Universidade Federal de Santa Maria
Programa de Pós Graduação em Ciência do Solo

1. IDENTIFICAÇÃO DO PROGRAMA:		
Programa	Programa de Pós-Graduação em Ciência do Solo	
2. TIPO DE COMPONENTE:		
Atividade ( )	**Disciplina (X)**	**Módulo ( )**
3. NÍVEL:		
	Mestrado (X)	Doutorado (X)
4. IDENTIFICAÇÃO DO COMPONENTE:		
Nome:	**Plant nutrition and compositional soil-plant diagnosis**	
Carga Horária Prática	45	
Carga Horária Teórica	45	
Nº de Créditos:	6	
Optativa:	Sim (X)	Não ( )
Obrigatória:	Sim ( )	Não (X)
Área de Concentração:	PROCESSOS QUÍMICOS E CICLAGEM DE ELEMENTOS	
5. DOCENTE RESPONSÁVEL: Léon Etienne Parent		

JUSTIFICATIVA: Brazil is one of the largest fruit producer and exporter worldwide. However, productivity is below expectations. Fertilization may contribute up to 50% to productivity gains. There is a dearth of information on nutrient requirements of fruit species and cultivars in Brazil. The wise use of nutrients requires sound protocols to diagnose soil and plant nutrient status at local scale. Soil testing is the most common procedure to assess the nutrient status of agroecosystems. Tissue testing has the advantage over soil testing as diagnostic tool for deep rooted plants such as fruit crops that access nutrients deeper than would be found through normal soil analytical procedures. Tissue composition integrates several factors such as plant genetics and developmental stage, the environment (climate and soil) and nutrient management. For given nutrient regimes and climatic conditions as regulated by irrigation, genetics interacts primarily with soil properties. Hence, the leaf tissue diagnosed at a specific developmental stage can reveal important aspects of soil fertility, more so in irrigated where water is not limiting than in rainfed agriculture.
Several interpretation methods have been elaborated to diagnose soil and plant nutrient status. Recent Brazilian research showed that nutrient interactions can be handled properly to reach high diagnostic accuracy. Nutrient standards have been developed and published, then programmed on a website to assist identifying nutrient problems in several horticultural crops. Citizen science and experimental research can build large data sets amenable to efficient local diagnoses and recommendations. In this course, participants will learn how to develop nutrient standards using tools of compositional data analysis and machine learning.

OBJETIVOS: The objectives of this course are:

- To capture the evolution of tissue and soil testing concepts and interpretation methods.
- To organize soil and tissue data sets to facilitate their modelling.
- To elaborate balance designs using CoDapack 2.01, and conduct Compositional Nutrient Diagnosis (CND) standards and CND diagnosis using Excel.
- To predict crop performance using machine learning methods in Orange 3.23.
- To recover nutrient balance at local scale using neighbouring “enchanted” islets.

6. EMENTA: At the end of the course, the participant will be able to:

- Reconstitute the history of soil and tissue testing and interpretation methods.
- Calibrate CND standards and conduct CND diagnosis using ellipsoids.
- Collect nutrient data in an organized way.
- Predict crop performance at local scale using machine learning methods.
- Diagnose local nutritional problems and find solutions in the neighbourhood.

7. PROGRAMA DA DISCIPLINA/ATIVIDADE/MÓDULO:

General information

Sixteen nutrients are essential to plants (C, H, O, N, S, P, K, Ca, Mg, B, Cl, Zn, Mn, Fe, Cu, Mo) and five others are considered beneficial (Ni, Si, Na, Co, Se). We will first review agronomic “laws” of the minimum, the optimum and diminishing returns describing crop response to essential nutrients; nutrient transfer processes; expressions for nutrients interactions; selection of diagnostic tissues; the main procedures used to quantify and calibrate soil and crop nutrient status. We will review the log-normal, logistic and Dirichlet distributions and the early DRIS concept, and introduce log ratio transformations as alr, clr, and ilr. Thereafter, we will introduce new interpretation methods based on compositional data analysis, matrix calculations and data partitioning techniques, as well as machine learning methods to predict crop performance using well-organized and documented data sets. Finally, we will apply compositional data analysis and machine learning methods to soil and tissue data to rebalance the soil-plant system locally.

