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Development of a Robotic Inspection System for Early Detection and Locating of Biotic Stresses in Greenhouse Crops

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2019 ASABE Annual International Meeting

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**Abstract.** **A major challenge in greenhouse crops is the inability to detect stresses and risks early enough preventing uncontrolled spreading of stresses causing irreparable damage. Often, although the knowledge how to handle a stress is available, due to late detection it is too late to act correctly. Hence, farmers often react wastefully. Therefore, there is a compelling need to develop an effective, affordable robotic inspection system using close sensing.**

**The objective of this research is to develop a human integrated intelligent sensory-robotic system for inspection and early detection of biotic stresses and risks in greenhouse crops. The system developed consists a mobile platform, a manipulator mounted on the platform and a sensory system mounted on the platform and the manipulator. A mechanical design of the platform was conducted and the robotic platform was developed.**

**3D mapping algorithms were developed and tested in lab and greenhouse environments using two depth cameras: Microsoft Kinect – TOF camera and Intel RealSense D435 stereo camera. Autonomous real time navigation algorithms were tested successfully. The algorithms were developed using the 3D mapping model, depth cameras and encoders mounted on the platform wheels.**

**A collaborative human robot control algorithm was also developed to guide the robotic system in performing the disease detection task, implemented on the robotic platform and tested in experiments in lab and orchard environments. In these experiments the robotic platform was located in Israel and controlled in real time using the collaborative control system from Purdue University, about 10,000 km away from the robotic platform. Commands, images and data were transferred between these two locations, representing a system controlled by a farmer from a remote location.**

**An advanced image analysis for early detection of TSWV disease based on 'outlier removal auxiliary classifier generative adversarial nets' (OR-AC-GAN) algorithm was developed at the University of Maryland, representing an expert center for disease detection.**

The abstract is often the only part of the paper to be read, so include your major findings in a useful and concise manner. Include a problem statement, objectives, brief methods, quantitative results, and the significance of your findings. The abstract should be no more than 250 words long.

**Keywords.** **Agricultural robotics, Autonomous driving, SLAM, Early Disease Detection, ROS, Hyper Spectral,**  Put keywords in alphabetical order. List both specific and general terms that will aid in searches..

# Introduction

A major challenge in greenhouse crops is the inability to detect stresses and risks early enough preventing uncontrolled spreading of stresses causing irreparable damage. Often, although the knowledge how to handle a stress is available, due to late detection it is too late to act correctly. Hence, farmers often react wastefully. Therefore, there is a compelling need to develop an effective, affordable robotic inspection system using close sensing. In greenhouse environments, the conditions are especially controlled to maximize the crops growth rate and production, which can expose plants to biotic and abiotic risks. Up to 40% of the world crop production is lost through diseases, insects and weeds, according to a 2013 estimate by the Food and Agriculture Organization of the United Nations. Due to scarce human resources, time limitations, and the high cost of current monitoring methods, mostly manual inspection procedures can lead to inaccurate use of nutrients and late detection of diseases. In addition, as farm sizes increase and the availability of labor decreases, more effective agricultural practices are necessary. A high frequency, high resolution and optimally planned crop monitoring apparatus, collaboratively supervised by a human operator to reduce cost, reinforced by agile robotics and spectral sensing technologies could lead to intelligent, efficient, safe, and more effective biotic and abiotic stress management.

The objective of this research is to develop and enable for the first time a human integrated intelligent sensory-robotic system for inspection and early detection of biotic and abiotic stresses and risks in greenhouse crops. This novel system will reduce human labor, reduce the amount of misused watering, pesticides and fertilizers, and detect and prevent in time the spreading of diseases.

# Materials and methods

## Instrumentation

In ARL(Agricultural Robotic Lab at ARO), robotic platform (figure 1) have been developed that fits to drive in greenhouse, carry robotic manipulator, contain inside motors, a battery, sensors, PC that controls all the robot aspects and other components.

The body of the mobile platform is made from aluminium sheet to provide strength and keep the weight low.

A 24V 20AH battery powered two pieces of DC motor + worm gear ECM250/030 which can provide 22Nm @ 75 RPM each, that drive four 20mm shafts with wheels which on the two back shafts are mounted two encoders in resolution of 32 pulses per cycle. Arduino Mega micro controller receives and process the data from the encoders and command Roboteq AX3500 motor driver via serial communication. The microcontroller can receive the commands to drive the platform from two options: Via Xbox controller or via Intel NUC5i7RYH that used as the process center of the platform.

