NATURE FARMING In Japan

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Abstract

When chemical fertilizers began to spread in Japan several decades ago, many farmers and agricultural scientists blindly believed in chemical fertilizers and pesticides that pests would become extinct and hungers would be exterminated by chemicals. At this moment, Mokichi Okada, an orient philosopher, warned people with an opinion contrary to others and proposed his philosophy of nature farming, an agricultural system similar to organic agriculture. The main points of his nature farming philosophy includes the following: 1) fertilizers pollute the soil and weaken its power of productivity; 2) pests would outbreak from the excessive use of fertilizers;

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3) nutrition favorable for pathogens causes disease susceptibility; 4) vegetables and fruits produced by nature farming taste better than those by chemical farming; 5) fertilizer poisons exist at various levels. These suggestions of Okada's nature farming philosophy have been proved with modern scientific theories and experiments. For example, experiment results show that the accumulations of nitrogen intermediate metabolites in the tissue make the plant susceptible to diseases and pest insects. As discussed in accordance with many research achievements, fertilizer poisons exist at the medicinal or molecular level as nitrate-induced cancers and other health problems such as blue baby syndromes, at the macro ecological level as eutrophication and the consequent green and red tides caused by excessive nitrogen and phosphorus from fertilizations; and at macroclimatic level as global warming by the greenhouse gases from excessive fertilization. Now, Mokichi Okada's followers are promoting nature farming in Japan in collaboration with the recent organic movement. The principles and technologies of nature farming have been undergone development, improvement and adaptation to today's sustainable food production.

1 Introduction

When human being is enjoying a multitude of benefits from the prosperity achieved through economic development and scientific advances, serious crises of environment and food safety have closed up to us. The rapid deterioration of both the natural environment and agricultural products has become a matter of great concern for many people in the world (Kumazawa, 1996; Pimentel, 1991; Schaller, 1993; Stockdale et al., 2001). There are only a few decades before air, water, and land resources are polluted to a point of no return. People have become aroused about the possible ill effects of polluted air, water and food due to excessive use of chemical fertilizers and pesticides for crop production and even the use of nuclear energy for disinfection or antisepsis (Conway and Pretty, 1991; Linder, 1973; Maga et al., 1976; Maga, 1983). Concern is expressed whether the supply of such natural resources as agricultural land, forests, minerals, and outdoor recreational areas will continue to meet the growing world population if we allow the modern chemical agriculture to go further (Clancy, 1986; Dahal, 1993; Harwood, 1990; Tantemsapya, 1995; Udakawa 1993; Vogtmann, 1984). Conventional agriculture is heavily dependent on input of chemicals and petrol energy. Excessive uses of chemical fertilizers and pesticides have caused environmental pollution and degradation, impaired food safety and quality and adverse effect on human and animal health (Musa, 1976). Moreover, chemical agriculture often creates an unsustainable ecosystem and the consequent unstable crop production (Vogtmann, 1984). Concerns over these problems in sustainability of environment and agriculture prompted scientists and policymakers to reevaluate the modern chemical farming systems and seek appropriate alternative practices to ensure more sustainable food production and environment maintenance. Recently organic agriculture has received more attention all over the world (Hasumi, 1991; Lampkin, 1990; Lockeretz and Kohl, 1981; Rasmussen, 1995). In addition to organic agriculture, nature farming becomes popular in Japan (Anonymous, 1993; Matsumoto, 1993; Minamino, 1994; Okada 1993; Xu, 2000). Similar to organic agriculture in many aspects, nature farming is one of the main ecological farming systems in Japan. Agricultural products labeled by nature farming organizations in accordance with the national organic law are popular in consumers seeking pesticide-free fruits and vegetables. Recently nature farming has received increasing attention in Japan and from the whole world. Nature farming was first advocated as an alternative to chemical farming in 1935 by Mokichi Okada (1882-1955), a Japanese philosopher (Okada, 1991, 1993). Both systems of organic agriculture and nature farming advocate soil quality as the fundamental basis for healthy crops and healthy people. Nature farming differs from other organic agriculture systems primarily in its philosophical origin (Hsieh, 1993). As organic agriculture, the recent nature farming is not the reversion to the old agriculture of the 1940s (Vogtmann, 1984). Many new concepts, principles and technologies have developed since the original philosophy was established. For example, it no more restrict applications of animal manure if it is composted and beneficial microbial fertilizers are proposed to enrich the soil biodiversity and to purify the polluted environment (Higa, 1993, 1994, 1998a, 1998b). The purpose of this book is to review and discuss the history, philosophy, principles and perspectives of nature farming to provide a better understanding of this environment sound agriculture system.

