Canadian Agri-Science Cluster for Horticulture 3

Update to Industry

Semi-Annual – Spring 2022

Activity title: Enhancement of Canadian Potato Industry through Smart Agriculture

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Names of Collaborators and Institutions: Drs. Farooque (PEI University), Zaman (Dalhousie University), Schumann (Florida University), Esau (Dalhousie University), Al-Mughrabi (NBDAAF), Comeau (AAFC), Zebarth (AAFC), Lafond (AAFC), Ziadi (AAFC), Chokmani (INRS-ETE), Adamchuk (McGill), Biswas (Guelph) and Duchemin (AAFC)

Activity Objectives (as per approved workplan):

The overall objective is to develop and evaluate precision agriculture (PA) practices suitable for applications in potato production areas of Canada including delineation of management zones (MZs) and variable rate application (VRA) of fertilizer, pesticides, irrigation, plant density as compared to uniform rate application on the basis of tuber yield and quality, nutrient leaching and economic benefits in the provinces of Québec and Prince-Edward Island (PEI).

Research Progress to Date (use plain language, not to exceed 500 words):

Activity 14A Precision Agriculture in Québec: The 14 ha field selected in 2019 (commercial potato production; cultivar Russet Burbank) was also utilized in 2021 in order to evaluate its potential for the nitrogen (N) fertilization experiment under PA approach. Delineation of 3 MZs was based on the soil apparent electrical conductivity (ECa) and pH soil maps. Four treatments consisted of N rates varied from 162 to 252 kg N/ha were applied. On September 20th 2021, total and marketable yield (1-row X 3-m X 2 X 72= 144 yield evaluations) were measured on 72 georeferenced sampling points (SP). Statistical analysis were performed to explore significant differences between the 3 MZ, the 4 N rates and Yields (Total and Marketable). In average, MZ1 and MZ2 gave 10 Mg/ha higher than the MZ3 (**Fig. 1**). The results also showed very significant linear effect of the N rates (**Fig.2**) but not interaction of the MZs and the N rates. Same results were observed on the marketable yield. All soil and plant samples are under analysis and will be finished by the end of April 2022.

On November 2nd and 4th 2021, soil penetration resistance over a depth of 80 cm was measured all along each of the 4 blocks and over 6 transversal transects crossing some of the 72 georeferenced SP, for a total of 189 measurements. A compacted layer, i.e. for a penetration resistance between 4 and 6 MPa with at least 5-cm thickness, was found at a depth ranging between 30 and 45 cm from the soil surface (**Fig. 3**). Ground penetrating radar survey was done on March 4th 2022 over the same soil penetration resistance transects (**Fig. 4**).

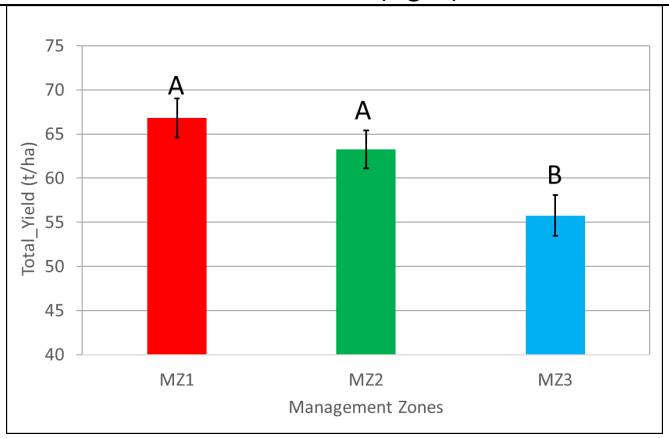


Fig. 1 : Effect of MZs on the total yield.

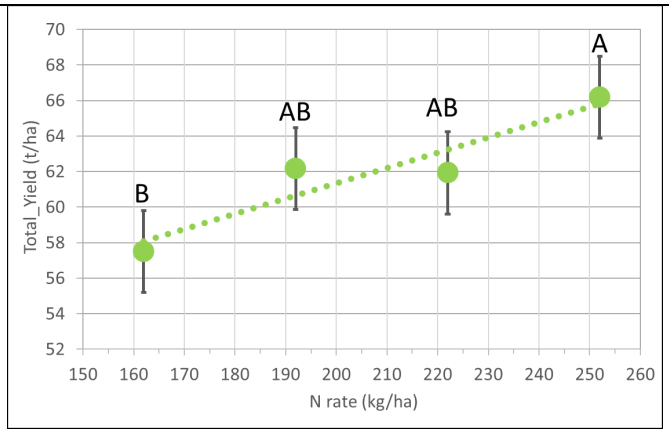


Fig. 2 : Linear effect of the N rates.

