

Harnessing Microbial Resources for Sustainable Crop Production : The Philippine Experience

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Abstract The Philippines is primarily an agricultural country with rice, corn and coconut as the main crops. Its rich microbial diversity has contributed substantially to augment or partially substitute for chemical fertilizer requirements. From 1980-1990, the BIOTECH-UPLB conducted vigorous bioprospecting and screening activities in search for microbe based technologies for agriculture. Research and development activities and products of BIOTECH on biofertilizers and other microbe-based technologies were collated. Secondary data and agricultural statistics were collected from the reports of different institutions. Majority of the microbial fertilizers at commercial scale are recommended for rice and corn. The reduction of 30 to 50% on cost of nitrogen fertilizers indicated that utilization of biofertilizers like BIO-N for rice and corn could contribute in enhancing sustainable crop production.

Key word : microbial resources, biofertilizers, sustainable crop production

Introduction

The Philippines is still primarily an agricultural country. The latest Census of Agriculture done in 2002 reported that there were 4.8M agricultural farms with a total land area of 9.7M ha nationwide. In 2006, the agricultural sector contributed to 18.70% to the Gross Domestic Product (GDP) and registered a 3.85% growth out of the 5.37% total GDP growth. The crops sub-sector, which comprise half of the agricultural output surpassed its year-ago performance with a 3.94% expansion. Main crops are rice, corn and coconut. The country's exports and imports of agricultural products continue to increase over the last three years. Coconut oil, banana and pineapple remained the top three agricultural exports in 2006. Major markets were Netherlands and USA for coconut oil, Japan for fresh bananas and USA for pineapple products. On the other hand, wheat and meslin were the top agricultural imports in 2006 (Bureau of Agricultural Statistics-Philippines, 2007).

The Filipino farmers, in general, are economi-

cally struggling. Land holding per family is relatively small, only three ha and even less, on the average. Moreso, a number of serious problems beset them. Productivity is low due to declining soil fertility and poor soil health, low fertilizer usage because of the high cost, inappropriate land use, pest and diseases and unfavorable weather conditions. Only 7M out of the 30M ha total land area can be considered constraint-free. Soil erosion is a major problem as 22.6M ha or 75% can be classified under slight to severe erosion while 5.08M ha are already severely eroded. Soil acidity is another major soil problem. The most extensive soil type is ultisol which covers 12.4M ha or 41.5% of the country's total land area. This soil is strongly acidic, has an inherent low fertility and is usually used for rainfed farming. Approximately 16.9M ha or 56% are acid upland soils (National Agricultural Ecosystem R&D Team. 2001). There is also the abundance of pests and diseases as tropical conditions (high temperature and humidity) are ideal for the growth of insect pests and plant pathogenic microorganisms. Moreover, weather conditions are not very favorable. There is drought during the dry season while too much

rain during the rainy seasons with an average of 26 typhoons that hit the country per year. Aside from low productivity, there is low profitability of farm enterprise as production inputs like imported synthetic fertilizers and pesticides cost very high. Furthermore, the prices of farm produce are very unstable. The unstable market price for rice, corn and vegetables is basically due to over supply during harvest time. Farmers have no processing and storage facilities especially during the rainy season so they are forced to sell their produce at a low price. In addition, the farmers are not organized (poor marketing system) thus easily manipulated by middlemen.

Recognizing the need of the Filipino farmers to increase productivity at a low cost and the potentials of microorganisms to affect various processes, and given the rich microbial diversity of the country, the National Institute of Molecular Biology & Biotechnology (BIOTECH) which is one of the centers of excellence of the University of Philippines Los Baños – the leading university for agriculture in the country, embarked on bio-prospecting and screening activities from 1980 – 1990 to search for microbial strains with high nitrogen fixing potential, mycorrhizal fungi to increase phosphorus uptake and bio-control strains to increase agricultural productivity. Other government research institutions and private entrepreneurs have also followed suit.

This paper aims to present the general picture of Philippine agriculture with emphasis on the utilization of microorganisms as biofertilizers and biocontrol agents to increase crop production.

Materials and Methods

Research and development activities and products of BIOTECH on biofertilizers, microbial pesticides, and related microbe-based technologies for agriculture were collated. Secondary data and agricultural statistics were collected from the reports of different agencies/institutions involved in various aspects of agricultural crop production especially those who are into the use of microbial inoculants. Interviews with selected

experts were conducted to validate some of the published research results.

Result and Discussion

Microbe-based fertilizers available in the market

Ten microbe-based fertilizers and their manufacturers, guaranteed analysis and recommended crops are summarized in Table 1. These are among the 90 organic fertilizers registered at Fertilizers and Pesticides Authority in 2006.

It should be noted that the majority of the microbe-based fertilizers at commercial scale are recommended for rice and corn which are staple crops of the Philippines. Except for BIO-N, these biofertilizers are being commercialized by the private sector.

It was reported that **BIO-N** replaces 30-50% or more of the plant's total nitrogen requirement, enhances shoot growth and root development of host crop, makes plant resistant to drought and pest attack, reduces incidence of corn ear-worm attack and increases yield and milling recovery of corn and rice (Garcia and Anarna, 2006). Furthermore, it should be pointed out that aside from economic benefit, the use of these biofertilizers is contributing to the protection of the soil quality.

For rice, application of 50% and 75% of the recommended rate of fertilizer plus BIO-N resulted in yields comparable with the application of 100% recommended rate. The cost and return analysis revealed that highest net income and benefit-cost ratio (BCR) of 1.56 were obtained from plants applied with 100% recommended rate of chemical fertilizers plus BIO-N (PCARRD, 2006).

