Guest: Dr. Lav Khot

Institution: Washington State University

Interview date: 5-10-22

Background:

Dr. Khot is an Associate Professor of Agricultural Engineering in the Center for Precision and Automated Agricultural Systems at Washington State University (WSU) in Prosser, WA. He was hired to develop precision agriculture approaches to manage crops grown in central Washington state. Much of his work has focused on remote sensing, building crop input models for irrigation, nutrient management, and pesticide application.

He also is currently the Director of WSU’s AgWeatherNet, which is a large, statewide network of sensors that can be used to develop decision support tools for agriculture.

A lot of his research is focused on remote sensing, some of it with drones/UAS. His team has been using drones in this domain for several years and the focus is centered around the data and applications, not as much on platform development.

One major focus is on crop water stress, crop water use mapping, etc. Other applications include assessment of crop lodging in cooperation with USDA-ARS scientists. On the genetics side they’ve worked with folks on forecasting yield of climate resilient crops like pinto bean. They’ve also done some work with potatoes in cooperation with Dr. Rick Knowles and Dr. Mark Pavek at WSU.

Types of work include projects focused on estimation of crop loss (potatoes and hail damage), crop loss cherry (freezing) and water loss/drought for several crops.

More recently his group has acquired a platform that can be used for pesticide application. Lots of work needed to configure flight parameters for delivery in grape, apple, etc.

Also has a project with Dr. Elizabeth Beers focused on release of beneficial insects in orchards for integrated pest management.   
  
He is involved in a multi-state group: S1069: Research and Extension for Unmanned Aircraft Systems (UAS) Applications in U.S. Agriculture and Natural Resources which is active through 2026.

Interview Questions:

*1.      What do you consider the biggest barriers to entry for implementing a UAS into a research program?*

When he started data collection platforms were not at all standardized. There was no homogeneity for mission planning, vehicle-sensor integration, clarity on what sensors the broader community would use, etc. This has improved somewhat as there are now integrated UAS sensor options on the market that can be controlled with a single app.

Analytics are still a major barrier. It is difficult to realize outcomes from the data collected due to this barrier. For example, it can be difficult for students or technicians to generate orthomosaics from the images collected, and harder still to get plot level data from orthomosaics using programs like QGIS.

There are also issues with data collection itself that sometimes cause problems. One can use multispectral or thermal sensors to study crop water use but there are caveats. For example, if images are taken directly after watering with overhead sprinklers it causes problems that confound the signal that is being looked for. The same is true with satellite imagery. It is important to take all remote sensing data with a grain of salt. Timing is really important and using UAS is good because it enables the researcher to really dial in the time of data acquisition.

As far as hardware selections go, they’ve developed a preference to “go local”. If they have problems with the drone or sensor it is often easier and faster to get support from local vendors than it is from international companies. They currently have 4 UAS platforms and are trying to move away from DJI due to U.S. government security concurs.

Their group prefers customizable open-source solutions where they can pull GPS, thermal and RGB data from the platform directly. This can be easier with an open-source platform.

*2.      What do you consider to be the most and least promising applications of UAS-based imaging for agricultural research?*

Precision agriculture. One application is monitoring of plant water use. Multispectral imaging can be used to assess plant stress. Another precision ag application is chemical application. Using UAS doesn’t scale well for large fields, but it can be useful for point application/spot spraying when a localized problem can be identified. One pest of interest is mealy bugs in grape crops. Application of plant growth regulators (PGR) may also work in some cases.

Phenotyping plants as applied to plant breeding. Folks feel it may help make breeding decisions earlier in the breeding cycle.

Crop insurance is another potential application. Examples include hail damage in potato, lodging in mint, etc. Crop lodging map.

Max asked a follow up question about difference/effectiveness of thermal and multispectral sensors. Dr. Khot mentioned that both are good tools for studying water stress. Multspectral is used to look more at the plant response to stress, whereas thermal imaging will give a direct measurement of temperature. These are very different types of measurements. Multispectral tends to have a larger variation potential than thermal.

*3.      What are some of the things you wish you had known before you began using a UAS for data collection?*

Here are some suggestions for a beginner: Set up white or different color boards that mark field boundaries. Setting up ground control points (GCP) first thing before data collection. This greatly enhances the ability to extract data from multiple time points. When using a multispectral make sure you do a calibration with a reflectance panel before and after each flight.

Often times you can reduce the data capture rate. For RGB imaging adjusting the ground travel speed and image capture rate to achieve 70% side and front overlap works well. For thermal imaging you can reduce the number of frames capture to achieve 80-90% overlap. Over the course of the season data builds up. Not uncommon to collect several hundred gigabytes or even terabytes of data, eliminating unnecessary data collection (reducing frame capture rate) will keep storage requirements efficient.

*4.      What educational resources have you found most useful when developing your own skillset with UAS-based imaging?*

Learn about the UAS and sensor platform by reading the manuals or documents associated with the ones you will be using. Learn the basics of drone flights. Dr. Khot teaches a course at Washington State University (BSE552: UAS in AG). He recommends looking at the Federal Aviation Administration web site. Particularly the FAA Part 107 chapters of flight basics. Hands on training is very helpful. He recommends going out with a more experienced pilot and trying out a drone mission or two. As for data analytics, his group has a couple of standard pipelines in the lab. They share analysis templates among group members and customize them for individual applications. Their workflow usually involves generating an orthomosaic in Pix4D then extraction of plot level data in QGIS or ARCGIS.

*5.      Are there other comments you believe would benefit an agricultural researcher considering implementation of a UAS into their research program?*

Remember that when planning data collection that you will always need to analyze and sometimes re-analyze the data that has been collected. The main purpose of any experiment is to generate data that is useful. Before you begin, think about what metadata you need to describe the experiment. Plant your resources not only based upon the drone and sensors but on the experiment. Think about what type of metadata or other data types you will need to collect. Without good metadata or ground truth data you are forced to make a lot of assumptions that might be wrong.

As far as drone basics go, good mapped GCPs and reflectance panel calibration of sensors is a good start for the acquisition stage.

Q: What are other related technologies that folks are developing?

One exciting technology is thermal RGB data from satellites. Lots of multispectral data available from Maxar and Planet Labs. Resolution is pretty good (~ 0.3 M / pixel). No really good source of thermal data from satellites so using thermal sensors on UAS provides benefit for that reason.

Q: Do you have a rule of thumb for how many GCPs are needed in a field?

Generally, at least one at each of the 4 corners of the experiment. If you have a large field (>5 acres) you might include some that crisscross through the middle of the field.

Q: What resources are needed to get more folks to adopt UAV? What can funding agencies (USDA, NSF, etc.) do to help make your UAV research program even more successful?

Collecting more datasets with good metadata. Need more diversity of crops. Need to make the data publicly available. This will help develop and perfect algorithms for classification and prediction.

More standardization of sensors. It is unfortunate that many times the bands collected by multispectral cameras do not match those captured by satellites. One example of this is Micasesne RedEdge camera. Original did not match but the newer 10-band system enables direct comparisons.

Dr. Khot is also interested in exploring the utility of non-imaging sensors on drones. The idea is to measure the temperature and microclimate across orchards… sort of a meteorological map at the micro scale. This might help us better understand bud emergence profiles of fruit trees. It would be nice to tie this data to the national service grid.