability of the human eye to discriminate between healthy foliage and foliage attacked by various kinds of insect pest, diseases, or affected by lack or excess of nutrients, etc.

With the development of precision agriculture over the past twenty years, a reduction in cost production was achieved with the capacity to apply pesticides and other inputs where and when needed. Precision agriculture is a farm management practice based on measuring inter and intra-field variability in crops that will allow an appropriate and targeted response on a small scale. This concept can be used to manage any crop challenge including insect pests. Determining the geographic distribution of an insect is simplified through analysis of spatial-temporal variability models that quantify the insect's population dynamics in time and space through analysis of spatial-temporal variability models. Data can be modeled and cluster analysis methods have been successfully applied to insect count data in order to predict regions of relatively high and low count densities and to generate distribution maps. The figure on the right (Fig. 1) shows the probability of aphids exceeding 3 per trap per week in an agricultural area of the south Columbia basin. The difficulty with this method is scaling it to provide pest predictions over extended geographical areas.

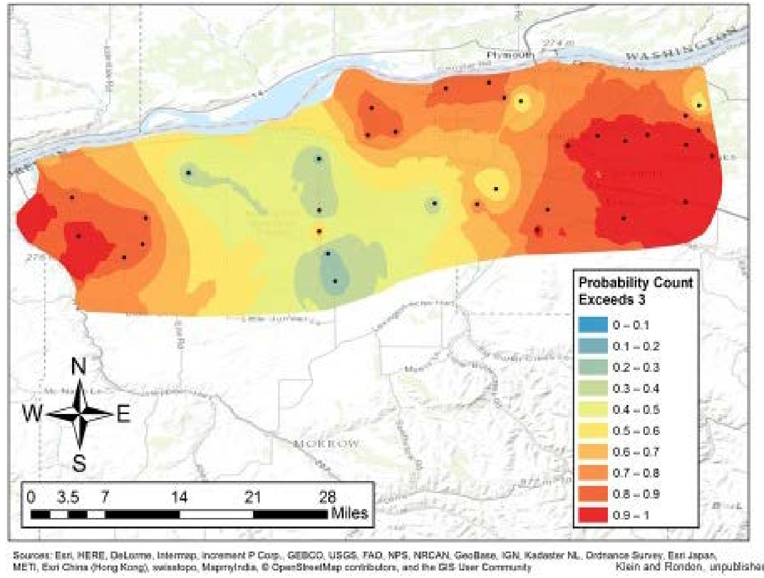


Fig 1. Probability of aphids exceeding 3 aphids. Graph by M. Klein & S.I.Rondon

Remote sensing with **u**nmanned **a**ircraft **s**ystems (UAS) has potential applications in precision agriculture. Using UAS imagery may be acquired over smaller or larger areas at high temporal and spatial resolutions. Integrated pest management (IPM) already uses geospatial tools to control insect populations and we hypothesized that high spatial resolution made possible by UAS flights would allow earlier detection of insects. This application will provide the ability to spot-treat only those areas of the field needing pest control and to manage a healthier crop by adjusting needed inputs within the field rather than at the whole field level.

How to collect high resolution imagery? The Colorado Potato Beetle case study

In 2014, small plots (2.6 × 9.2 m) were established at the Hermiston Agricultural Research and Extension Center located near the Columbia River in Hermiston, OR, USA (45.81944° N; 119.28333° W). Plots were set in a randomized block design with 4 treatments and 4 replications. Different numbers of Colorado potato beetle (CPB) (*Leptinotarsa decemlineata* L.) (Fig. 2) were placed at the center of each plot: low – 1.5 CPB/plant, medium – 4.5 CPB/plant, and high – 7.5 CPB/plant. The control treatment had no additional CPB per plant; any adults or larvae found in the control plots either emerged from the soil or migrated from other areas.

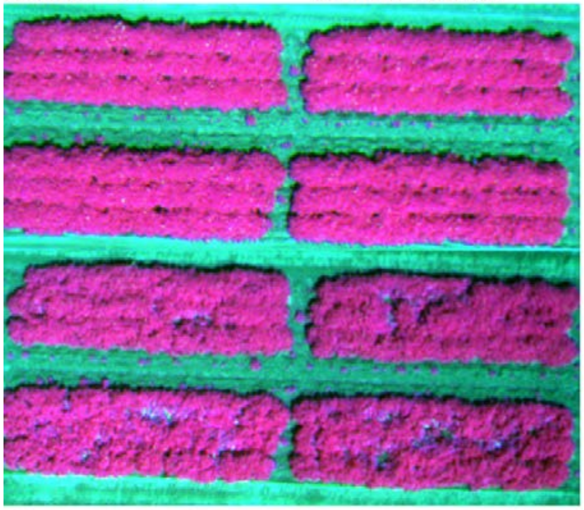
Fig. 2 Colorado potato beetle. Photo by OSU IAEP Rondon.

Using a DJI (Shenzhen, Guangdong, China) “Spreading Wings” hexacopter with a Tetracam (Fig. 3) and five camera bands (NIR, blue, green, red, red-edge), the plots were overflown on 10 consecutive days starting mid-June 2014. Damage caused by CPB was observed on the day of the last flight (Fig. 4).

