Optimization of Fertilizer Use in Agricultural Fields Using Raman and Near-Infrared Spectroscopy

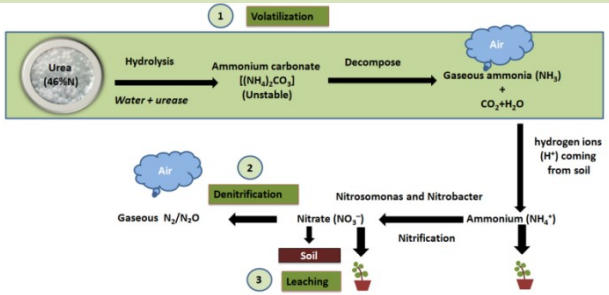
JASNA KP[1], NAVNEET KAUR[2], T. S. SAHOTA[1] , AND GAUTAM DAS[1]

Department of Physics, Lakehead University, Ontario P7B 5E1, Canada. [2]Center for Aquaculture and Seafood Development (CASD), Memorial University of Newfoundland, Canada.

Introduction

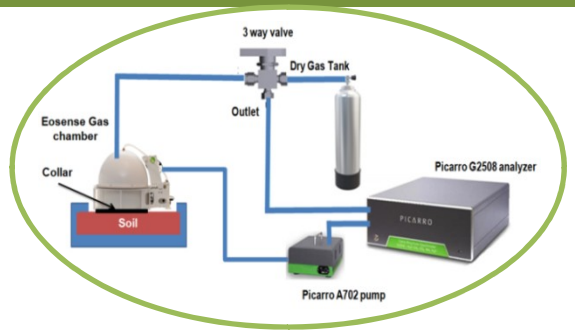
Ontario has more farmers than any other province in Canada, and the use of N-fertilizer is higher, contributing nearly 20% of Canada's agricultural greenhouse gas emissions. As food demand increases and soil N is inadequate, farmers depend on N fertilizers to meet crop needs. However, a significant portion of the applied fertilizers is lost through various processes (e.g., volatilization), polluting the atmosphere and water bodies. To reduce this loss and improve agricultural efficiency, we demonstrated a non-invasive method to estimate plant N needs using Raman spectroscopy and to quantify emission of gases (nitrous oxide, methane, ammonia and carbon dioxide) from fertilized soil using infrared absorption spectroscopy, thereby supporting demand-driven fertilization, enhancing economic benefits while minimizing gas emissions.

N-loss pathways



Methodologies used

Data collection process

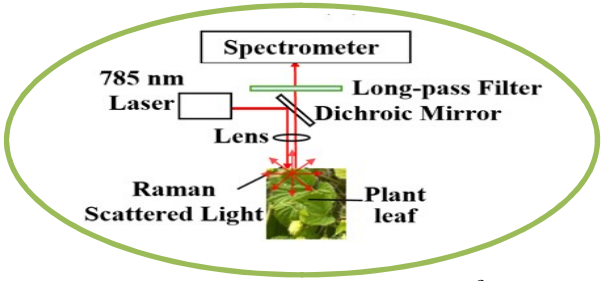


Gas analyzer (Cavity Ring Down Spectroscopy- CRDS) Experimental setup

Treatments Used

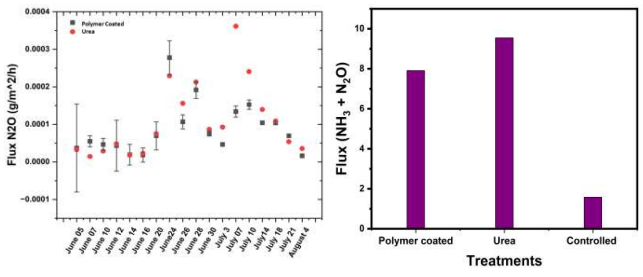
1.Urea
2.Polymer coated
3.Controlled

Gas collection at Canola field (LUARS – Lakehead University Agricultural Research Station)



Raman Spectroscopy system [a]

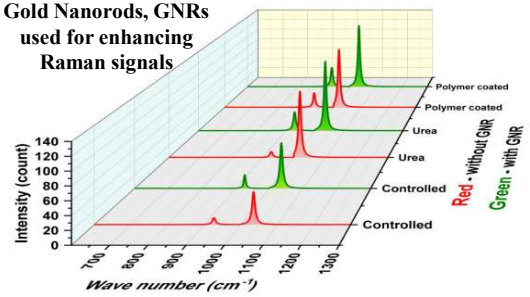
Results



Nitrogen (N) loss via gas emission [a]

a . (Submitted CLEO conference 2026) – under review

Gold Nanorods, GNRs used for enhancing Raman signals



Raman Peaks at ~ 910 cm^{-1} 2(b). ~ 1046 cm^{-1}

Conclusion

We proposed and demonstrated a noninvasive method that integrates Raman spectroscopy and near infrared absorption spectroscopy to estimate optimal use of fertilizers, which will bring economic benefits to farmers and reduce emissions from the fertilized agricultural fields and the environmental impact of the N fertilizers.

Acknowledgement

Nutrien
Ontario Centres of Excellence
NSERC CRSNG
INNOVATION.CA
CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION
Sustainable Canadian Agricultural Partnership
Ontario
Canada