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Plant & Soil Science:
Fundamentals & Applications

Sarika Garg, Ph.D.

Plant & Soil Science: Fundamentals & Applications

Plants are the cornerstone of existence on earth and a vital resource for human prosperity. All plants need nearly 15 essential elements in order to germinate properly. These essential elements are 'mineral nutrients' and are procured from the soil. This makes it imperative to have a proper comprehension of the soil.

The word 'soil' is evolved from Latin word Solum. Soil has numerous interpretations. For some users, soil is the foundation for concrete construction. On the other hand, several users including farmers and earth science specialists believe 'Soils clasp existence and universe'. Soil is a complex mix of minerals, air, water and innumerous microorganisms. It is primarily a medium for food, atmosphere, organisms, water and nutrients. Hence, soil is indispensable and requires much care and attention. In the modern era, soil should meet the communal necessities not only for food and shelter but also for natural environment.

There are many challenges for soil such as erosion and degradation, population, environment, land management, etc. Soil scientists are working hard to meet such needs and challenges. As an editor, I have thrown light on key facts and discoveries being revealed by soil scientists. Chapters in the book provide interdisciplinary nature of the soil, its properties and its effects on the growth and development of plants. The significance of nutrients for crop quality has also been discussed. Benefits of nitrogen fertilizers have also been talked about. In this book, there is also one chapter focussed on the recovery of plants after soil drought. The impacts of soil microbes are also discussed.

Sarika Garg procured her doctoral degree at the Max Planck Unit For Structural Molecular Biology, University of Hamburg, Germany in 2011. This was followed by Postdoctoral Scientist position at University of Saskatchewan, Canada. Later, she moved to CRCHUM, University of Montreal for her second Postdoc. She has diverse research interests and has contributed immensely in many research fields viz. Enzyme Technology, Environmental Science, and Neuroscience. She has numerous research papers and review articles to her credit. She has coauthored two books 'Enzymes & Enzyme Technology'; and 'Biochemical Tests: Principles and Protocols'. She has also contributed several chapters in various books including a chapter on Regulation of Gene Expression in Encyclopedia of Molecular Cell Biology and Molecular Medicine. She is a recipient of 2012 SHRF Postdoctoral Fellowship Award and 2012 Laura E. Chapman Research Award. She is currently working as a Career Counselor in her very own venture 'higherstudiescounseling.com', Montreal, Canada and as a freelancer science writer.

Delve Publishing

ISBN 978-1-68095-760-0

9 781680 957600 00000

Garg

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Editor:

Sarika Garg

Delve Publishing

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Editor: **Sarika Garg**

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708 3rd Avenue, 6th Floor
New York, NY 10017
United States of America

www.delvepublishing.com

ISBN: 978-1-68095-760-0

Library of Congress Control Number: 2016951516

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Sarika Garg

Ph.D. Montreal, Canada

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Preface

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I hope that this book will prove to be useful for teaching, learning and research.

Editor
Sarika Garg, Ph.D.
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CHAPTER 1

THE INTERDISCIPLINARY NATURE OF SOIL

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ABSTRACT

The holistic study of soils requires an interdisciplinary approach involving biologists, chemists, geologists, and physicists, amongst others, something that has been true from the earliest days of the field. In more recent years this list has grown to include anthropologists, economists, engineers, medical professionals, military professionals, sociologists, and even artists. This approach has been strengthened and reinforced as current research continues to use experts trained in both soil science and related fields and by the wide array of issues impacting the world that require an in-depth understanding of soils. Of fundamental importance amongst these issues are biodiversity, biofuels/energy security, climate change, ecosystem services, food security, human health, land degradation, and water security, each representing a critical challenge for research? In order to establish a benchmark for the type of research that we seek to publish in each issue of SOIL, we have outlined the interdisciplinary nature of soil science research we are looking for. This includes a focus on the myriad ways soil science can be used to expand investigation into a more holistic and therefore richer approach to soil research. In addition, a selection of invited review papers are published in this first issue of SOIL that address the study of soils and the ways in which soil investigations are essential to other related fields. We hope that both this editorial and the papers in the first issue will serve as examples of the kinds of topics we would like to see published in SOIL and will stimulate excitement among our readers and authors to participate in this new venture.

INTRODUCTION

In the current times of numerous publications in numerous journals, one can rightly ask whether a new journal, like SOIL, is necessary. We, the editors, asked that same question when approached by the European Geosciences Union to launch a new journal. Upon reflection, we decided that a "golden" open-access journal with a focus on the interdisciplinary aspects of soils would fill in a very much needed niche within the soil science publishing world. Within soil science, there are no fully open-access journals (referred to as "gold" in the publishing world) where the review process and publishing are conducted in an open forum where anybody around the world with access to the internet can participate in and learn from the communicated science of soil within an interdisciplinary context. Given the current and future global issues that are in need of a soils perspective, a journal like SOIL should be welcomed. The study of soils naturally involves an interdisciplinary ap-