2 Philosophy of nature farming

Several decades ago, Mokichi Okada (1993) wrote: “Kyusei Nature Farming is a simple and effective method of growing quality food crops, without harming the environment. This technology, advocated long before the green revolution, uses available resources in a sustainable manner to produce high yields. It is an integrated approach to chemical free food production.” As believed by Okada, the green fields, emerald oceans, and desolate deserts are all inhabited with abundant life. For billions of years, the earth has changed dramatically with creations and destructions, giving birth to water, atmosphere, and land full of life, which, in various forms, has thrived through balanced ecological cycles of energy and substances. Nature has been designed in such a way that it purifies everything and produces rich biota and biomass. Different plant colonies grow in forests, on plains, and in or by lakes and marshes in a balanced state, and maintain productivity without being seriously affected by diseases and insects. The one of the keywords of Okada's philosophy is that Nature is the God. Nature has its power or capacity to support all life forms including the human being. If respecting the nature or the law of nature, human can produce its food without destroying the environment. Nature does not discriminate any life forms in the world and consistently integrates the plants and animals into a diverse landscape. Therefore, a major tenet of nature farming is to create and maintain natural biodiversity. When early humans replaced hunting and gathering of food with domestication of crops and animals, the landscape changed accordingly. Since then, humankind has greatly reduced biological diversity by a limited selection of crop plants and animals. Annual crop monoculture represents a typical example. In response to this man-made biological simplification, nature has struggled to restore diversity. For example, the weed or other pest incidence is the effort of nature to restore the biodiversity from the monoculture. However, the human has continued to fight with nature over the biodiversity by using chemicals to kill insects and weeds. Why the nature makes incidences of weeds and pests occur? It is because human being makes nature lose diversity. If human being continues fighting with nature, the situation gets worse. Therefore, now the followers of Mokichi Okada suggest human establish a harmony and peaceful relation with nature instead fighting forever. The principles and technologies have been undergone development, improvement and adaptation to today's sustainable food production.

2.1 Principles and requirement of nature farming today

Nature farming is an ecological farming system based on sound agronomic husbandry. It is the predominant certified organic farming method in Japan, gaining recognition around the world for its emphasis on food quality, soil health, pest control, and related sustainable farming topics. The nature farming today is not a version back to its original to 1940's and it has developed in principles, requirements and technologies. For a simple example, animal manure was not allowed to be applied in nature farming system but today there is no restrict to animal manure as organic fertilizer if it is composted without contaminants included. As general ideology, nature farming today has five basic requirements as follows (Anonymous, 1993; INFRC, 1988; Matsumoto, 1993).

1) It must produce high quality food to enhance human health.
2) It must be economically and spiritually beneficial to both farmers and consumers.
3) It must be sustainable and easily applied.
4) It must conform to nature and protect the environment.
5) It must produce enough food for the world population.

2.2 Establishment of nature farming philosophy

2.2.1 Nature farming initiation

Okada proposed the concept of nature farming in 1935, later conducted experiments in Tokyo, and recommended the techniques to farmers (Matsumoto, 1993; Xu, 2000). In order to promote nature farming, Okada organized the Nature Farming Society in 1953, creating a structure of regional branches each in charge of several towns and villages, and nominating regional representatives as overseers. At the same time, he started publication of a monthly magazine entitled “Nature Farming” to disseminate his philosophy and technology. However, chemical fertilizers and pesticides were spread out in Japan at this time and taken as saviors of the agricultural industry. Many scientists, policymakers and farmers believed that insects and diseases would be exterminated and famines would be ended by using chemicals. Therefore, nature farming proposed at this time was criticized, and was even called "an evil theory." Farmers who decided to put nature farming into practice suffered extreme hardships.