SLAM and 3D mapping algorithms were developed in ARL as well autonomous real time navigation algorithms using two depth cameras:

- Microsoft Kinect – TOF depth camera, which determines the distance of object by project IR light on the object and measure the Time Of Flight until return to the sensors and calculate the distance from the data.

- Intel RealSense D435- also stereo depth camera, but the stereo vision in the IR field and using IR projector for places with poor lights condition. RealSense camera also have RGB sensor for visualization. Inside the RealSense, a processor make the calculations and create the depth map, As a result, it reduces the work from the NUC PC.

Additional camera was installed (Logitech web camera) to help to remote operators to get sense about the environment in real time.

A ROS (Robot Operating System), is installed on NUC PC, set of utilities and libraries for implementing all different kinds of functionality on the robot. As create 3D and 2D maps, SLAM (Simultaneous localization and mapping), control the manipulator, communicate with the Arduino and other peripherals and communicate with other robots and remote control units such as Purdue University and University of Maryland.

On the top of mobile platform is mounted an industrial manipulator (UR 5) which have six DOF and carries the spectral cameras that will detect diseases at the crop. Using an advanced image analysis for early detection of TSWV disease based on 'outlier removal auxiliary classifier generative adversarial nets' (OR-AC-GAN) algorithm was developed at the University of Maryland, representing an expert center for disease detection.

A collaborative human robot control algorithm was also developed to guide the robotic system in performing the disease detection task, implemented on the robotic platform. The robotic platform is located in Israel and controlled in real time using the collaborative control system (HUB-CI) algorithms that developed in Purdue University. Commands, images and data transferred between these two locations, representing a system controlled by a farmer from a remote location.

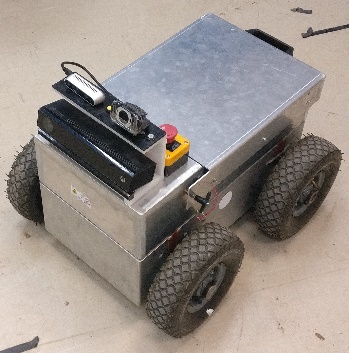


Figure 1- Mobile Robotic Platform

## Experiments

Tests set 1: SLAM with Kinect- in these tests set were checked SLAM using the Kinect camera only, without encoders and other sensors, in different type of lights in the lab and in the greenhouse, to simulate different part of the day. In this set been made tests in the lab and greenhouse during different time of the day and in different time of the year.

In the last part of this set encoders have been mounted on the shafts and added to localization calculations with the Kinect camera and been tested in the lab.

Tests set 2: SLAM with RealSense depth camera – in these tests set SLAM using only RealSense D435 without encoders and RealSense D435 with encoders were checked inside the lab. The tests conducted in different type of lights in the lab, simulating different part of the day.

Tests set 3: autonomous drive with Kinect – the first part is to create a 2D map that contains obstacles and free space where the platform can pass freely. The second part is to send desired point in the space and that the robot will reach to this point, using Kinect camera with encoders.

Tests set 4: autonomous drive with RealSense – the first part is to create a 2D map that contains obstacles and free space where the platform can pass freely. The second part is to send desired point in the space and that the robot will reach to this point, using RealSense camera with and without encoders.

Tests set 5: HUB-CI– in the set several types of communication tested for communicate wirelessly between robots or robot to remoted \*\*\*PC/Expert/Center\*\*\* for information sharing and dynamic decision-making.

In these tests, the following types of communications were tested:

1) Other PC in ARL wireless network send commands via ROS – the platform NUC PC connected via Wi-Fi to ARL network. Another PC with ROS in the same network sends and receives messages with data and commands to the robot.

2) Control to the platform PC from outside ARL network via TeamViewer- the platform NUC PC in ARL (Israel) controlled from another PC in Purdue university, USA about 10,000 km away via TeamViewer. The operator in Purdue can control the movement of the platform with his PC keyboard; can see the 3D map that created with the depth sensors.