Citation: Brevik EC, Cerdà A, Mataix-Solera J, Pereg L, Quinton JN, Six J, and Van Oost K (2015). The interdisciplinary nature of SOIL. SOIL, 1, 117-129. www.soil-journal.net/1/117/2015/, doi:10.5194/soil-1-117-2015

proach – a consequence of soils forming at the intersection of the atmosphere, biosphere, hydrosphere, and lithosphere. This interdisciplinary approach is reflected by the number of individuals who are famous for landmark accomplishments in other scientific fields who also made early contributions to soil science, such as Leonardo da Vinci, Robert Boyle, and Charles Darwin (Brevik and Hartemink, 2010). Many of the biggest names from the early days of soil science received their training in other disciplines because academic programs that provided training in soils had not yet been created; this was true in both the USA (Brevik, 2010) and Europe (Calzolari, 2013). Furthermore, as soils have become more prominent in addressing the many challenges facing our modern world, additional fields outside of the natural sciences, such as anthropology, arts, economics, engineering, sociology, and the medical fields, have also begun to take an interest in soil. While narrow, very focused studies are abundant in soil science today and are of great value, a true appreciation of the role for soils in addressing current and future global challenges requires a broader view. Many of the current environmental, social, economic, geologic, and human health issues can be better addressed if soils are considered and paid due attention (e.g., Howitt et al., 2009; Brevik, 2013a; McBratney et al., 2014). To better appreciate the many ways that soils knowledge can enhance the study of other disciplines, as well as ways these other disciplines can augment the study of soils, an overview of some key examples is provided. This editorial will start by looking at examples of connections between soils and the natural sciences, will then consider connections with the medical sciences and the social sciences, and will conclude with a look at a traditional soil science topic that can be advanced through interdisciplinary investigations.

SOILS AND BIODIVERSITY

Soil habitats range in size from micro-niches to entire landscapes, while soil biodiversity includes all varieties of life dwelling in the soil habitat below- and aboveground. It is now acknowledged that soil biodiversity supplies many ecosystem services essential to humans and the environment, such as the support of primary production through organic matter (OM) and nutrient cycling; climate control through the regulation of C and N fluxes; control of pests and diseases for humans, animals, and plants; and decontamination of the environment. This puts soil biodiversity at the epicenter of cross-disciplinary research. Soil biota have numerous and varied functions that play a significant role in determining the chemical, physical, and biological properties of soil (Table 1). Organisms not only contribute to total soil organic matter (SOM) formation, they also decompose SOM and transform nutrients (e.g., C, N, P, S), determining the chemical, and physical composition of their habitat. Finally, soil organisms perform a vital role in shaping the soil environment through formation and modification of the soil architecture with pores and tunnels, the transportation of soil particles, and the creation of new soil habitats through the weathering of rocks (Puente et al., 2004). While the diversity and abundance of soil organisms influence soil functioning, the diversity and activity of soil organisms also depend on soil properties (Bardgett, 2002). Plants play an important role in shaping soil, from surface to depth, with the diverse architecture of their root systems. Plants are at the center of soil–plant–microbial interactions. The rhizosphere is rich with microorganisms (Cardon and Whitbeck, 2007) and nutrients, and exhibits a gradient in oxygen concentrations. Plant-growth-promoting rhizospheric (PGPR) microbes contribute to biofertilization, biocontrol, and phytostimulation (reviewed by MartinezViveros et al., 2010; Pereg and McMillan, 2015). The sustainability of crop production systems is a key issue for ensuring global food security. The links between human activity and soil biodiversity and thus soil function are illustrated in the influence agricultural management practices have on soil biodiversity (Berg and Smalla, 2009; Reeve et al., 2010). Natural diverse vegetation contributes to an increase in soil biodiversity, while intense mono-cropping supports the growth of only a subset of soil microbes, causing a decrease in biodiversity (Figuerola et al., 2014). Furthermore, increased use of fertilizers and pesticides might compromise both the activity and survival of certain microbes in the soil.

Due to the reliance of soil biological community structure and activity on the stability of abiotic and biotic soil properties, any change in these conditions may precipitate a shift in biodiversity. Climate change, land use change, pollution, invasive species, and any factor contributing to soil degradation can impact biodiversity. For example, agricultural dust has been shown to be a vector carrying terrestrial microbes into the ocean that are pathogenic to marine organisms, affecting ecological niches such as coral reefs and fish (Garrison et al., 2003). In recent years soil scientists have made enormous progress toward understanding soil organisms and their roles in ecosystems. Nonetheless, much remains to be discovered to allow the development of practices that will promote the sustainable use of soils. Understanding what causes changes in the belowground biodiversity and how diversity is linked to soil function, as well as how it influences aboveground diversity, would contribute to sustainability and restoration of ecosystems. Biodiversity is evaluated using a myriad of methods that can be categorized as those that determine species abundance and diversity or those that measure functional diversity (Cooper and Rao, 2006). While the diversity and abundance of plants and macrofauna can be measured through direct sampling, microfauna is more complicated to assess due to the potentially enormous number of microorganisms that can be found in one gram of soil and that less than 1 % of the microorganisms can be cultivated or characterized (Torsvik and Ovreas, 2002). The development of culture independent, molecular biology methods to assess biodiversity has revealed the hitherto unknown extent of microbial diversity, enabling the detection of 10–1000 times the diversity revealed by culturing techniques. The methods for the analysis of the genetic material, mainly based on the amplification of 16S (prokaryotic) and 18S (eukaryotic) rRNA encoding sequences, are varied (Cooper and Rao, 2006). While the diversity of microbes can be determined using DNA-based techniques, the activity of microbes under particular sets of conditions requires RNA technology to add breadth to the traditional analysis of microbial activity (e.g., enzyme kinetics), with techniques such as qRT-PCR and RNA sequencing becoming more widely used. The study of microbial diversity and function in the soil requires a good understanding of the biology of microbes and utilizes methods developed for biological and biomedical research, again emphasizing the cross-disciplinary nature of the study of soil biota and in general soils.

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