The Asia-Pacific Natural Agriculture Network (APNAN): A Case Study for Regional Research

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Kyusei Nature Farming

The principles of Kyusei Nature Farming were first advocated in 1935 by Mokichi Okada of Japan, the founder of Sekai Kyusei Kyo. He believed that nature farming could help to transform the world into a "paradise on earth by eradicating disease, poverty, and conflict." The Nature Fanning method is considered to be an agricultural system offering a means of solving many of the problems arising from modern agricultural practices, and it is now the focus of worldwide attention. Positive results from Kyusei Nature Farming have been achieved in Japan, Taiwan, and Thailand and they were presented at conferences of the International Federation of Organic Agriculture Movements (IFOAM) in 1986 and 1989.

To further the knowledge and application of Kyusei Nature Farming, Professor Teruo Higa, Department of Horticulture, University of the Ryukyus, Okinawa, Japan and the International Nature Farming Research Center, Atami, Japan established the International Promotion Committee of Kyusei Nature Farming. Motivated by overwhelming interest and response, the Promotion Committee decided to hold an international conference on Kyusei Nature Farming. Consequently, the First International Conference on Kyusei Nature Farming was held at Khon Kaen University, Khon Kaen, Thailand during October 17-21, 1989. Scientists representing Japan, Taiwan, and Thailand presented the results of their research on Kyusei Nature Farming in which they had used a microbial inoculant of beneficial microorganisms referred to as "Effective Microorganisms" or EM. Their results indicated that Kyusei Nature Farming along with the added dimension of EM could improve soil quality and the growth and yield of crops without the use of chemical fertilizers and pesticides. Other participating scientists at this First Conference were from Bangladesh, Brazil, India, Indonesia, Korea, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, and the United States. They presented results on organic farming systems and alternative agricultural practices since they had not yet been introduced to EM technology and its potential to enhance the productivity of natural farming systems.

Development of EM Technology

As in many other natural farming systems, Kyusei Nature Farming does not advocate the use of synthetic chemicals which can adversely affect soil quality, food quality, and the environment. Kyusei Nature Farming differs from other natural farming methods in that it utilizes microbial inoculants of beneficial microorganisms referred to as Effective Microorganisms (EM) developed by Professor Teruo Higa of the University of the Ryukyus, Okinawa, Japan to improve soil quality; enhance plant growth, health and yield; and maintain a natural balance in the environment. Results, so far, indicate that EM can assist farmers in making a successful transition from chemical-based, conventional agriculture to nature farming systems with less risk. Although the results of EM technology showed substantial yield increases for field crops such as rice, vegetables and fruits compared with conventional production systems that used chemical fertilizers and pesticides, most of these field trials were not statistically designed and their economic features (i.e., input costs and net returns) were not presented.

To many scientists at the First Conference, Kyusei Nature Farming appeared to be a version of organic farming without the use of synthetic chemicals. They were also aware that crop yields with organic farming were generally lower than what might be achieved with chemical fertilizers and pesticides. It is for these reasons that Professor Teruo Higa developed and perfected EM technology as an added dimension to Kyusei Nature Farming to ensure optimum soil quality (including soil fertility), crop production, and crop protection from harmful insects and diseases.

Before discussing the results of the experiments, it is worthwhile to explain the basis of EM technology. Soil biology is of primary importance to the success of organic farming and nature farming systems. The effect of beneficial microorganisms in agriculture, such as microorganisms antagonistic to soil pathogens, nitrogen-fixing microorganisms, photo-synthetic bacteria and fermentative bacteria on plant growth, are vital to nature farming methods that seek to avoid the use of chemical fertilizers and pesticides.

Professor Higa has concluded that the application of mixed cultures of beneficial microorganisms to soil is more effective than pure cultures of the same microorganisms. As a result, he has produced several formulations of EM inoculants consisting of various beneficial microorganisms including photosynthetic bacteria, ray fungi (i.e., actinomycetes), yeasts and lactic acid bacteria (*Lactobacillus* spp.). Experiments with EM applied to various horticultural crops, on soils and on plant surfaces have shown that EM can increase the yield and quality of crops compared with control treatments not receiving EM. EM technology now has many impressive results where, in addition to the benefits described above, no chemical fertilizers or pesticides were used but organic amendments such as composts, green manure crops, and animal manures were regularly applied. This has allowed the establishment of an agricultural system which differs from conventional farming methods and which is easily practiced and is environmentally- and economically-sustainable.