At the beginning, the nature farming was *Muhiryo Saibai* in Japanese, and translated as “Cultivation without fertilizers”. However, natural composts were extensively used. Thus, “no-fertilizer” is actually inaccurate. Later, Okada changed the term to “nature farming”. Okada said “to explain nature farming in terms of fundamental theory, I must begin with a discussion of the nature of soil”. On his opinions, the Creator made the soil for the cultivation of grains and other vegetables essential to the support of life. Consequently, the essence of soil is a mystery far beyond the complete comprehension of the modern materialistic science. He criticized agriculture at that moment as falling into evil ways. At his age, farmers underestimated the power of soil and accepted the necessity of using fertilizers, resulting in soil degenerations and alterations and weakened soil power. Unaware of this and suffering under delusion that insufficient use of fertilizers causes poor crops, farmers resort to still more fertilizers. According to Okada, it is possible to produce large quantity of crops by means of the nature farming method, using only composts without chemical fertilizers and animal manure. At the time, however, few farmers would lend an ear to what he said no matter how hard he tried to convince them. He was convinced that the nature farming was the only way to save the farming population and is thus deeply connected with the fate of the whole nation. He was painfully aware of the need to win the understanding of both the farmers and the general Japanese population. He appealed that nature farming was startling in the way it reduces costs and labour; there is no need to pay for the fertilizers, pest damage was reduced to a small fraction of what it was in conventional cultivation systems, and damage from wind and storm was halved. As observed by Okada at that time, nature farming dramatically reduced insect pests, which emerged because of the use of chemical fertilizers.

Furthermore, crops grown under nature farming systems suffer much less than others from the wind and storm damage that had been occurring almost yearly at that time. Okada found that the root hairs of plants grown under nature farming systems were much more numerous and longer than those grown with chemical fertilizers. It was also observed that plants grown under nature farming were lower with shorter leaves but bore more grains or fruit. Okada indicated that ignorant of the power of soil, human beings greatly weakened the soil by applying chemical fertilizers and he suggested that, to maintain the power of soil, it was necessary to prevent the soil from being polluted and keep the soil pure by adding nothing but natural composts. Okada summarized six advantages as follows: 1) the cost of fertilizers was saved, 2) labour was halved, 3) productivity was increased, 4) grain volume increased so that there was little loss in cooking and the grain was delicious, 5) insect damage was minimized, and 6) the danger of ascarids and other parasites, a topic of major concern at that time was eliminated entirely. As always proposed by Okada, the fundamental theory of nature farming is respect for nature, which will be discussed in the following paragraphs.

