Course: Soil Microbiology

Identification

Code: SOL
Credits: 5 (3 hours theory - 2 hours practice)
Level: Master and Doctorate
Professors: Celso Aita and Sandro José Giacomini
System: Annual (II Semester)

Discipline objectives

To identify the main populations that make up the soil microbial community, their biochemical functions, diversity, structure, and interrelationships. To enable students to identify and evaluate the main transformations of microbial origin, their determining factors, and their relationship to the quality of the soil and the environment and plant nutrient availability.

Syllabus

Origin and evolution of life on planet earth; microbial metabolism; components of soil microbiota; ecophysiology of the main bacterial groups; microbial growth and its control; biogeochemical cycles of carbon, nitrogen, iron, sulfur, and phosphorus; mycorrhizae; pesticides: microbial degradation and effects on microorganisms; microbiology of flooded soils; plant growth-promoting rhizobacteria; microorganisms and environmental quality.

Methodology and/or teaching instruments

Lectures and individual seminars by the students.

Forms of evaluation

Written tests, seminars, and class participation.

Program: Title and Breakdown of Units

Unit 1

Origin and evolution of life on planet Earth
1.1 - Genetic and biochemical similarities among living beings
1.2 - Microbial diversity
    1.2.1 - Differences between prokaryotic and eukaryotic organisms

Unit 2

Microbial metabolism
2.1 - Definitions
2.2 - Sources of nutrients and growth factors
2.3 - Control of enzyme synthesis
2.4 - ATP production
2.5 - Catabolic diversity and microbial biosynthesis
    2.5.1 - Aerobic respiration
    2.5.2 - Anaerobic respiration
    2.5.3 - Fermentations
    2.5.4 - Microbial photosynthesis
    2.5.5 - Oxidation of inorganic compounds

Unit 3

Components of the soil microbiota
3.1 - Bacteria
    3.1.1 - Characteristics and taxonomic classification
    3.1.2 - Nutritional classification
    3.1.3 - Classification into physiological groups

3.2 - Fungi
- 3.2.1 - Main functions in the soil
- 3.2.2 - Taxonomic classification

3.3 - Algae, protozoa, and other microorganisms
- 3.3.1 - Main functions in the soil

Unit 4

Ecophysiology of the main bacterial groups

4.1 - Spore-forming bacteria
4.2 - Enteric group bacteria and related organisms
4.3 - Aerobic chemolithotrophic bacteria and associated organisms
4.4 - Chemoheterotrophic aerobic bacteria
4.5 - Filamentous actinomycetes and related organisms
4.6 - Obligatory anaerobic bacteria

Unit 5

Microbial growth and its control

5.1 - Cell growth and bacterial populations
- 5.1.1 - Bacterial growth phases
- 5.1.2 - Mathematical expression of bacterial growth

5.2 - Effects of abiotic factors in microorganisms
- 5.2.1 - Temperature and pH
- 5.2.2 - Water, oxygen, and nutrient availability

Unit 6

Carbon biogeochemical cycle

6.1 - Importance of microorganisms in the carbon cycle
6.2 - Nature and metabolism of carbon sources
6.3 - Decomposition dynamics of organic materials
- 6.3.1 - Simple polysaccharides
- 6.3.2 - Aromatic substances

6.4 - Formation, composition, and functions of soil organic matter

Unit 7

Nitrogen biogeochemical cycle

7.1 - Nature and metabolism of nitrogen sources
- 7.1.1 - Mineralization, immobilization, nitrification, and denitrification
  - 7.1.1.1 - Biochemical mechanisms
  - 7.1.1.2 - Involved microorganisms
  - 7.1.1.3 - Influence of abiotic factors

7.2 - Biological fixation of atmospheric nitrogen
- 7.2.1 - Enzymes and energetics
- 7.2.2 - Asymbiotic biological fixation
  - 7.2.2.1 - Biochemical mechanisms
  - 7.2.2.2 - Involved microorganisms
- 7.2.3 - Symbiotic biological fixation
  - 7.2.3.1 - Biochemical mechanisms
  - 7.2.3.2 - Known symbiotic associations
  - 7.2.3.3 - Inoculants and inoculation

Unit 8

Phosphorus and sulfur biogeochemical cycles

8.1 - Microbial transformations in the soil
- 8.1.1 - Mineralization and Immobilization
  - 8.1.1.1 - Biochemical mechanisms
  - 8.1.1.2 - Involved microorganisms
  - 8.1.1.3 - Influence of abiotic factors
- 8.1.2 - Microbial solubilization of P and S

8.2.1.1 - Biochemical mechanisms
8.2.1.2 - Involved microorganisms
8.1.3 - Ecto and endomycorrhizae
8.1.3.1 - Forms and distribution
8.1.3.2 - Physiology and function of mycorrhizae
8.1.3.3 - Nutrient fluxes between mycorrhizal fungi and hosts

Unit 9

Pesticides: microbial degradation and effects on microorganisms

9.1 - Factors that affect biodegradation in soil
9.2 - Transformation reactions
9.3 - Metabolism and co-metabolism
9.4 - Adaptation and development of new degrading capabilities
9.5 - Applied aspects of pesticide biodegradation
9.6 - Inhibitory effects of pesticides on microorganisms