The Founding of APNAN

In view of the growing interest in EM technology, a number of scientists recognized the need to conduct statistically-sound scientific experiments, i.e., with properly randomized and replicated treatments to establish the validity of EM as an alternative agricultural practice. Consequently, in 1989, at the conclusion of the First International Conference on Kyusei Nature Farming, the participating scientists from 13 Asia-Pacific countries and the USA founded the Asia-Pacific Natural Agriculture Network (APNAN), a non-governmental, non-political association of scientists to promote research, development, and implementation of natural agriculture practices and technologies. The founding of APNAN with headquarters in Bangkok, Thailand (described earlier in greater detail by Parr et al., 1991) was also motivated by the expressed interest in the technology and use of EM soil inoculants, including mechanisms of action, application methods, residual effects, EM-soil microbial interactions, and the effect of soil type, soil organic matter and stress factors on the effectiveness of these formulations, as well as their potential agronomic and economic value. A steering committee with members from the 13 Asian and Pacific countries was established to provide scientific and administrative counsel to APNAN's President and Coordinator. Professor Teruo Higa, University of the Ryukyus, Okinawa, Japan, the innovator of EM technology, was elected as the founding President of APNAN.

The stated purpose or goal of APNAN is to establish an international network of scientists in the Asia-Pacific Region that will promote research and education programs on natural farming practices and technologies.

The specific objectives of APNAN are to:

- Avoid or largely exclude the use of synthetic agricultural chemicals, especially fertilizers and pesticides.
- Enhance environmental quality and protection of the natural resource base.
- Improve the productivity and profitability of small farmers and the long-term sustainability of their farming systems.
- Optimize the use of on-farm resources and minimize the dependence of farmers on purchased inputs, especially fertilizers and pesticides.
- Enhance the safety and nutritional quality of food.

Regional Research on Nature Farming: The Role of APNAN

The first meeting of the APNAN Steering Committee was held April 17-18, 1900 at Atami, Japan. Facilities for this meeting were provided by the International Nature Farming Research Center and

Sekai Kyusei Kyo, Atami, Japan. Two issues were discussed: (a) the development of short-term research experiments to evaluate the effectiveness of EM in the farming systems of each APNAN country, and (b) the establishment of the APNAN headquarters in Bangkok, Thailand. It was decided that short-term common experiments should be implemented in APNAN member countries to determine the effectiveness of EM inoculants in the farming systems of each country. APNAN scientists agreed to conduct a field experiment utilizing a split-plot design entitled "Effects of Organic Amendments and Effective Microorganisms on Crop Production and Soil Characteristics." APNAN scientists also agreed to utilize certain standard procedures in the conduct of this experiment including the following:

- Use two types of organic amendments (e.g., crop residues, green manures, composts) with different C:N ratios.
- Apply organic amendments at a rate of 10 tons/hectare, dry weight basis.
- Provide proper controls, i.e., with and without chemical fertilizers, EM, and organic amendments.
- Randomize and replicate plots using a statistically-valid experimental design.
- Spray properly diluted EM 4 stock solution onto the soil after incorporation of organic amendments.

Additional details are a matter of record (APNAN, 1990).

Technical Training on EM Technology

APNAN members and their associates are encouraged to obtain training on EM technology at the University of the Ryukyus, Okinawa, Japan and at the Kyusei Nature Farming Center (KNFC) at Sara Buri, Thailand. Dr. Higa can also accept a limited number of graduate students to work on advanced degrees involving EM technology at the University of The Ryukyus. Non-academic trainees may also be accepted either at Sara Buri, Thailand or the University of the Ryukyus in Okinawa for periods of 6 to 12 months. All applications should be made through the APNAN office in Bangkok. Funding for training will be made by the International Nature Farming Research Center, Atami, Japan. APNAN is now affiliated with the International Federation of Organic Agriculture Movements (IFOAM) which provides an opportunity for collaborative research with other IFOAM participants.

Evaluation of Scientific Data and Research Results

The results of the common experiment being conducted by APNAN scientists in their respective countries are usually presented first at the annual APNAN Steering Committee meetings. This provides an opportunity for fellow APNAN members to constructively comment on the experimental protocol and scientific credibility of the research. Most of the APNAN scientists have conducted short-term field experiments (2 to 3 years duration) on vegetables and rice; however, the APNAN Steering Committee has encouraged the implementation of long-term studies, particularly on marginal soils, since it takes time to establish the new EM microflora and to enhance soil fertility and productivity. Some APNAN scientists have been conducting new experiments including the effect of EM on decomposition of various crop residues, farm manures, city wastes, and agricultural processing wastes and effluents such as palm oil mill effluent (POME).