2.2.2 Communication and co-operation between Okada and Rodale

Okada initiated his nature faming in Japan and faced much hardship from various directions (Okada, 1991, 1993; Matsumoto, 1993). At the same time, however, another pioneer in the world tried to establish an agriculture system similar to nature farming. This man was Jerome Irving Rodale, the founder of an organization called “The Soil and Health Foundation”, forerunner of today's “Rodale Institute” for the study and dissemination of sustainable agriculture in the United States (Harwood, 1984; Harwood, 1990). Aware of Okada's activities, Rodale began to correspond with Okada as his partner in Japan. In September 1951, J. I. Rodale wrote to Mr. Okada suggesting that he would like to cooperate with Mr. Okada to enhance what he saw as similar ideas and concepts concerning the relationship between soil, food, and health. Okada told the members who gathered at his office in Atami that he would like to work together with Rodale. At that meeting, one of Okada's members asked him to write more details about some of the negative effects of chemical fertilizer upon human health, and the relationship between soil health and human health. Okada answered as follows: “I haven't written about this yet, have I? Then I will write more strongly next time. However, I feel what Mr. Rodale wrote in his book Pay Dirt is enough. Don't you think so...” As written in one of his books, Okada explained, “thus the principle of the natural agriculture method is an overriding respect and concern for nature. Nature can teach us everything”. At the same time, in the book *Pay Dirt*, J. I. Rodale wrote, "that a whole new era of agriculture research is in the making, one that will more nearly help to create healthy society and keep it in close touch with the land from which it gets its strength and sweetness." Again, he insisted that agriculture is the base or foundation for the transformation from which to build, as he says, "a country of prosperous farms and a healthy, vigorous people creating a fine, new community life "in their pursuit of happiness." Okada was delighted and heartened by his correspondence with Rodale and pledged his support and his desire to strengthen the bond that spanned the Pacific Ocean. Unfortunately, however, because Okada passed away, their cooperation did not bear enough fruit as expected. Nevertheless, this association has proven beneficial forty years later, in 1991, in the form of a concrete cooperative agreement and the establishment of a global partnership between the successors of these two pioneers. Now, as the successor of Okada, *Shinji Shumeikai* that is a branch becoming independent from *Sekai Kyusei Kyo* (SKK), the religion founded by Okada has strengthened the partnership, in collaboration to study and expand nature farming as an alternative method to modern agriculture in Japan and over the world and lay the programmatic and long-term relationship between the two organizations in promoting and helping to implement their mutual strategic goals and objectives. As part of The Rodale Institute's international program, the Rodale Institute is supporting a research project for Okada's nature farming in the United States and for Rodale's regenerative agriculture in Japan and other international sites.

2.2.3 Other early pioneers in organic farming

Albert Howard, a British colonial officer in India with the title of Imperial Chemical Botanist, carried out agricultural experiments in the early 1900s (Howard, 1940, 1947; Howard, 1953). He observed the reaction of suitable and properly grown varieties of plants when subjected to insects and other pests and found that the factor most important in soil management was a regular supply of compost prepared from animal and vegetable wastes, and the maintenance of soil fertility was the fundamental basis for a healthy crop. As a result of his experiments, Albert reached the conclusion that crops have a natural power of resistance to infection and proper nutrition is required to make this power operative. Returning to England in 1931, Albert became known as the pioneer of the organic movement.

Jerome Irving Rodale launched a movement with his Organic Gardening and Farming magazine published in 1945 and established an experimental organic farm at Emmaus, Pennsylvania (Rodale, 1945). He was active in organizing organic garden clubs throughout the United States. Rodale got scientific support from one of the most brilliant soil scientist, Dr. William A. Albrecht, Chairman of the Department of Soils at the University of Missouri (USDA, 1938). Dr. Albrecht conducted extensive experiments with growing plants and animals and observed that declining soil fertility, due to a lack of organic material, major elements, and trace minerals, was responsible for poor crops.

Then, Charles Walters, Jr. has edited and published a straight-punching and hard-hitting monthly, Acres USA: A Voice for Eco-Agriculture, against social injustice, environmental deception, and commercial hypocrisy as applied to agriculture (Walters and Fenzau, 1979).

Rachel Louise Carson (1907-1964) wrote several articles to teach people about the wonder and beauty of the living world, including "*Help Your Child to Wonder*" in 1956 (Carson, 1965). The key point of Carson's philosophy is the view that human beings are but one part of nature and just distinguished primarily over other parts by their power to alter nature but in some cases irreversibly. Disturbed by the excessive use of chemical pesticides after World War II, Carson reluctantly changed her focus in order to warn the public about the long-term effects of misusing pesticides. In *Silent Spring* (Carson, 2002, written in 1962), she challenged the practices of agricultural scientists and the government, and called for a change in the way humankind viewed the natural world. Carson was attacked by the chemical industry and some in government as an alarmist, but courageously spoke out to remind us that we are a vulnerable part of the natural world subject to the same damage as the rest of the ecosystem. Testifying before Congress in 1963, Carson called for new policies to protect human health and the environment.