Unit 10

Microbiology of flooded soils

10.1 - Physical-chemical conditions prevailing in flooded soils
10.2 - Microorganisms present in anoxic conditions
12.3 - Anaerobic metabolism and decomposition of organic materials
12.4 - Microbial nutrient transformations in flooded soils
12.5 - Microorganisms and greenhouse gas emissions in flooded soils

Unit 11

Plant growth-promoting rhizobacteria (PGPR)

11.1 - Rhizospheric environment
11.2 - Main growth-promoting bacteria
11.2 - Importance in plant nutrition
11.3 - Potential and limitations of inoculation with PGPR

Unit 12

Microorganisms and environmental quality

12.1 - Methanogenesis
12.2 - Composting
12.3 - Bioremediation
12.4 - Aerobic biogranulation
12.5 - Microbial biofilms

Recommended literature

ALDWELL, D.R. **Microbial physiology and metabolism**. Belmont: Star Publishing Company, 2000. 403 p.

ALEXANDER, M. **Introduction to soil microbiology**. New York: John Willey & Sons, Inc., 1977. 467 p.

ATLAS, R.M., BARTHA, R. **Microbial ecology: fundamentals and applications**. Califórnia: Benjamin Cummings Publishing Company, Inc., 1997. 533 p.

BECKER, W.B. **Energy and the living cell**. New York: J. B. Lippincott Company, 1977. 346 p.

BETHLENFALVAY, G.J., LINDERMAN, R.G. **Mycorrhizae in sustainable agriculture**. Madison: ASA Special Publication number 64, 1992. 124 p.

BLACK, J.G. **Microbiology: Principles and Explorations.** 7th ed. Hardcover- Wiley, 2008. 968p.

CARDOSO, E.J.B.N., TSAI, S.M., NEVES, M.C.P. **Microbiologia do solo**. Campinas: Sociedade Brasileira de Ciência do Solo, 1992. 360 p.

CREAGER, J.C., BLACK, J.G., DAVISON, V.E. **Microbiology: principles and applications**. New Jersey: Prentice-Hall, Inc., 1990. 753 p.

ELSAS, J.D.V., TREVORS, J.T., WELLINGTON, E. M.H. **Modern soil microbiology**. New York:Marcel Dekker, Inc., 1997. 693 p.

GOTTSCHALK, G. **Bacterial metabolism**. New York: Springer-Verlag, 1979. 281 p.

HATFIELD, J.L., STEWART, B.A. **Soil biology: effects on soil quality**. Boca Raton: CRC Press, Inc., 1994. 169 p.

HUNGRIA, M., ARAUJO, R.S. **Manual de métodos empregados em estudos de microbiologia agrícola**. Brasília: EMBRAPA-CNPAF, 1994. 642 p.

KOSUGE, T., NESTER, E.W. **Plant-microbe interactions**. New York: Macmillan Publishing Company, 1994. 444 p.

MADIGAN, M.T., MARTINKO, J.M., DUNLAP, P.V., CLARK, D.P. **Brock: Biology of Microorganisms**. 12th. ed. Pearson: Benjamin Cummings, San Francisco, Estados Unidos, 2009. 1061 p.

MOREIRA, F.M. de S., SIQUEIRA, J.A. **Microbiologia e bioquímica do solo**. 2ª ed., atual. e ampl., Lavras, MG: Ed. da Universidade Federal de Lavras, 2006. 729p.

PAUL, E.A. **Soil Microbiology, Ecology and Biochemistry.** 3rd ed. Hardcover – Academic Press, 2007. 552p.

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PRESCOTT, L.M., HARLEY, J.P., KLEIN, D.A. **Microbiology**. 6th ed. Boston: McGraw-Hill, 2007. 1088p.

MAIER, R.M., PEPPER, I.L., GERBA, C.P. **Environmental microbiology**. 2nd ed., Amsterdam, Holanda, Elsevier: Academic Press, 2009. 598p.

SCHLEGEL, H.G. **General microbiology**. Cambridge: Cambridge University Press, 1997. 697 p.

SIQUEIRA, J.O; FRANCO, A.A. **Biotecnologia do solo: fundamentos e perspectivas**. São Paulo: Editora Gráfica Nagy Ltda., 1988. 236 p.

SIQUEIRA, J.O. **Avanços em fundamentos e aplicação de micorrizas**. Lavras: Universidade Federal de Lavras/DCS e DCF, 1996. 290 p.

SPRENT, J.I., SPRENT, P. **Nitrogen fixing organisms: pure and applied aspects**. New York: Chapman and Hall., 1990. 266 p.

SYLVIA, D.M., FUHRMANN, J.J., HARTEL, P.G., et al. **Principles and applications of soil microbiology**. New Jersey: Prentice-Hall, Inc., 1998. 528 p.

TORTORA, G.J., FUNKE, B.R., CASE, C.L. **Microbiology: an introduction**. 10ª ed. Benjamin Cummings, 2009. 960p.

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