3) Control via TeamViewer on other PC in ARL wireless network and send commands via ROS – this test is superposition of tests )a( and )b( – in this test an operator from Purdue controlled on PC with ROS at ARL network via TeamViewer and through it send and receive messages with data and commands to the robot.

4) Transfer data and commands via Dropbox – series of commands entered to excel file in Dropbox folder by operator in Purdue University, and script on the NUC PC read this commands and react according them.

# Results

Tests set 1: in this set SLAM was created by the Kinect. In the first part (Kinect only-without encoders),While the 3D map that received was good early in the morning and late afternoon when the sun radiation is low and doesn’t interrupt to infrared sensors (figure 2), the localization didn’t work well and lost his current position, especially when turning, what caused to drive the platform relatively slow.

After the encoders added to the Kinect the localization improved dramatically and the speed drive of the platform increased. The localization also worked fine and the robot did not lose his position in the space when the Kinect did not work in direct sun light. \*\*\* need to perform test in the greenhouse with encoders\*\*\*\*

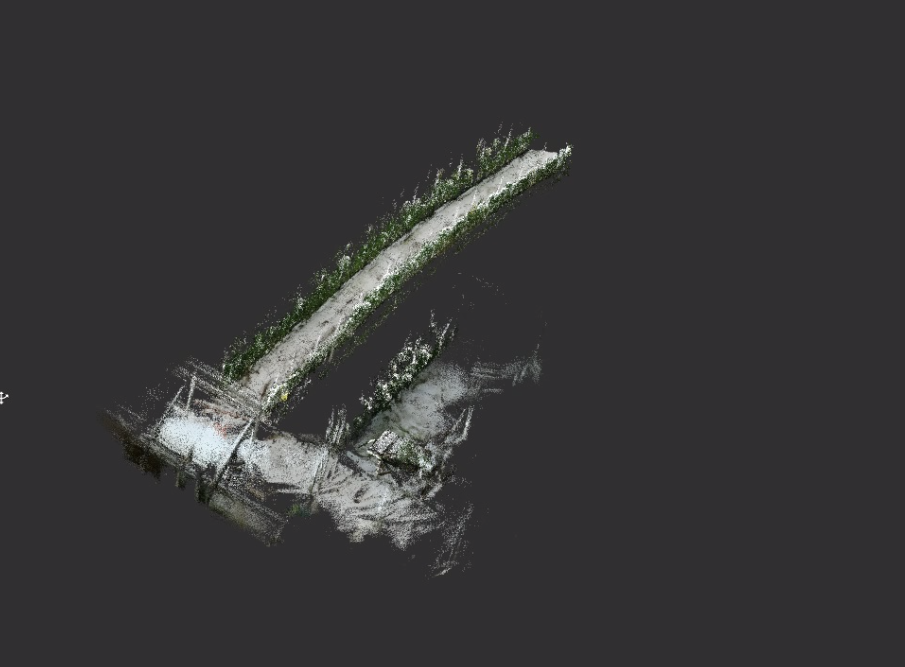
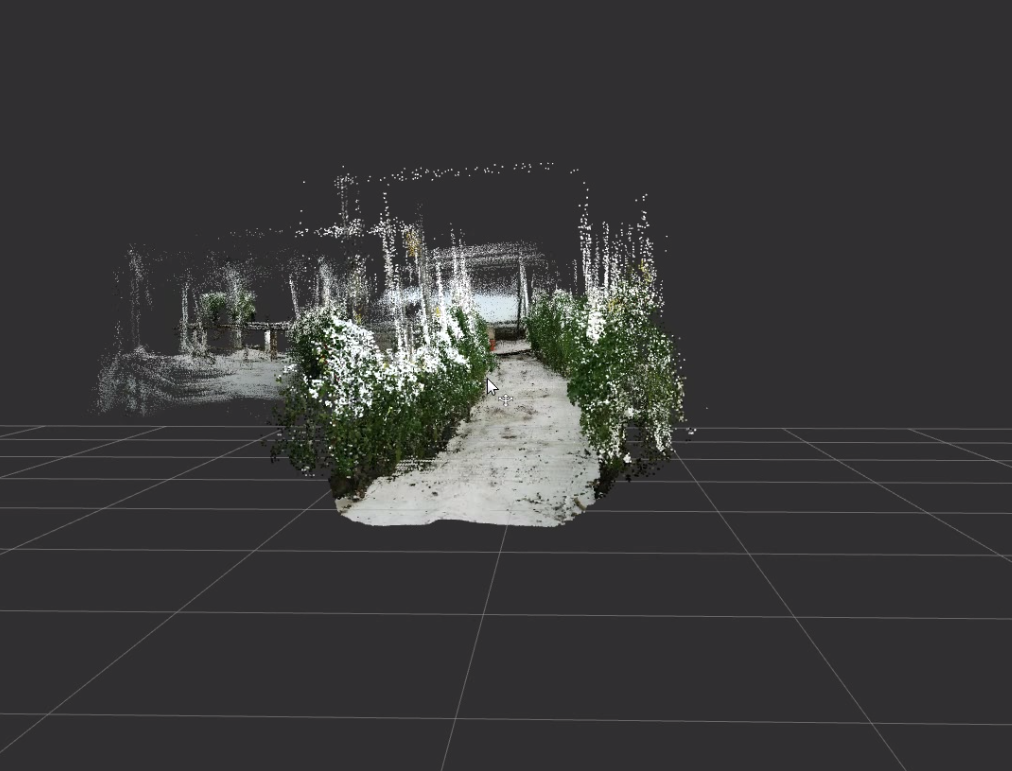
 