Permaculture (Hemenway, 2001; Mollison, 1988), a compound word from “permanent agriculture” was coined by Bill Mollison in the 1970's in Australia. Permaculture is another farming system rooting in a philosophy similar to nature farming. It was a beneficial assembly of plants and animals in relation to human settlements, mostly aimed towards household and community self-reliance. In recent years, it has come to encompass appropriate legal and financial strategies, including strategies for land access, business structures, and regional self-financing. Permaculture is based on three ethics: 1) care of the earth because all living things have intrinsic worth; 2) care of the people; and 3) reinvest all surpluses, whether it is information, money, or labour, to support the first two ethics.

In 1972, the International Federation of Organic Agriculture Movements (IFOAM) was founded in Versailles, France. Roland Chevriot, the former president of Nature et Progrès and other persons, led the initiative. The founding members aimed to establish a communication network among organic agricultural communities that had appeared in several countries. IFOAM represents the complete spectrum of stakeholders in organic agriculture movements worldwide (Foguelman and Lockeretz, 1999).

2.2.4 Historic contributions to organic agriculture and nature farming

As early as in 1580, Thomas Tusser observed human behavior and advised people to care the land and do crop rotations (Tusser, 1580). Wolfinger (1965) suggested the practice of green manuring. Charles Darwin established the real foundation for his study of the principles underlying farming and gardening as written in his book entitled *The Formation of Vegetable Mould Through the Action of Worms with Observations on Their Habits*. King (1911), as a chief of the USDA Division of Soil Management, wrote the book *Farmers of Forty Centuries (or) Permanent Agriculture in China, Korea, and Japan* after his retirement and described the natural agriculture in the eastern countries. Steiner (1924) marked the beginning of the biodynamic agriculture movement in his textbook, which was based on the series of lectures Steiner gave in Silesia (E. Germany) in 1924. Pieters (1927) as an agronomist working for the USDA, defined "green manuring," and cover, catch and shade crops and also described the natural agriculture in China and Japan, Greece and Rome, through the Middle Ages to England and America in the 19th Century. Waksman (1936) told the story of humus, its origin from plant and animal residues, its chemical composition, its physical properties, its importance in nature, especially in soil processes and in plant growth, and finally its decomposition. William A. Albrecht (USDA, 1938), as the Professor of Soils at the University of Missouri and one of the fathers of the ecological agricultural movement, represents an effort to see "the subject as a whole--scientific aspects, practical aspects, social and economic aspects; the needs of individuals, groups, and the Nation." Northbourne (1940) first used the term "organic farming". Balfour (1943) published her book, *The Living Soil,* which is an extremely readable exposition of the evidence in favor of biological agriculture by one of the founders of that country's "Soil Association." Her conclusions were based on 32 years' comparison of organic, mixed and chemical sections of a farm at Haughley, England. Faulkner (1943) has stated that plowing is wrong, and that the moldboard plow is not a satisfactory implement for the preparation of land for the production of crops. Pfieffer (1947) stressed the importance of the "life process (biological process)", with the farm or garden as a biological organic unit, not a series of unconnected processes. Cocannouer (1950), in his pioneering work, advocated the controlled use of weeds. Sykes (1951) called organic farming as *Humus Farming*. Hainsworth (1954) supplied in his book *Agriculture, A New Approach* with one of the best early sources of technical information regarding natural fertilizing and represented an "attempt to gather together relevant material that may have some bearing on the results achieved by organic methods". Wickenden (1954) wrote organic gardening practices and built the organic concept in his book, *Gardening with Nature: How to Grow Your Own Vegetables, Fruits and Flowers by Natural Methods,* based on his chemistry background, and in 1949 he wrote a popular book *Make Friends with Your Land (*Wickenden, 1949*)*. Easey (1955) has done a substantive work on the subject of *Practical Organic Gardening* with a thorough and well-documented framework. Turner (1955) wrote his book *Fertility Pastures: Herbal Leys as* *the Basis of Soil Fertility and Animal Husbandry. Ley* is also spelled "lea" and the dictionary defines ley as "arable land sown to grasses or clover for hay or grazing and usually plowed and planted with other crops after two or three years". Hunter (1964) has done the early works on biological control of insect pests. In his book *Our Margin of Life,* Poirot (1964) wrote seriously about agriculture, the importance of the soil, and a philosophy based on his observations and beliefs. In *Biodynamic Agriculture: An Introduction,* originally published in German, Koepf (1976) described organic agriculture of unusual interest. Berry (1977) proposed, “The care of the earth is our most ancient and most worthy, and, after all, our most pleasing responsibility”. Details of sustainable agriculture were presented at the first conference of the International Federation of Organic Agriculture Movements (IFOAM), in French, German, and English (Besson and Vogtmann, 1978). Oelhaf (1978), trained in theology, science and engineering, looks at more than just comparative economic issues and presents a detailed study of internal and external costs and benefits of ecological and conventional agriculture. Walters and Fenzau wrote about eco-agriculture from an organic perspective on the basis of plant and soil science, agronomy and pest control. Since 1980’s, organic agriculture has been popularly described, practiced and discussed in more details (Boeringa, 1980; Jackson, 1980; USDA Study Team on Organic Farming, 1980; Stonehouse, 1981; Hill and Ott, 1982; Altieri, 1983; Lowrance et al., 1984; Fukuoka, 1987ab; Harwood, 1983; Merrill, 1983; Scofield, 1986).

