Understanding the soil rhizosphere system

Sustainable management of the soil rhizosphere system for efficient crop production and fertilizer use

The workshop aimed to promote an understanding of the dynamics of soil nutrients in the rhizosphere, especially in relation to plant growth, inorganic and organic fertilization, and other cultural management practices.

THE MEANING OF THE WORD 'RHIZOSPHERE' has evolved from a limited definition to describe a narrow zone of intense bacterial activity around plant roots, to a broader one referring to the zone of soil surrounding the root which is affected by it. The zone is characterized by the concentration gradients which occur both in a radial and longitudinal direction along an individual root. Interactions between crop root and rhizosphere are beneficial to crop production through increase in bioavailable soil P, N-fixation, and production of antimicrobial compounds that inhibit the growth of pathogens. Clearly, the goal in the management of the rhizosphere is to maximize the balance of its beneficial effects on sustainable crop growth.

In recent decades, much progress has been made to understand the soil-plant interactions in the rhizosphere. A good soil-rhizosphere system is perceived as the basic condition to ensure good crop production and quality. Some countries in the Asian and Pacific (ASPAC) region have developed innovative technologies that can be extended to other countries, particularly on soil fertility, root system, microbiological activities, and efficient fertilizer use. Information on these technologies must be made available to enable each country to develop strategies to ensure good soil fertility, effective fertilizer use, good microorganism population, and crop quality in the soil-rhizosphere system.

The soil rhizosphere workshop was organized in cooperation with the Land Development Department (LDD) of Thailand primarily to provide a venue for the sharing and exchange among countries in the ASPAC region of recent innovative techniques for efficient crop production and cost-effective fertilizer use under a sustainable management of the soil rhizosphere system. It aimed to promote an understanding of the dynamics of soil nutrients in the rhizosphere, especially in relation to plant growth, inorganic and organic fertilization, and other cultural practices/management.

Photos courtesy of J.H. Chen, National Chung-Hsing University, Taiwan ROC.

Combined use of biofertilizer and chemical and organic fertilizers on cabbage.

Sustainable management of the soil rhizosphere system

Methods for the sustainable management of the soil rhizosphere system for efficient crop production and fertilizer use clearly fall into three distinct ways and methods: a) cultural management/practices; b) efficient nutrient application/fertilizer management; and c) use of organic fertilizers and bio-fertilizers.

Participants visit the Chai Pattana - Mae Fah Luang reforestation project of LDD under a Royal Initiative grant, in Prachuap Khiri Khan province, central Thailand. One of the project's objectives is to investigate the use of Ratchaburi ecotype vetiver grass, which generates more roots and biomass, to improve degraded soil.

Cultural management/practices. One practice that can be used in sandy soil with coarse texture and low organic matter content, low water holding capacity and low cation exchange capacity, is sub-soiling treatment for better crop growth. Field experiments employing perennial forage crops with deeper root systems also demonstrated land productivity improvement.

Root distribution and cropping system of rice (*Oryza sativa* L.) play a significant role in sustainable rhizosphere management. Subsurface irrigation systems can be adopted to improve soil characteristics and rice root distribution, in relation to the physical properties of the soil and fertilization practices. Application of organic sources into paddy soil can also be beneficial in improving the root distribution in the subsoil layer and in magnifying the soil rhizosphere.

Efficient nutrient application/fertilizer management. Over application of chemical fertilizer can result in considerable decreases of microorganism population and friendly insects, crop susceptibility to disease attack, acidification or alkalization of the soil or aggravation of soil physical properties, and pollution of water resources through leaching — causing irreparable damage to the overall system.

Hence, designing sustainable management practices that focus on rhizosphere soil is more efficient and cost-effective for improving crop productivity with lesser agrochemical inputs. One of the more promising practices is the innovative Starter Solution Technology (SST), which reduces fertilizer application, increases vegetable yields, decreases fertilizer residues in the soil, and is simple to apply. Other practices for managing the fertility of rhizosphere soil include supplying nutrients through drip irrigation, applying organic fertilizers and biocharcoals to increase soil-buffering capacity, and localized amendment as strategies for problem soils. All of the proposed management practices can be easily adopted by Asian farmers.

Use of organic fertilizers and bio-fertilizers. Organic farming has become popular due to consumer concern with human health and the environment. Using organic fertilizer, the nutrient supply is more balanced, which helps to keep plants healthy. Among the beneficial effects of organic fertilizer includes: enhancement of soil biological activity; enhancement of colonization of mycorrhizae; improved root growth due to better soil structure; and slow release of nutrients which contribute to the residual pool of organic N and P in the soil, reducing N leaching loss and P fixation.

Likewise, soil micro-organisms play a significant role in regulating the dynamics of organic matter decomposition and the availability of plant nutrients such as N, P and S. It is well-recognized that microbial inoculants constitute an important

component of integrated nutrient management that leads to sustainable agriculture. In addition, microbial inoculants can be used as an economic input to increase crop productivity; fertilizer doses can be lowered and more nutrients can be harvested from the soil.