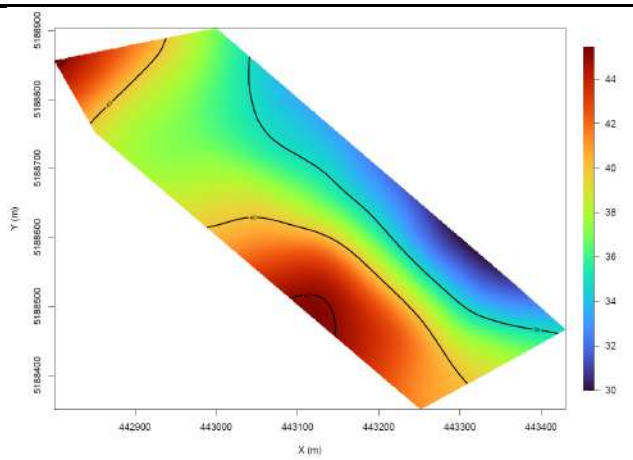


Fig. 3 : Depth (cm) of the compacted layer.

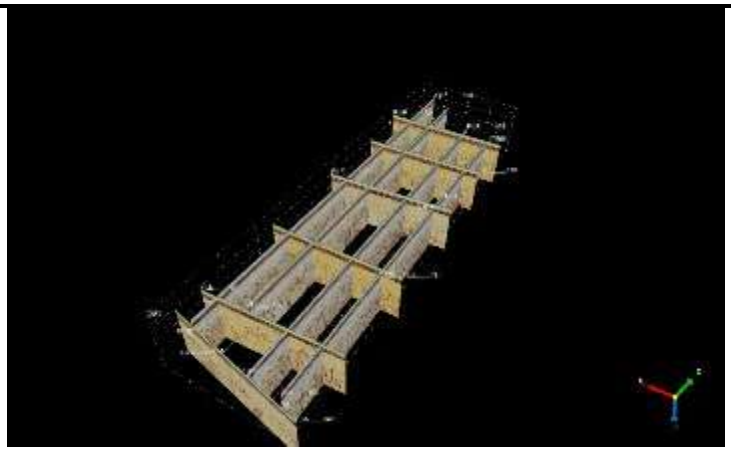


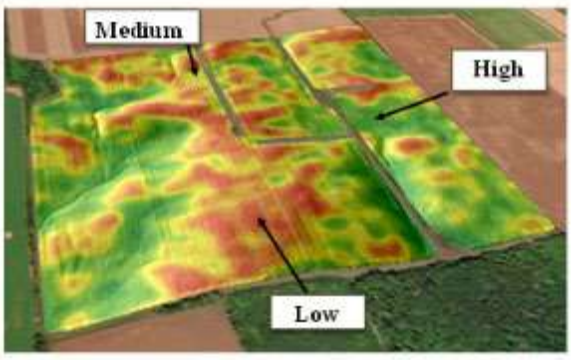
Fig. 4 : GPR survey lines

Activity 14B Precision Agriculture in PEI:

In 2021, the variable rate (VR) application (nitrogen and seeding) based on developed management zones (MZs) using soil, water, and topographic mapping (DualEM-II coupled with topography) was tested in five fields across Prince Edward Island. Before germination, preliminary soil electrical conductivity (ECa) and topography surveys were conducted to delineate fertility-based MZs e.g., low, medium, and high. Eight sampling locations were selected in each MZ for soil and yield sampling (soil organic matter, soil macronutrients, and soil micronutrients) and sensor data collection (soil moisture, ECa, soil temperature, and slope data). Three fields were used to test the VR seeding based on developed MZs i.e., low, medium, and high productivity (Fig. 5). Two fields were used to evaluate the impact of VR nitrogen application based on developed MZs. VR seeding and nitrogen applications were performed based on soil-based management zones, mapped with DualEM-II/SWAT sensor. The drone imagery was done over the growing season to map the crop and soil performance (Fig. 6).

In VR nitrogen treatments, two-way analysis of variance for two treatments (VR and Grower Standard Practice) and three zones (low, medium, and high productivity) suggested significant differences in tuber yield and revenue. Results revealed that the VR nitrogen resulted in $740, $203, and $18 more in MZs 1, 2, and 3 when compared with the grower standard practice for nitrogen application.

In VR seeding trials, wider spacing in the low productivity zone resulted in $210/acre more revenue when compared with the grower standard practice. The tighter spacing in the high productivity zone also resulted in $210/acre more profit than the grower standard seed spacing. Results suggested that the average profit per acre using the VR method (Figure 5) was $106/acre (considering all acres and mapping cost of $10/acre). VR applications showed a great potential to increase tuber yield and profit margins, improve soil health, and lower environmental risks to promote sustainable potato production in Atlantic Canada.