2.2.5 Nature farming concept in relation with Laozi’s philosophy

Okada founded a religion called *Sekai Kyusei Kyo* and related organizations to extend his nature farming philosophy and technology after the World War II. However, his successors or followers who were originally united in under the same organization separated with different organizations and modified the term Nature Farming by adding an adjective before it or by translating it into different English words. For example, one can read in documents the terms Kyusei Nature Farming, MOA Nature Farming, and Shumei Nature Farming. Moreover, Nature Farming, called “Shi Zen Noh hoh” in Japanese are translated to “Natural Agriculture” or “Natural Farming” instead Nature Farming. Which is correct? All say that XX Nature Farming was proposed by Okada but Okada never put an adjective before the term Nature Farming. It is not suggested and not necessary to change or modify the term Nature Farming. As the translation, one needs to know the original Japanese meaning of the term Nature Farming. As proposed by Okada, nature farming must respect nature and follow the law of nature without harming the environment. One can ask a kid to solve the following language problems. Allocate the terms, 1) nature, 2) natural and 3) naturalist, into an appropriate place: ( ) farming, ( ) gas, ( ) club. Absolutely the solutions are “nature farming", "natural gas" and "naturalist club". Therefore, it is not correct to use the term *Natural Farming* or *Natural Agriculture* for the translation of the Japanese word "*Shizen Nohhoh*". It is also not correct to use the term *Nature Agriculture* for "*Shizen Nohhoh*" because the meaning of the term *agriculture* is broadened to more than crop production. The modern Japanese word for nature, *shizen*, is actually the same word as in Chinese with a little difference in pronunciation. Its pronunciation in Chinese is "*Ziran*". Some people say it appeared after the Meiji period (1868-1912) and some say it is a translation for the Latin word natura and was first proposed by Amane Nishi (1829-97). These are all wrong. The word "*Ziran*" or two characters as "*Zi*" and "*Ran*" has existed in the Daodejing written by Laozi, an ancient Chinese philosopher (Bokenkamp, 1997; Csikszentmihalyi and Ivanhoe, 1999; Giles, 1948; Kohn and Roth 2002). The original meaning of the word "Ziran" did not mean "Nature". It means the way things are. One can review the 25th chapter of Laozi's Daodejing as follows.

"*There is something that is perfect in its disorder, which is born before Heaven and Earth. So silent and desolate! It establishes itself without renewal and functions universally without lapse. We can regard it as the Mother of Everything. I don't know its name. Hence, when forced to name it, I call it 'Tao'. When forced to categorize it, I call it 'great'. Greatness entails transcendence. Transcendence entails going-far. Going-far entails return. Hence, Tao is great, Heaven is great, the Earth is great and the human is also great. Within our realm, there are four greatnesses and the human being is one of them.*

Human beings follow the Earth;
Earth follows Heaven;
Heaven follows the Tao;
The Tao follows the way things are".

