# Temporal Dynamics of UAV-Based Vegetation Indices for Estimating Dry Beans Harvest Readiness

**Mujahid Hussain[1], Pantha Azad[1], Kenneth Anku[1], Kristen Macmillan[1], Dilshan Benaragama[1]***

[1]Department of Plant Science, Faculty of Agricultural and Food Sciences, University of Manitoba, Winnipeg, MB, Canada

*Correspondence: dilshan.benaragama@umanitoba.ca

## Introduction

Accurate estimation of harvest readiness and grain moisture is essential for improving dry beans harvest management. Traditional maturity assessment methods are labor-intensive and often unable to capture field variability. UAV-based multispectral remote sensing provides a rapid and non-destructive approach for monitoring crop dry-down and physiological changes under field conditions (1). Vegetation indices such as NDVI, SAVI, VARI, and CI_RE can be used to evaluate crop growth, senescence, and moisture dynamics (2). Therefore, this study evaluated temporal changes in vegetation indices and their relationship with grain moisture content during dry beans maturation.

## Objectives

- Evaluate UAV-based multispectral sensing for monitoring dry beans crop dry-down and harvest readiness.
- Analyze temporal dynamics of vegetation indices (NDVI, SAVI, VARI, and CI_RE) during crop maturity progression.
- Determine the relationship between UAV-derived vegetation indices and grain moisture content across different growth stages.
- Assess the potential of UAV remote sensing as a rapid and non-destructive tool for precision harvest management in dry beans production systems.

## Materials & Methods

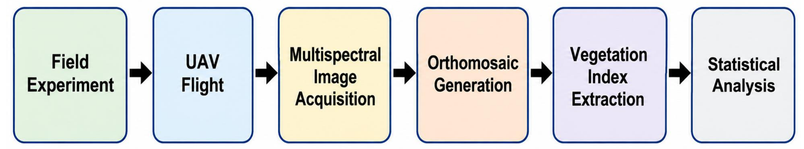
A field experiment was conducted at the University of Manitoba Ian N. Morrison Research Farm, Carman, Manitoba, using two seeding dates (Early and Standard) and five seeding rates arranged in a split-plot design with four replications. Grain moisture content was measured at three 10-day intervals following seed formation. UAV imagery was acquired simultaneously using a DJI Matrice 350 RTK equipped with a MicaSense Altum multispectral sensor. Vegetation indices including NDVI, SAVI, VARI, and CI_RE were extracted from orthomosaic images and analyzed in relation to grain moisture content.

**Figure 1.** Dji Matrice 350 RTK UAV platform used for image acquisition.

**Figure 2.** MicaSense Altum multispectral sensor used for crop reflectance monitoring.

| Parameter | Value |
|---|---|
| UAV Platform | DJI Matrice 350 RTK |
| Sensor | MicaSense Altum |
| Flight Altitude | 12 m AGL |
| Sampling Dates | 3 |
| Replications | 4 |
| Indices | NDVI, SAVI, VARI, CI_RE |

## Workflow



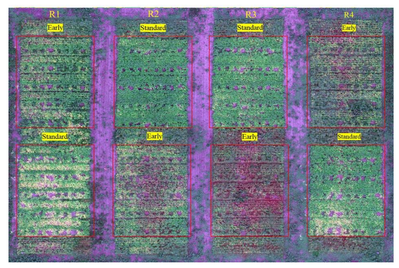




**Figure 3 A.** RGB orthomosaic of experimental plots showing replications (R1–R4) and seeding date treatments.

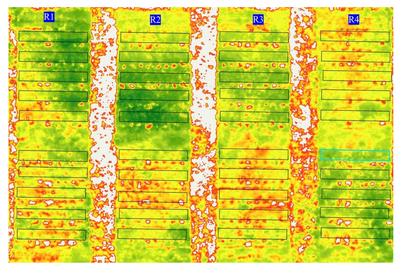



**Figure 3 B.** Thermal imagery illustrating spatial variability in crop canopy temperature across experimental plots.

## Conclusion

- Grain moisture decreased significantly as dry beans maturity progressed.
- NDVI, SAVI, VARI, and CI_RE effectively tracked crop dry-down and maturation.
- NDVI, SAVI, and VARI showed stronger relationships with grain moisture and canopy water content than CI_RE.
- UAV-based multispectral imaging provides a rapid and non-destructive tool for estimating harvest readiness.

**Take-Home Message**

UAV-derived vegetation indices can reliably support dry bean harvest timing and precision crop management.