Pedagogical approach

Slide presentations, references and readings, in-class and take-home exercises

Materials

Slides, data sets, references and more than 15 solved exercises, Orange 3.23 data mining videos with subtitles in portuguese (https://www.youtube.com/channel/UClKKWBe2SCAEyv7ZNGhIe4g)

Softwares

Excel, Orange 3.23 freeware (machine learning), CodaPack 2.02.21 freeware (alr-, clr- and ilr-transformations, biplot analysis), Jamovi freeware (principal component analysis).

8. FORMA DE AVALIAÇÃO E FREQUÊNCIA:

One-week course (indoor class).

Personal work (homework).
Attendance to the course is mandatory.
Evaluation: exercises, readings, elaboration of a project; report as a scientific article; presentations in class.

9. BIBLIOGRAFIA:

Books and book chapters

General topics:

Barber, S. A. 1995. Soil nutrient bioavailability : a mechanistic approach. Wiley, NY.

Bataglia, O.C., Furlani, A.M.C., Teixeira, J.P.F., Furlani, P.R., Gallo, J.R. 1983. Metodos de Analise Quimica de Plantas. Boletim Técnico 78, Instituto Agronômico de Campinas (IAC), Campinas – SP, Brazil.

Beaufils, E.R. 1973. Diagnosis and recommendation integrated system (DRIS). A general scheme of experimentation and calibration based on principles developed from research in plant nutrition. University of Natal, Pietermaritzburg, South Africa. 132 p.

Epstein, E., Bloom, A.J. 2004. Mineral Nutrition of Plants. Principles and Perspectives. Second Edition. Sinauer Associates, Oxford University Press, UK. 380 pp.

Marschner, H. 1986. Mineral Nutrition of Higher Plants. London, Orlando: Academic Press, NY doi:10.1146/annurev.es.11.110180.001313. Updated in 1995.

Raij, B. V, Andrade, J. C., Cantarella, H., Quaggio, J. A. 2001. Analise química para avaliação de fertilidade de solos tropicais. Instituto Agronômico de Campinas (IAC), Campinas – SP, Brazil.

Srivastava, A.K., Hu, C. (Eds). 2019. Mineral nutrition of fruit crops. Elsevier, Amsterdam.

Westerman, R.L. 1990. Soil Testing and Plant Analysis. 3rd Ed., Soil Science Society of America Book Series #3, Madison WI. 784 pp.

Wilkinson, S.R. 2000. Nutrient Interactions in Soil and Plant Nutrition, pp. D89-D112 in: M. E. Sumner, Ed., Handbook of Soil Science, CRC Press, Boca Raton FL.

Suggested reading:

Parent, S.-É., Parent, L. E. Rozane, D. E. Hernandes, A., Natale, W. 2012. Nutrient balance as paradigm of plant and soil chemometrics. Chapter 4 in Soil Fertility, ed. Issaka, R.N., [NY: InTech Publ.], P. 83-114. http://www.intechopen.com/books/soil-fertility. Free access.

Free-access documents

General topics:

1. Aitchison, J., Barcelo-Vidal, C., Martin-Fernandez, J.A., Pawloswky-Glahn, V. 2000. Logratio Analysis and Compositional Distance. Mathematical Geology 32(3), 271-275. http://ns.leg.ufpr.br/lib/exe/fetch.php/pessoais:abtmartins:logratioanalysisandcompositionaldistance.pdf
2. Badra, A., Parent, L.E., Allard, G., Tremblay, N., Desjardins, Y., Morin, N. 2006. Effects of leaf nitrogen concentration versus CND nutritional balance on shoot density and

foliage colour of an established Kentucky bluegrass (Poa pratensis L.) turf. Canadian Journal of Plant Science 86, 1107–1118.