Figure 2 - Greenhouse 3D map- Kinect

Tests set 2: in this set SLAM was created by RealSense. In the first part (RealSense only) inside the lab, SLAM worked good in the desired velocities, created good 3D maps. \*\*\* need to perform test in the greenhouse \*\*\*

After the encoders added, there is no noticeable improvement inside the lab from the results without the encoders (figure 3). \*\*\* need to perform test in the greenhouse \*\*\*

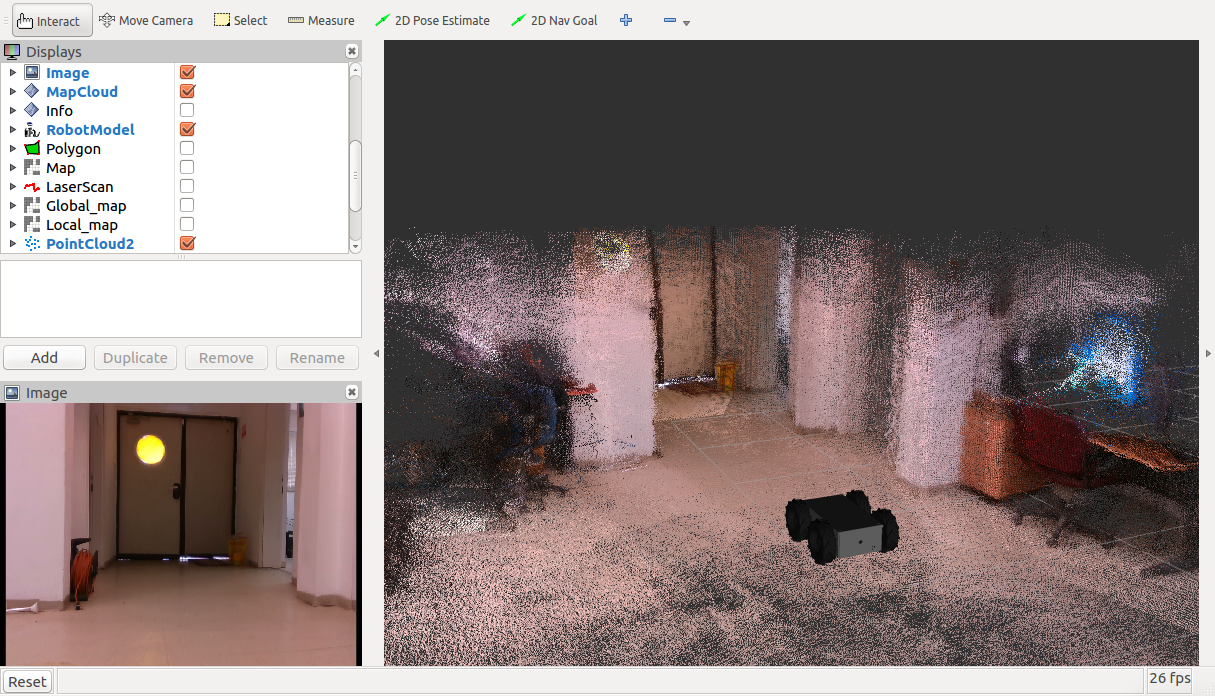
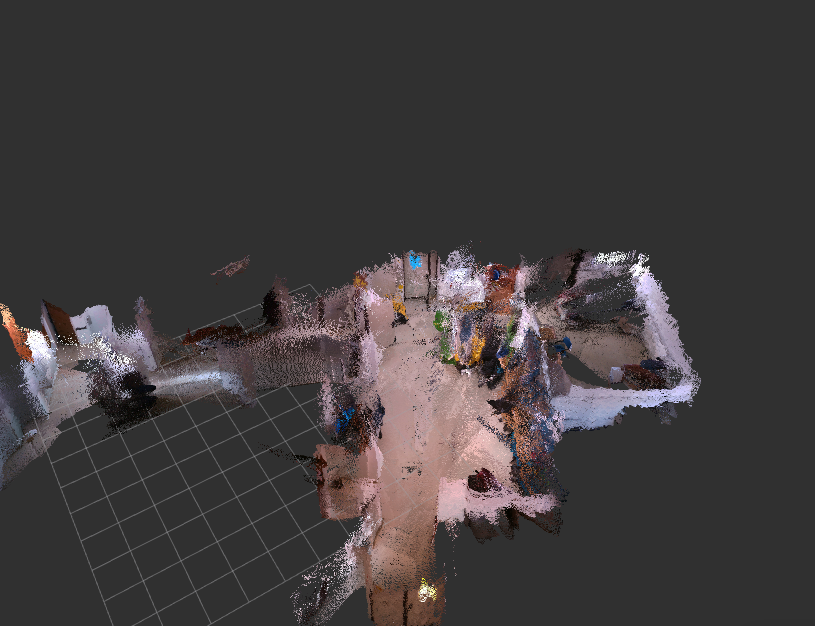
 

