Use of UAV acquired imagery as a precision agriculture method for measuring Crop Residue in southwestern Ontario, Canada

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Preserving crop residue in the field after harvest is a common for water storage (Daughtry, and Hunt 2008), soil erosion control (Enciso et al. 2014) and assessment and modeling of soil carbon sequestration (Aguilar et al. 2012). This agricultural management practice is of interest in agro-ecosystems in North America, such as the mid-West and Great Lakes states where agricultural practices, including tillage practices, can affect water quality of the Gulf of Mexico and Great Lakes (Molder et al. 2015). Such practices are of greater importance in the Canadian agro-ecosystem of southwestern Ontario, an area where, retaining crop residue cover ≥30% on the surface is considered a conservation tillage practice (Lal, 2015) and is an important objective of the Great Lakes Agricultural Stewardship Initiative funded by Agriculture and Agri-food Canada (AAFC) and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA, 2015).

Previous studies have found that conservation tillage and crop residue cover are important for reducing time and fuel consumption, improving water and soil quality (Yang et al. 2005), increasing the amount of organic matter (Van Eerd et al. 2014), reducing greenhouse gas emissions (Smith et al. 2008) and reducing soil erosion by up to 75% by maintaining a corn crop residue cover of 15% (Ketcheson and Stonehouse 1983). Crop residue cover estimation has been used to qualify specific fields for federal or provincial conservation programs (i.e., Land Stewardship I and II Programs offered by OMAFRA from 1987 to 1994). Such quantitative information on the amount of crop residue cover by field, which can then be extrapolated to regions, is essential to understand the state of soil management and the capacity for additional change in an area of interest.

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The ability of tillage and planting systems to maintain soil residue cover is currently measured by using one or more of the following methods: Line-transect method (e.g., knotted rope), Meter stick method, Photograph comparison method, Calculation method and Photographic-grid method. Each of these techniques, described more completely by Dodd et al. (1989), has various advantages and disadvantages. A common feature of each, however, is that they tend to be laborious and time-consuming to complete properly. These might be reasons why few landowners directly measure their field residue levels. Line-transect and digital photograph-grid methods are the two main approaches that have been widely used to quantify crop residue cover from ground observations. However, the standard ground-based line-transect method requires significant effort to collect an optimal number of samples (Laamrani et al. 2017), is time consuming, labor intensive and cannot provide continuous data over large areas, as percent residue cover is estimated at spatially and temporally disconnected fields. Several studies have found that the digital photograph-grid method can be a suitable alternative to the line-transect method (i.e., Laamrani et al. 2017). However, one of the main issues in the use of photographs to derive percent residue cover is that multiple manipulations are required (i.e., photograph collection, grid preparation, visual counting by different observers, script or spreadsheet calculation of percentage cover).

Medium-High resolution Remote sensing imagery (i.e., Landsat) is a valuable tool to assess and map tillage practices, crop residue cover and cover crops over large areas. However, monitoring and deriving information on crop residue cover from space has been restricted in the past by low spectral and spatial-temporal resolution and availability of ground truth data. Therefore, there is a need to identify low-cost, reliable, quick and easy to implement methods for residue estimation. The evolution of information technologies and a better understanding of the interactions between electromagnetic radiation and cover crop have opened up new potential for Unmanned Aerial Vehicle (UAV) remote sensing applications. UAVs can offer a number of advantages in term of providing precise and controlled method for soil cover mapping, which may help to reduce input costs and time. In this context, the aim of this study is to determine whether very high resolution multi-spectral remote sensing datasets derived from UAV can be used as alternative method of crop residue estimation for soil cover (bare and crop residue) quantification. To do so, multi-spectral and RGB field images were collected with UAV at the Elora Research Station of the University of Guelph in southwestern Ontario over plots from different long term crop rotations and tillage systems and analyzed with imagery processing methods. These UAV-derived data were compared against a point counting established digital photograph-grid method described in Laamrani et al. (2018). Several flight configurations of monitoring UAV to acquire remote images are tested (i.e., altitudes of 10–50 m).

Preliminary results showed that residue estimates from the UAV approach were in good agreement in good agreement with those obtained from the benchmark photographic proximal remote sensing method. This UAV alternative method could be used for future data collection efforts for high quality ground datasets of residue amounts. The UAV method could therefore be used to track the recommended minimum soil residue cover of 30%, implemented to reduce farmland topsoil and nutrient losses that impact water quality. Such quantitative information on the amount of crop residue cover by field is essential to understand the state of soil management and can be used, for example, as input for assessment and modeling of soil carbon sequestration.

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