Fig 3. Hexacopter. Photo by OSU IAEP Rondon.

Plot 301 – Low

Plot 302 – Medium



Plot 104 – Control

Plot 102 – Medium

Fig 4. Aerial picture of the plots. Photo by UAV group.

In general, UAV imagery was able to detect CPB damage, however, there was no correlation in visual ranking related to UAV imagery. Smaller pixel sizes are still required to show visual differences related to the CPB feeding damage.

Preliminary conclusions

Modern precision agriculture relies on site-specific management tactics to maximize yield and resources while reducing ecological impacts. Pin-pointing problem areas will allow for spot application rather than whole-field treatment. The ability to efficiently map the distribution of pest populations will impact the future of pest management. By integrating the pest population distribution with economic models, incorporating yield and crop value, it will be possible to determine where pest control measures should be applied, and if the potential economic return justifies application at all. Several aspects of precision agriculture have been widely adopted as many producers have access to some of the technology; however, growers will need to continue to adapt as precision agriculture technology improves and offers more benefits.

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References

Gitelson, A. A., Kaufman, Y. J., and Merzlyak, M. N., "Use of a green channel in remote sensing of global vegetation from EOS-MODIS," Remote Sens. Environ. 58, 289-298 (1996).

Hare, J. D. "Ecology and management of the Colorado potato beetle," Annu. Rev. Entomol. 35, 81-100 (1990).

Herwitz, S. R., Johnson, L. F., Dunagan, S. E., Higgins, R. G., Sullivan, D. V., Zheng, J., Lobitz, B. M., Leung, J. G., Gallmeyer, B. A., Aoyogi, M., Slye, R. E., and Brass, J. A., "Imaging from an unmanned aerial vehicle: agricultural surveillance and decision support," Comp. Elec. Agric. 44, 49-61 (2004).

Huang, Y., Thompson, S. J., Hoffmann, W. C., Lan, Y., and Fritz, B. K., "Development and prospect of unmanned aerial vehicle technologies for agricultural production management," Int. J. Agric. Biol. Eng. 6, 1-10 (2013).

Hunt, E. R., Daughtry, C. S. T., Mirsky, S. B., and Hively, W. D., "Remote sensing with simulated unmanned aircraft imagery for precision agriculture applications," IEEE J. Selected Topics App. Earth Obs. Remote Sens. 7, 4566-4571 (2014).

Hunt, E. R., Hively, W. D., Fujikawa, S. J., Linden, D. S., Daughtry, C. S. T., and McCarty G. W., "Acquisition of NIR-green-blue digital photographs from unmanned aircraft for crop monitoring." Remote Sens. 2, 290-305 (2010).

Hunt, E. R., Cavigelli, M., Daughtry, C. S. T., McMurtrey, J. E., and Walthall, C. L., "Evaluation of digital photography from model aircraft for remote sensing of crop biomass and nitrogen status," Precis. Agric. 6, 359-378 (2005).

Mulla, D. J., "Twenty five years of remote sensing in precision agriculture: key advances and remaining knowledge gaps," Biosyst. Eng. 114, 358-371 (2013).

Park, Y. L., Krell, R. K., and Carroll, M., "Theory, technology and practice of site-specific insect pest management," J. Asia-Pacific Entomol. 10, 89-101 (2007).

Rondon, S.I. "Pest management strategies for potato insect pests in the Pacific Northwest of the United States", Insecticides - Pest Engineering, Farzana Perveen (Ed.). Pp 309-333. ISBN: 978-953-307-895-3. In-Tech. (2012).

Rouse, J. W., Haas, R. H., Schell, J. A., and Deering D. W., "Monitoring vegetation systems in the Great Plains with ERTS," Third Earth Resources Technology Satellite-1 Symposium. Vol. 1, 309-317. NASA SP-351 (1974).

Scharf, P. C., Shannon, D. K., Palm, H. L., Sudduth, K. A., Drummond, S. T., Kitchen, N. R., Mueller, L. J., Hubbard, V. C., and Oliveira, L. F., "Sensor-based nitrogen applications out-performed producer-chosen rates for corn in on-farm demonstrations," Agron. J. 103, 1683-1691 (2011).

Shanahan, J. F., Kitchen, N. R., Raun, W. R., and Schepers, J. S., "Responsive in-season nitrogen management for cereals," Comp. Elec. Agric. 61, 51-62 (2008).

Vincini, M., Frazzi, E., and D'Alessio, P., "A broad-band leaf chlorophyll index at the canopy scale," Precis. Agric. 9, 303-319 (2008).

Wu, J., Wang, D., Rosen, C. J., and Bauer, M. E., "Comparison of petiole nitrate concentrations, SPAD chlorophyll readings, and QuickBird satellite imagery in detecting nitrogen status of potato canopies," Field Crops Res. 101, 96-103 (2007).

Wright, D.L. and Marrois, J. J., "Sustainability aspects of precision agriculture for row crops in Florida and the southeast united states," EDIS #SS-AGR-184 (2015).

Zhang, C. and Kovacs, J. M., "The application of small unmanned aerial systems for precision agriculture: a review," Precis. Agric. 13, 693-712 (2012).