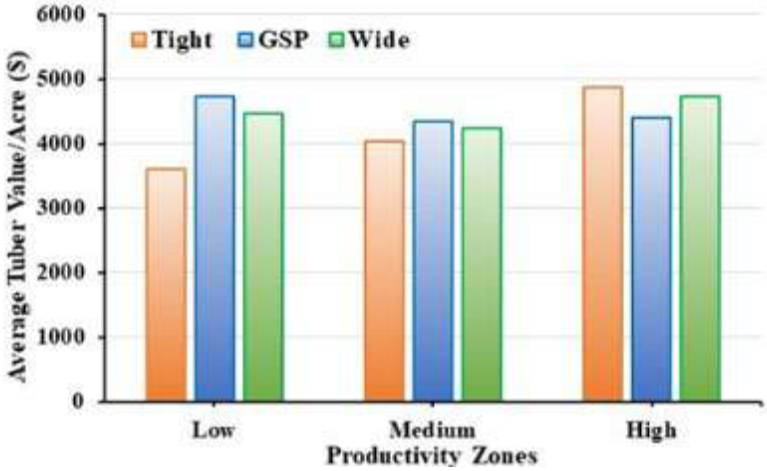


Figure 5: Average crop value per acre considering seed cost and size profile in variable seeding trials.

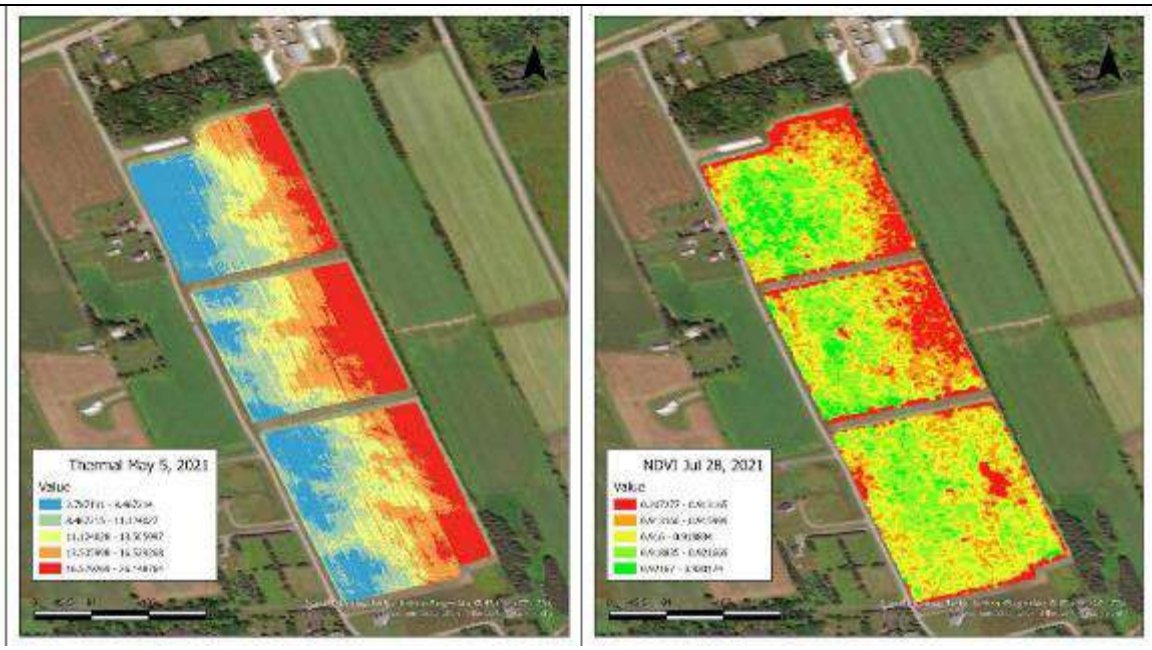


Figure 6: Thermal and NDVI mapping in selected fields.

Extension Activities (presentations to growers, articles, poster presentations, etc.):

Cambouris, A.N., M. Duchemin, N. Ziadi, K. Chokmani et J. Lafond. 2022. Résultats préliminaires saison 2021 : Ferme Cantin et Fils. Virtual Meeting help on April 7th, 2022 (participants : 10).
Lafond, J.A., Goussard, N., **Cambouris, A.N.** 2022. Géoradar et compaction 2021-22. Rapport des travaux 2021-22. Virtual Meeting help on April 7th, 2022 (participants : 10).
Cambouris, A.N. Stratégies d'échantillonnage des sols géoréférencés. Webinar organized by the MAPAQ and CRAAQ presented online, November 16th, 2021 (#of participants: 224).
Farooque, A. & **Cambouris, A.** 2021. Learning to Manage Your Soil with Precision Agriculture: Spudsmart Magazine. Available at: https://spudsmart.com/learning-to-manage-your-soil-with-precision-agriculture/
Barrett, R., MacDonald, E., Afzaal, H. and **A. Farooque**. 2021. Remote sensing creates maps of fields to guide P.E.I. farmers. CBC Article. Available at: https://www.cbc.ca/news/canada/prince-edward-island/pei-remote-sensing-maps-manage-fields-1.6212504
Farooque, A. A. 2021. Soil EC based Management Zones for Nutrient Management and Variable Rate Seeding. Invited Talk – Online Webinar at Regional Meetings in PEI (East, West and Centre), organized by the Potato Board PEI (50 participants)