3. De Wit, C.T. 1992. Resource use efficiency in agriculture. Agricultural Systems 40, 125–151. doi:Doi: 10.1016/0308-521x(92)90018-j.
4. Diaz-Zorita, M., Perfect, E., Grove, J. H. 2002. Disruptive methods for assessing soil structure. Soil Tillage Research 64, 3–22. doi:10.1016/S0167-1987(01)00254-9.
5. Egozcue, J.J., Pawlowsky-Glahn, V. 2005. Groups of parts and their balances in compositional data analysis. Mathematical Geology 37, 795–828. Available at: http://springerlink.metapress.com/openurl.asp?genre=article&id=doi:10.1007/s11004-005-7381-9
6. Fernández, V., Brown, P.H. 2013. From plant surface to plant metabolism: the uncertain fate of foliar-applied nutrients. Frontiers in Plant Science, 31 | https://doi.org/10.3389/fpls.2013.00289
7. Fortin, J.G., Morais, A., Anctil, F., Parent, L.E. 2014. Comparison of machine learning regression methods to simulate NO3 flux in suction lysimeters under potato cropping. Applied Mathematics 5, 832-841.
8. Gibson, K.J., Matthew K.S., Topping T.S., Gregory W.S. 2019. Utility of citizen science data: A case study in land-based shark fishing. PLoS ONE 14(12), 1-15. e0226782.https://doi.org/10.1371/journal. pone.0226782
9. Parent S.-É., Parent L.E., Egozcue J.J., Rozane D.E., Hernandes A., Lapointe L., Hébert-Gentile V., Naess K., Marchand S., Lafond J., Mattos D. Jr, Barlow P., Natale W. 2013. The plant ionome revisited by the nutrient balance concept. Frontiers in Plant Science 4(39), 1-10. Doi: 10.3389/fpls.2013.00039
10. Pawlowsky-Glahn, V., Egozcue, J.J., Tolonosa-Delgado, R. 2007. Lecture Notes on Compositional Data Analysis. Training course on Compositional Data Analysis, University of Girona, Technical University of Catalonia and Georg-August-Universität Göttingen. https://www.researchgate.net/publication/37814008_Lecture_Notes_on_Compositional_Data_Analysis
11. Peck, T. R. 1990. Soil testing: Past, present and future. Communications in Soil Science and Plant Analysis 21(13-16), 1165-1186, doi10.1080/00103629009368297
12. Pellerin, A., Parent, L.E., Fortin, J., Tremblay, C., Khiari, L., Giroux, M. 2006. Environmental Mehlich-III soil phosphorus saturation indices for Quebec acid to near neutral mineral soils varying in texture and genesis. Canadian Journal of Soil Science 86, 711-723.
13. Souza, H.A., Parent, S.-É., Rozane, D.E., Amorim, D.A., Modesto, V.C., Natale, W., Parent, L.E. 2016. Guava waste to sustain guava (*Psidium guajava*) agroecosystem: nutrient “balance” concepts. Frontiers in Plant Science 7, article 1252. doi: 10.3389/fpls.2016.011252

Suggested readings:

1. Aitchison, J. 1994. Principles of compositional data analysis. Multivariate Analysis and

Its Applications. IMS Lecture Notes - Monograph Series 2, 73-81. https://projecteuclid.org/download/pdf_1/euclid.lnms/1215463786

2. Deus, J.A.L, Neves, J.C.L., Corréa, M.C.M., Parent, S.-É., Natale, W., Parent, L.E. 2018. Balance design for robust foliar nutrient diagnosis supervising the fertigation of banana “Prata” (*Musa* spp.). Nature Scientific Reports doi: 10.1038/s41598-018-32328-y

3. Nowaki, R.H.D., Parent, S.-É., Cecílio Filho, A.B., Rozane, D.E., Meneses, N.B., Santos da Silva, J.A., Natale, W., Parent, L.E. 2017. Phosphorus Over-Fertilization and Nutrient Misbalance of Irrigated Tomato Crops in Brazil. Frontiers in Plant Science, section Crop Science and Horticulture 19 May 2017 | https://doi.org/10.3389/fpls.2017.00825

4. Parent, L. E., Dafir, M. 1992. A theoretical concept of compositional nutrient diagnosis. Journal of the American Society for Horticultural Science 117, 239-242.

5. Parent, S.-É., Parent, L.E. 2017. Balance designs revisit indices commonly used in agricultural science and eco-engineering. CodaWork 2017. The 7th International Workshop on Compositional Data Analysis. K. Hron and R. Tolosana-Delgado (eds). Abbadia San Salvatore, Italy, June 5-9. http://www.compositionaldata.com/codawork2017/ proceedings/

6. Parent, S.-É., Parent, L.E., Rozane D.E., Natale, W. 2013. Nutrient balance ionomics: case study with mango (*Mangifera indica*). Frontiers Plant Science 4, article 449.