The last word "the way things are" is written in Chinese as "Ziran" or "Zi Ran". Zi means "itself" and "Ran" means "the state without changes". In English language, the term "nature" means the existing system of things; the world of matter, or of matter and mind; the creation; the universe; the personified sum and order of causes and effects; the powers which produce existing phenomena, whether in the total or in detail; the agencies which carry on the processes of creation or of being, often conceived of as a single and separate entity, embodying the total of all finite agencies and forces as disconnected from a creating or ordering intelligence; the established or regular course of things; usual order of events; connection of cause and effect; the sum of qualities and attributes which makes a person or thing what it is, as distinct from others; native character; inherent or essential qualities or attributes; peculiar constitution or quality of being.

The term “Law of Nature” is to be distinguished both from Scientific Laws and from Natural Laws. Within metaphysics, there are two competing theories of Laws of Nature. On one account - the Regularity Theory - Law of Nature is the statement of the uniformities (regularities) in the world, i.e. is mere description of the way the world is. On the other account - the Necessitarian Theory - Law of Nature is the 'principle' that governs the natural phenomena of the world, i.e. the natural world 'obeys' the Laws of Nature.

According to the definition by Armstrong (Armstrong, 1983.) and others, the term “Shizen” in Japanese or “Ziran” in Chinese actually means “the Law of nature” or just “Nature” in broad sense. The term “nature” has existed in Laozi’s work for more than two thousand years. As written by Laozi, human beings follow the Earth, the conditions related with the land; earth follows heaven, something like the climate and weather; heaven follows the Tao; the Tao follows the way things are, the nature or the law of nature. For agriculture or faming practice, it needs the three factors without exclusion, the heaven (weather and climate, light and temperature), earth (the land and the related conditions), and the human being. All the three factors must follow the nature and therefore farming must follow nature or the law of nature too. This is the key point of Okada’s nature farming philosophy.

2.3 A healthy powerful soil

Mokichi Okada believed that medical science and agriculture play the most vital roles in the maintenance of life and health, and regarded these two as the fundamental pillars upon which the coming civilization would be constructed. For a civilization, the guaranteed safety of life is one of the preconditions and it needs farming system capable of maintaining a healthy environment and producing safe foods with a nutritious value adequate for the health of human beings. Nature farming is based primarily upon a healthy soil capable of raising healthy crops by its natural inherent power. Okada suggests that the earth, which maintains a discrete order and harmony while nurturing life, is itself alive. Furthermore, he regards the soil, which has evolved upon the surface of the earth through the work of plants and microorganisms over millions of years, as a living body with its own miraculous vital energy. According to Okada’s nature farming philosophy, the harmony and prosperity of human beings and all other life can be assured by conserving the ecosystem while conforming to the laws of nature and by fundamentally respecting the soil (INFRC, 1988). If you respect nature, you can bring out the natural strength of the living soil (Okada, 1991). Because soil is responsible for nurturing plants and the most basic element in the food chain, it is indispensable for all life on this planet and determines the existence and quality of life on land. The philosophy roots basically in the Laozi’s philosophy, where it is scripted that human beings follow the Earth (land and soil), the Earth follows heaven (climate and weather), the heaven follows the Tao (the law of nature), the Tao follows the nature the way things are. Human beings, who are a part of nature, are capable of maintaining their own existence if they respect nature and the soil and use its inherent power to foster the cultivation of sustainable crops. The same power of synthesis and growth within the soil also permeates the universe, arising wherever the elements of fire (energy), water (solvents and medium), and earth (elements) meet. Soil is particularly related to the functioning of the earth element and so is largely responsible for life processes. Soil is not just a substance. The modern chemical agriculture ignores the inherent power and integrated properties of the soil, instead to depend upon the power of chemical fertilizers and consequently leads to a decline in the power of the soil (Parr et al., 1992).

In 1941, Okada conducted experiments and concluded that the chemical farming method was neither compatible nor in accordance with nature. He wrote: “If we grow crops with true love and respect towards the natural power of the soil, the soil will function to an astonishing degree. All the difficult problems and troubles that harass both farmers and consumers today can be solved through this method of cultivation”. He also composed a poem criticizing chemical agriculture for environmental pollution and degradation.