For resource-limited Filipino farmers the reduction of 30 to 50% of cost on nitrogen fertilizers attributed to the use of BIO-N for rice and corn, plus the other environmental benefits, indicated that microbe based technologies could enhance sustainability of agriculture production.

Other products of BIOTECH include other biofertilizers, diagnostic kits and microbial pesticides (Figure 1). Another biofertilizer product is

Table 1. Microbial fertilizers registered with the Fertilizers and Pesticides Authority (FPA) as of December 31, 2006.

Product Name	Company Name	Guaranteed Analysis	Crops
Bio-N Microbial Fertilizer	BIOTECH-UPLB	<i>Azospirillum</i>	Rice, corn
Vital N	Arnicem Int'l. Trading Corp.	<i>Azospirillum</i>	Rice, corn, celery
Microfix™ Biofertilizer	Green Gold Agrivet Marketing	<i>Azospirillum</i>	Rice, corn
Nitro-Fix Nitrogen Fixing Inoculant Fertilizer	Summa Biotechnologies Corp.	<i>Azospirillum</i>	Rice, corn
Exquisite BD Soil Conditioner	Exquisite Phils., Inc.	<i>Bacillus laterosporus</i>	Rice, corn, pole sitao
EM-1 Microbial Inoculant	E.M. Research Phils., Inc.	<i>Lactobacillus</i> <i>Streptococcus</i>	Rice, tomato, potato, onion, cabbage, lettuce
Mega Bio-Organic Liquid Fertilizer	Three 12 Enterprises	<i>Bacillus megaterium</i> <i>Bacillus cereus</i>	Rice, corn, vegetables
Biocon Microbial Inoculant	Tribio Technologies, Corporation	<i>Trichoderma</i>	Fritzie Palm, eggplant, papaya, banana, pechay, tomato
NBEM-21 Powder Activator	J.P. BYM Food Mix Mfg. & Export	Bacteria Yeast	Raw material (decomposer)
All Grow Humus Maker	Pine Valley Corp.	<i>Bacillus</i> sp.	Raw material (decomposer)

NitroPlus which contains Rhizobium effective for field legumes such as soybean, peanut, pole sitao, cowpea and mungbean. It has been demonstrated that NitroPlus can increase crop yields and farmers' income. Average yield increases due to Nitro-Plus are 124% for soybean, 29% for mungbean and 39% for peanut increasing net returns by 251%, 168% and 30%, respectively (Sison and Torres, n.d.). Still another biofertilizer is Biogroe which contains plant growth promoting rhizobacteria that produces hormones and nutrients in soluble form. Biogroe is recommended for vegetables, other crops, ornamentals and fruit trees.

Endo- and ecto- mycorrhizal inoculants are also available. **VAMRI** is an endomycorrhizal root inoculant containing *Glomus* spp. recommended for agricultural crops, ornamentals and fruit crops. It enhances absorption of water and nutrients especially phosphorus and serves as biocontrol agent of soil-borne pathogens including nematodes. Mycorrhizae secrete growth-

promoting substance, altering the morphology, physiology and biochemical components of the host plants. Mycogroe is an ectomycorrhizal inoculant that contains spores of *Scleroderma*, *Pisolithus* or *Astreus* spp. recommended for pines, eucalypts, acacias, agoho, alnus and dipterocarps. It increases survival of inoculated trees especially in grasslands.

Bio-control inoculants include **Bactrolep**, a microbial insecticide containing *Bacillus thuriensis* which is toxic against Asiatic corn borer and diamond backmoth. Another microbial pesticide produced by BIOTECH contains nucleopolyhedron-virus (NPV) which is being used to control common cutworms, the major pest of onions in the country.

BIOTECH experience in technology transfer and commercialization

The Department of Agriculture, through the GMA-CORN PROGRAM, initially funded the establishment of several BIO-N Mixing Plants in



Figure 1. Different microbe-based products developed by BIOTECH. A. Biofertilizers, B. Diagnostic kits, and C. Microbial pesticides.

identified corn-producing provinces in the country to meet the demand of farmers for the inoculant. The Bio-N technology has been transferred to 41 provinces via reconstitution of inoculant concentrates produced by BIOTECH through these mixing plants. At present there are 60 mixing plants all over the country and 5 more are being put up. Quality control of the product is jointly done by the Bureau of Soil and Water Resources Management which have laboratories in key cities/provinces and by BIOTECH.

Constraints in microbe-based technology commercialization

There are still problems in large-scale production. Interpolation of the requirements has not been properly studied in many of the products. Most of the technology takers are classified as small and medium scale enterprises and do not have the financial capabilities to sustain production. This is also the reason why large scale production systems have not been thoroughly studied. Moreover, there is conflict in the mandate of government R&D institutions as they are not mandated to commercialize. Most products have shelf life in the market for as long as the inventor is active in producing his own products. Patenting mechanism also needs to be strengthened.

Conclusion

Soil nutrient management is important to increase and sustain crop production. The high cost of fertilizers and the associated problems of its continuous heavy use necessitated the identification and development of cheaper and environmentally safe materials for soil fertility

improvement and maintenance. Technology development efforts of UPLB-BIOTECH yielded microbe-based fertilizers which give 30-50% reduction in chemical fertilization. The experiences of UPLB-BIOTECH from technology generation up to technology commercialization demonstrated the potential of harnessing microbial resources for sustainable crop production.

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