## Results & Discussion

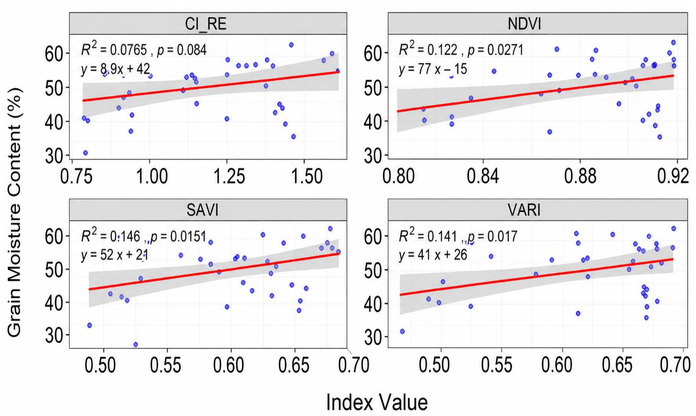



**Figure 4.** Relationships between vegetation indices and grain moisture content (%) at Time point 1.

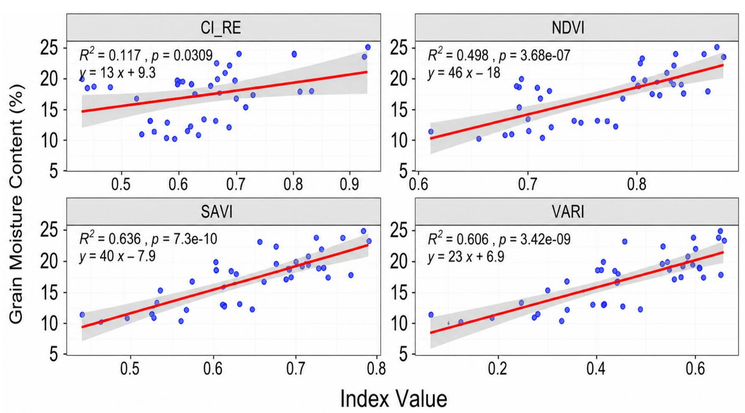
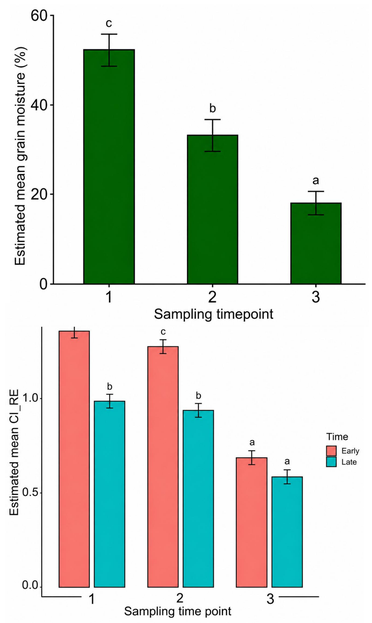



**Figure 5.** Relationships between vegetation indices and grain moisture content (%) at Time point 2.



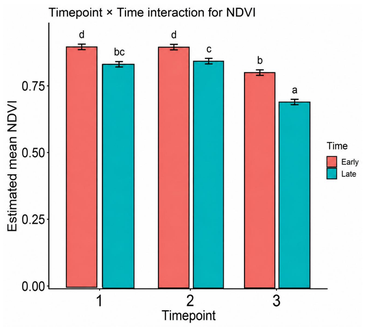




**Figure 6-8.** Grain moisture, NDVI, and CI_RE decreased significantly during crop maturation, reflecting senescence and progression toward harvest readiness.

At Time Point 1 and Time Point 2, all vegetation indices showed positive relationships with grain moisture content and canopy water content (CWC). NDVI, SAVI, and VARI exhibited relatively stronger correlations, while CI_RE showed weaker associations, indicating that UAV-derived vegetation indices are effective tools for monitoring crop moisture status and dry beans maturation.

Temporal variation in NDVI across sampling timepoints during dry beans maturation. NDVI values declined significantly during crop maturation and dry-down progression, with higher values observed at earlier growth stages.

## References

1) Deng, L., Mao, Z., Li, X., Hu, Z., Duan, F., & Yan, Y. (2018). UAV-based multispectral remote sensing for precision agriculture: A comparison between different cameras. ISPRS journal of photogrammetry and remote sensing, 146, 124-136.

2) Xue, J., & Su, B. (2017). Significant remote sensing vegetation indices: A review of developments and applications. Journal of sensors, 2017(1), 1353691.

## Acknowledgements

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## Contact

Mujahid.Hussain@umanitoba.ca