Agriculture, Ecosystems and Environment 140 (2011) 339–353

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Review

Efficient soil microorganisms: A new dimension for sustainable agriculture and environmental development

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ARTICLE INFO

Article history:
Received 30 August 2010
Received in revised form 20 January 2011
Accepted 21 January 2011
Available online 12 February 2011

Keywords:
Agriculture
Biofertilizers
Biocontrol
Cyanobacteria
Rhizobacteria

ABSTRACT

Sustainable agriculture is vital in today's world as it offers the potential to meet our agricultural needs, something that conventional agriculture fails to do. This type of agriculture uses a special farming technique wherein the environmental resources can be fully utilized and at the same time ensuring that no harm was done to it. Thus the technique is environment friendly and ensures safe and healthy agricultural products. Microbial populations are instrumental to fundamental processes that drive stability and productivity of agro-ecosystems. Several investigations addressed at improving understanding of the diversity, dynamics and importance of soil microbial communities and their beneficial and co-operative roles in agricultural productivity. However, in this review we describe only the contributions of plant growth promoting rhizobacteria (PGPR) and cyanobacteria in safe and sustainable agriculture development.

Contents

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doi:10.1016/j.agee.2011.01.017

1. Introduction

According to United Nations estimates, the global human population is projected to reach 8.9 billion by 2050, with the developing countries of Asia and Africa to absorb the vast majority of the increase (Wood, 2001). Decreasing irrigational water supplies and other environmental concerns exacerbate the challenges we face to meet the nutritional requirements of the growing population.

The various ways in which microorganisms have been used over the past 50 years to advance medical technology, human and animal health, food processing, food safety and quality, genetic engineering, environmental protection, agricultural biotechnology, and in more effective treatment of agricultural and municipal wastes collectively the most impressive record. Many of these technological advances would not have been possible using straight forward chemical and physical engineering methods, or if they were, they would not have been practically or economically viable.

Nevertheless, while microbial technologies have been applied to various agricultural and environmental problems with considerable success in recent years, they have not been widely accepted by the scientific community as it is often hard to consistently reproduce their beneficial effects. Microorganisms are effective only when they are provided with suitable and optimum conditions for metabolism including the available water, oxygen, pH and temperature of the ambient environment. The types of microbial cultures and inoculants available in the market today have increased rapidly owing to new technologies. Significant achievements are being made in systems where technical guidance is coordinated with the marketing of microbial products. Since microorganisms are useful in overcoming problems associated with the use of chemical fertilizers and pesticides, are now widely applied in agriculture.

Environmental pollution, by excessive soil erosion and the associated transport of sediment, chemical fertilizers and pesticides to surface waters and groundwater, and ineffective treatment of human and animal wastes poses serious environmental and social problems throughout the world. Although engineers attempted to solve such problems using established chemical and physical methods found that it cannot be done without deploying microbial methods and technologies.

For many years, soil microbiologists and microbial ecologists differentiated soil microorganisms as 'beneficial' or 'harmful' depending how they affect soil quality, crop growth and yield. Beneficial microorganisms are those that fix atmospheric N, decompose organic wastes and residues, detoxify pesticides, suppress plant diseases and soil-borne pathogens, enhance nutrient cycling and produce bioactive compounds such as vitamins, hormones and enzymes that stimulate plant growth.

The recent interest in eco-friendly and sustainable agricultural practices (Kavino et al., 2007; Saravanakumar and Samiyappan, 2007; Harish et al., 2009a,b). Biofertilizer and biopesticide containing efficient microorganisms, improve plant growth in many ways compared to synthetic fertilizers, insecticides and pesticides by way of enhancing crop growth and thus help in sustainability of environment and crop productivity. The rhizospheric soils contain diverse type of efficient microbes with beneficial effects on crop productivity. The plant growth promoting rhizobacteria (PGPR) and cyanobacteria are rhizospheric microbes and produce bioactive substances to promote plant growth and/or protect them against pathogens (Glick, 1995; Harish et al., 2009a). This communication highlighted contributions of PGPR, cyanobacteria and some beneficial microbial interactions in the agriculture improvement and environment sustainability.

2. The efficient and potential soil microbes

Such microorganisms may comprise of mixed populations of naturally occurring microbes that can be applied as inoculants to increase soil microbial diversity. Investigations have shown that the inoculation of efficient microbial community to the soil ecosystem improves soil quality, soil health, growth, yield and quality of crops. These microbial populations may consists of selected species of microorganisms including plant growth promoting rhizobacteria, N_2-fixing cyanobacteria, plant disease suppressive bacteria and fungi, soil toxicant degrading microbes, actinomycetes and other useful microbes.

Efficient and potential soil microbial biota is only suitable for sustainable agriculture practices and may not the so for other alternatives. It is an added dimension to optimizing our soil and crop management practices such as crop rotation, organic amendments, conservation tillage, crop residue recycling, soil fertility restoration, maintenance of soil quality and the biocontrol of plant diseases. If used adequately, microbial communities can significantly benefit the agriculture practices.

3. Why sustainable agriculture is so important?

Sustainable agriculture is a broadbased concept rather than a specific methodology. It encompasses advances in agricultural management practices and technology, and the growing recognition indicates that the conventional agriculture that developed post World War-II, will not be able to meet the needs of the growing population in the 21st Century.

Conventional agriculture is facing either reduced production or increased costs, or both. Farming monocultures, such as wheat fields, repeated on the same land results in the depletion of topsoil, soil vitality, groundwater purity and beneficial microbe, insect life, making the crop plants vulnerable to parasites and pathogens. An everincreasing amount of fertilizers and pesticides as well as the energy requirements for tilling to aerate soils and increasing irrigation costs are of prime concern. While conventional methods enabled large increases in crop yields, thus high profits only initially, have failed to be considered as the ideal approach for future.

The steady increase in corporate farming based conventional methods in the last few decades, primarily profit driven, has increased the destabilization of rural communities as well as speeded up the detrimental effects on both the farmland ecology and neighboring natural environments. Cost cutting efforts have frequently targeted farm workers; financial recompense for the work performed, has degraded significantly compared to other areas of human endeavor. This not only decreases their own standard of living but has a flow on effect impacting the economic viability of small, rural towns.

The expansion of urban population and business and industrial complexes has reduced the available farmland. The location of much of the world's primary and best quality farmland is in areas that are steadily becoming prime real estate for top end residential assets. In economic terms, farming simply cannot compete. The profits from transforming the farmland into residential subdivisions are astronomically higher than those achievable from farming it by any method.

4. The contributions of soil micro-flora in sustainable agricultural production

A fundamental shift is taking place worldwide in agricultural practices and food production. In the past, the principal driving force was to increase the yield potential of food crops and their productivity. Today, the drive for productivity is increasingly combined