Figure 3 - ARL Lab 3D map- RealSense

Tests set 3: inside the lab, a 2D map was created successfully, using Kinect, but the platform did not reach to the desired point. \*\*\* need to perform more test+ test in the greenhouse \*\*\*

Tests set 4: with RealSense + encoders inside the lab, 2D map was created successfully (figure 4) and the platform reach to the desired point. \*\*\*small rotation problems\*\*\* \*\*\* need to perform test in the greenhouse \*\*\*

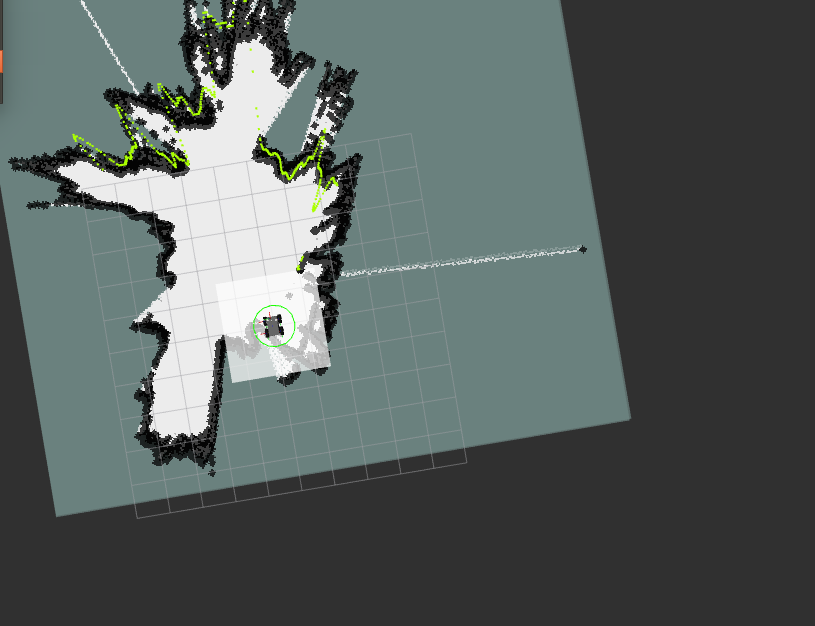


Figure 4 - ARL lab 2D map -RealSense

Tests set 5: in these tests communications types were tested for the collaborative control system, HUB-CI.