Farooque, A.A. 2021. Technical Tour. Presented and showcased the project results and demonstrated trials to the Growers, Industry and Government Representatives, Organized by the PEI Potato Board – September 2021 (20 participants).

Farooque, A.A. 2021. Two Days *Workshop on Digital Agriculture and its Role in Sustainability. Delivered at the PMAS Arid Agriculture University, Pakistan.* December 13-15, 2021 (70 participants)

Peer Reviewer Journal Articles
Perreault, S., El Alem, A., Chokmani, K., & **Cambouris, A.N.** 2022. Development of Pedotransfer Functions to Predict Soil Physical Properties in Southern Quebec (Canada). Agronomy 2022, 12, 526. https://doi.org/10.3390/agronomy12020526

Nyiraneza, J., **Cambouris, A. N.,** Nelson, A., Khakbazan, M., Mesbah, M., Perron, I., ... & Lafond, J. (2021). Potato Yield, Net Revenue and Specific Gravity Responses to Nitrogen Fertilizer under Different Canadian Agroecozones. Agronomy, 11(7), 1392.
Clément, C. C., **Cambouris, A. N.,** Ziadi, N., Zebarth, B. J., & Karam, A. (2021). Potato Yield Response and Seasonal Nitrate Leaching as Influenced by Nitrogen Management. Agronomy, 11(10), 2055.

Khan, R., ***A.A. Farooque*****,** F. Abbas, and X. Wang. 2022. Mitigation of greenhouse gas emissions through sustainable agriculture management. *In Review*. *Sustainability Journal*.

Khan, H., Esau, T., **Farooque, A. A.,** Abbas, F., Zaman, Q. U., Barrett, R., & Acharya, B. (2021). Identification of Significant Factors Affecting Potato Tuber Yield for Precision Management of Soil Nutrients. *Applied Engineering in Agriculture*, *37*(3), 535-545.

Khan, R., **Farooque, A. A.,** Brown, H. C. P., Zaman, Q. U., Acharya, B., Abbas, F., & McKenzie-Gopsill, A. (2021). The Role of Cover Crop Types and Residue Incorporation in Improving Soil Chemical Properties. Agronomy, 11(10), 2091.

Scientific presentations at national and international conference:

Martins, S, R. Lhissou, K. Chokmani, **A.N. Cambouris,** 2022. Identifying the irrigation critical point in potato crops fields using UAV remote sensing to smart Farming proposes - A Case Study. Presented at the 2022 Northeast Potato Technology Forum (Virtual), March 16-17, 2022. (participants: 150).

Khan, H., **Farooque, A.,** Esau, T., Abbas, F., Acharya, B., & Zaman, Q. (2021, July 1-14). Development of management zones for site-specific fertilization through proximal sensing of potato fields. American Society of Agricultural and Biological Engineering, virtual (45 participants)

MacDonald, E., and **A.A. Farooque.** 2022. Soil, water and topography maps as a management tool to improve profitability and sustainability within the potato industry. Proceeding of Annual International Conference of Canadian Society for Bioengineering. Charlottetown, PE Canada, July 24-27, 2022.

Khan, H., Acharya, B., Esau, T., **Farooque, A.,** Abbas, F., & Zaman, Q. (2021, June 27-30). Precision management of soil nutrients to identify significant factors influencing potato tuber yield. Proceeding of Canadian Society for Mechanical Engineering International Congress, virtual or on demand (35 participants)

COVID-19 Related Challenges:

If there is no other shutdown of our laboratories, we will be able to deliver everything we put in the plan.

Key Message(s):

- Develop map/sensor-based precision agriculture systems for Québec and Atlantic Provinces Canada's potato industry based on proper characterization and quantification of variability.
- Identify sensor-based options to perform mapping and tailor management practices to reduce labor and sample analysis cost.
- Apply nutrients based on need (VR) to evaluate the productivity benefits.
- Apply seeding based on soil productivity potential.
- Evaluate environmental benefits of the variable rate nutrient management.
- Develop user-friendly protocols for farmers/industry use.
- Train HQP and industry personnel in the emerging area of precision agriculture.

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