On the other hand, biofertilizers help with the expansion of the root system and better seed germination. A healthy plant usually has a healthy rhizosphere which should be dominated by beneficial microbes. The production technology for biofertilizers is relatively simple and installation cost is very low compared to chemical fertilizer production. Some of the innovative biofertilizer technologies presented in this workshop include: indigenous microbes (IMO) and enzymes from natural farming technology, effective microbes (EM) and arbuscular mycorrhizal fungi (AMF) , vesicular-arbuscular mycorrhizal fungi (VAM), and planting of vetiver grass to generate more roots and biomass.

Peospects and recommendations

The nature and the characteristics of nutrient release of chemical, organic and biofertilizers are different, and each type of fertilizer has its advantages and disadvantages with regard to crop growth and soil fertility. To ensure both an enhanced and safeguarded environment, sound fertilizer management is the key. A balanced fertilization strategy that combines the use of chemical, organic or biofertilizers must therefore be developed.

Toward this direction, the right combination of organic and inorganic fertilizer to maximize fertilizer use efficiency must be explored, in order to achieve improved crop production with less environmental degradation. There should also be a conscious effort in terms of preventing the increasing accumulation of heavy metals and salt from high and continuous use of organic fertilizers, particularly the practice of using low-quality compost.

Chemical, organic and microbial fertilizers have their respective advantages and disadvantages in terms of nutrient supply, soil quality, and crop growth. Developing a suitable nutrient management system that integrates the use of these three kinds of fertilizers is a big challenge for scientists and researchers. Lastly, it is essential that good soil management be practiced as an important element of sustainable agricultural practice, toward optimizing crop yield and quality, as well as reducing the risk of damage to the environment.

Production of liquid organic fertilizers from wastes using microbioactivator LDD2, a project of LDD in Chai Pattana - Mae Fah Luang.

International Workshop on Sustained Management of the Soil Rhizosphere System for Efficient Crop Production and Fertilizer Use

Held at LDD, Bangkok, Thailand on October 16-20
No. of countries participating: 7 (Japan, Korea, Malaysia, Philippines, Taiwan ROC, Thailand, and Vietnam)
No. of papers presented: 14
No. of participants: 50
Co-sponsor: Land Development Department (LDD), Thailand

List of papers

1. Amelioration of land productivity in upland areas in Northeast Thailand through a new tillage system and crop-animal integration
   - Kazuyuki Matsuo, NARC Kanto-Tokai Region), Japan
2. Rice root distribution and rice-based cropping systems for sustainable soil-rhizosphere management
   - Weon-Tai Jeon, National Institute of Crop Science, RDA, Korea

3. Fertility management of the soil-rhizosphere system for efficient fertilizer use in vegetable production
   - Chin-Hua Ma, The World Vegetable Center - AVRDC, Tainan, Taiwan ROC
4. Soil-enhancing technologies for improving crop productivity in Malaysia and considerations for their use
   - Aini Zakaria, MARDI, Malaysia
5. The production and application of biofertilizers in Vietnam
   - Van Suc Nguyen, National Institute of Soils and Fertilizers (NISF), Hanoi, Vietnam
6. Vetiver root and soil moisture conservation from vetiver grass establishment on degraded soils
   - Anuwat Potiham, LDD Region 5, Khon Kaen, Thailand
7. The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility
   - Jen-Hshuan Chen, National Chung Hsing University, Taiwan ROC
8. The potential role of PEON (phosphate buffer extractable organic nitrogen) in the soil for plant nutrition and its implication for organic farming
   - Noriharu Ae, Kobe University, Japan
9. Production of organic fertilizer from solid waste and its utilization in intensive organic-based vegetable production and for sustaining soil health and productivity
   - Nenita E. Dela Cruz, Central Luzon State University, Philippines
10. Water management and soil fertility for improved yields
    - Dong-Shig Oh, National Institute of Agricultural Science and Technology, RDA, Korea
11. Protease production and phosphate solubilization from potential biological control agents *Trichoderma viride* and *Azamonas agilis* from Vetiver rhizosphere
    - Vanlada Sunantapongsuk, Pracha Nakapraves, Siangjeaw Piriyaprin, LDD; and Leka Manoch, Kasetsart University, Thailand
12. Development of rhizobacteria as a biofertilizer for plant production
    - Sompong Meunchang, Praphai Thongra-ar, Sarattana Sanoh, Sirilak Kaewsuralikhit, Department of Agriculture, Thailand; and Shotaro Ando, National Institute of Livestock and Grassland Science, Japan
13. The relationship between soil microorganisms and nutrient elements of *Vetiveria zizanioides* and *Vetiveria nemoralis* in some problem soils of Thailand
    - Chaveevan Leaungvutiviroj, Siangjeaw Piriyaprin and Pitayakon Limtong, LDD, Thailand
14. Mycorrhizal fungi as biofertilizer for fruit tree production in Thailand
    - Supaporn Thamsurakul, Department of Agriculture; and Sompetch Charoensook, Institute of Research and Development for Agriculture, Thailand

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