1) In this part of the test PC with ROS managed to see all the data from the platform PC, including 3D map, location of the robot, data from all the sensors. In addition, the PC controlled successfully the movement of the platform from its keyboard and send command that simulated the action of take spectral image of the plant. This part tested inside the lab and in the greenhouse.

2) In this part, a remote operator controlled the NUC PC of the robotic platform through TeamViewer. This shows the goal of good communication and transfer data in real time is reached.

3) For effectively communication between units, ROS need that all the unit will be in the same network. According this, remote operator, at Purdue University, controlled a PC in ARL network through TeamViewer. With this PC, with ROS installed, the operator communicate with the platform and successfully simulated collaborative control in real time. The operator succeeded to see the SLAM map, send command to capture picture and to see what the robot view (figure 5). This part tested in the lab and outside the lab at nearby orchard at ARO.

4) In this part, the communication between Purdue University and ARL was performed through Dropbox. Even the commands and data were transformed successfully between the units there was a delay of few seconds between commands, it might be enough for the research purpose but not for commercial use.



Figure 5 - Remote operator view

# Conclusions

Even that the project does not over yet, those are preliminary results and more tests will be done it can be seen some important conclusions:

As shown at results from tests set (1) and tests set (3) – using Kinect for SLAM and autonomous driving is possible in close areas that do not have strong sun radiation, like places without big glass windows or greenhouses at early / late hours of the day.

It is possible even to get satisfy results if using encoders that help to localization.

From the results from tests set (2) and tests set (4) – using RealSense D435 for SLAM and autonomous driving give good results also in closed areas, like the lab and in open areas with direct sun radiation as greenhouse and orchards.

From these four tests it come that the use of Intel RealSense D435 is giving better result for both SLAM and autonomous driving from Microsoft Kinect.

Tests set (5) shown that the robotic platform can be controlled and communicated with remote units and be part of collaborative control system for early disease detection, but more efficient communication method is required. In the near future VPN will create between ARL, Purdue and UMD to simulate that all the research centers are in the same network and the data will reach to all the centers simultaneously in real time.

## Upcoming work

As mentioned before the project does not over yet and more work is needed.

In the part of SLAM and autonomous driving last experiments in the greenhouse is needed to get conclusions about the desired depth camera or integration between the two options.

In the part of communication VPN need to be finished and test the collaborative control through the VPN.

Other part that need to be done and not discussed here and need to be done is control the manipulator to reach the desired positions to bring the spectral camera for detecting diseases.

The last part to do is integration between all the subsystems and conduct full system experiments.

## Acknowledgements

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*m* = mass

*c* = the speed of light

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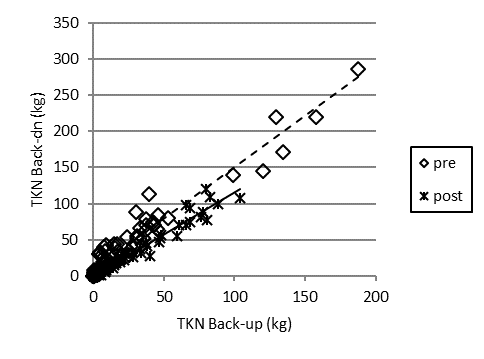


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## Miscellaneous If no author listed, use the name or abbreviation of the organization.

ABCD. (2014).Title. Association of BioCropsDiversity. Retrieved from <http://bcd.org/report.pdf>

Author, A. B. (2018). Patent title. U.S. Patent No. 123,456.

SAS. (1990).SAS User’s Guide: Statistics. Ver. 6a. Cary, NC: SAS Institute.

USDA-NASS. (2004). Report title. Bulletin 1234. Washington, DC: USDA-NASS. Retrieved from [www.usda.nass.gov/x1234.pdf](http://www.usda.nass.gov/x1234.pdf)

## Unpublished Material Do not list such material in the References section because it is not available to the reader. Put useful information in the text of your manuscript, e.g., “. . . this was rare (Charles Brown, USDA-ARS, personal communication, 23 May 2018).

# Appendix or Nomenclature (optional)