The APNAN Steering Committee meets once a year to review and evaluate research progress and to develop new research strategies. Meetings of APNAN scientists are also held following the International Kyusei Nature Farming Conferences that are now scheduled at two-year intervals. In alternate years, the Steering Committee will meet in Bangkok or at other locations in the APNAN countries. If appropriate, members of the Steering Committee will be designated as APNAN Coordinators in their respective countries. When sufficient information has been developed, the possibilities of establishing International Nature Firming Research Centers in different countries will be pursued.

Concept and Theories of EM Technology

A number of questions have arisen from the use of EM as a soil and plant microbial inoculant, and the beneficial effects that have been reported. For example, how does the application of EM to the soil increase the yield of plants? How can it protect against the occurrence of plant disease? Is soluble organic matter absorbed by the plant directly? Can disease-suppressive soils, zymogenic soils and synthetic soils be induced by the application of EM? These questions are very complex but the mechanisms or theories of how EM acts or interacts in the soil-plant ecosystem were reported earlier by Higa and Wididana (1991). Such theories are reviewed here for the reader's convenience and knowledge.

Disease-Suppressive Theory

Disease-suppressive soil is a soil that has biological capability to suppress the occurrence and incidence of plant diseases. There are three types of suppressive soils: a) soils in which the pathogen fails to become established, b) soils in which the pathogen occurs but fails to cause disease, and c) soils in which the pathogen causes disease but declines with crop rotations and the application of organic amendments. Experiments show that EM 2.3.4-treated soil had lower numbers of fungal diseases (*Thielaviopsis* and *Verticillium*) and bacterial diseases (*Xanthomonas*, *Erwinia*, *Agrobacterium* and *Pseudomonas*) than that of the control. The disease-suppressive effect is dependent on the soil, the plant and the combination of EM cultures used to induce disease suppressiveness.

Organic Energy Theory

Conventional theory advocates that soil organic matter is decomposed by microorganisms and its inorganic components then become available to plant roots. In the organic energy theory, soil organic matter is fermented by *Lactobacillus* and other lactic acid-producing microorganisms to soluble organic matter such as amino acids and saccharides that are then absorbed directly by plant roots.

Inorganic Nutrient Solubilizing Theory

Soil microorganisms are of great importance in the recycling of organic matter into nutrient components readily absorbed by plant roots. A poor soil often has a low organic matter content and, consequently, a low population of soil microorganisms. For phosphorus containing organic compounds that are largely unavailable to plants, many microorganisms can solubilize the phosphate so that it moves into the soil solution. The same phenomenon occurs when EM is applied to the soil, i.e., available soil phosphate is often increased.

Balanced Population of Soil Microorganisms Theory

The incidence and severity of plant diseases are dependent on soil conditions (i.e., physical, chemical, and biological properties), soil management (i.e., fertilizer, tillage, pesticides), crop management (i.e., monoculture cropping, multiple cropping, crop rotations), and plant genetics (i.e., disease susceptibility and resistance, host and non-host plants). These factors influence the population and complexity of soil microorganisms. The balance in the population and diversity of beneficial and harmful microorganisms will determine whether the soil ecosystem is favorable or unfavorable to the growth and health of plants.

Photosynthetic and Nitrogen-Fixing Theory

When EM is applied to soil and plant leaf surfaces, the populations of photosynthetic bacteria and N_2-fixing bacteria in the soil and on the leaf surfaces increase rapidly. This is closely related to greater yields, higher sugar and Vitamin C contents in the fruit, and greater vigor of these plants compared with untreated plants.

Recommendations

APNAN scientists need to do more intensive research on the various mechanisms involved in EM technology that are responsible for improved soil quality, and in the growth, yield and quality of crops, as well as plant protection. We need to know the conditions under which EM cultures can best be stored to maintain their viability and effectiveness. A high degree of control is required because the nutritional requirements and growth factors such as oxygen, pH, and temperature may be specific for each type of microorganism. We need to be able to monitor the EM populations in soil, including their dispersal, survival time and effectiveness. This would allow us to predict with greater confidence higher levels of consistency in the performance and benefits of EM (Parr et al., 1994). More intensive experiments under various agroecological environments are recommended to verify the EM theories.

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