What a foolish thing!
Today’s man is polluting
The earth’s precious soil
Which produces the treasure
Vitally important food.

Some paragraphs about the healthy soil in the original essays written by Mokichi Okada in 1953 and translated to English in 1983 (Okada, 1953) are presented here, so that readers can fully comprehend his philosophy on nature farming.

2.3.1 Organic materials are decomposed to humus and remain in the soil

It is important to use large quantity of natural compost, which I shall now discuss. In stimulating plant growth, it is of the greatest importance to allow the root hairs at the ends of the large roots to develop. This means preventing the soil from compacting and hardening. If natural compost has decomposed too much, it tends to harden easily; about half decomposed is best. This kind of remaining organic matter increases the soil’s power to hold water and nutrients. If the soil is loose enough to aerate the roots, the root hairs have plenty of room to grow. This roominess is the reason why plants grow well in such soil. To soften soil for dry field cultivation thus to permit roots to grow and spread, allow dried leaves and grasses to decompose until soft, then mix *this compost with the soil. Recently, it has been said that ground should be soft in order that air may penetrate the roots. The composts are employed to produce three effects; to prevent the soil from hardening, to warm the soil, and to retain moisture around plant roots.*

2.3.2 The adverse effect of fertilizers

Over ages, agriculture has steadily, though imperceptibly, fallen into evil ways. Underestimating the power of the soil, farmers have accepted the necessity of using manure or chemical fertilizers for the improvement of crops. As a result the soil has degenerated and altered and its generative power has weakened. Unaware of this and suffering under the delusion that insufficient use of fertilizers causes poor crops, farmers resort to still more fertilization, with the result that soil declines even further. Fertilizers produce quite good results for a while but they gradually have adverse effects when used over long periods because, forced to rely on these artificial substances, crop plants change so that they become incapable of drawing substances from the soil. The situation is similar to that of drug addiction. The fertilizer addiction which is destroying soil throughout Japan is equally terrible. Farmers have blindly trusted in fertilizers for such a long time that they are unable to open their eyes to the truth. One of the great agricultural worries today is insect pests. However, instead of finding out what causes them, farmers concentrate all their efforts on exterminating them. In other words, unable to find out the reasons why harmful insects occur, they take what seems to be the next-best alternative. In fact, fertilizers generate harmful insects, and the number of such pests has increased in recent years as the number of fertilizers used has increased. Furthermore, people are unaware that the insecticides used to exterminate pests penetrate the soil and cause it to degenerate, thus leading to the appearance of still more insects. The application of fertilizers gravely weakens crops. Heavily fertilized plants fall and break in wind and rain. They bear few fruit because their blossoms drop. In the case of rice, wheat, and beans, the plants grow too tall and their leaves are too big, so that crops are shaded, husks are thick, and seeds are small and sick. Vegetables and grains raised by nature farming are better tasting, larger, and faster growing, and crops are bigger than those produced with fertilizers.

2.3.3 Low nutrient availability at beginning but long sustainability of organic materials

When people change from the fertilizer method to nature farming, they generally experience the following series of developments. When the seedlings are first transplanted from beds to the paddy fields, for a while the color of their leaves will be poor and their stalks thin. Indeed, by comparison with seedlings in other fields, they will look so scrawny that neighboring farmers *will smirk, and the farmers trying the natural method will become worried enough to return to God in prayer. After two or three months, plant conditions will improve, and, at blooming time, the farmers' brows will un-knitted a little. They will finally be put at ease when, just before harvest time, they see that their crops are as good as or better than ordinary. When harvest comes around, they will be astounded to see not only that their crops are big, but also that the grain is of high quality, lustrous, strongly adhesive, and delicious.*

2.3.4 Soil recovery from degradation

For the first year or two after the shift is made from fertilized agriculture to nature farming, results will be poor. This phenomenon occurs because the soil has become addicted to fertilizers. ...It is imperative to be patient and wait two or three years until the soil and seeds are freed of the fertilizer poison and land can manifest its great power.

2.4 Pest outbreak due to uses of chemical fertilizers and pesticides

Mokichi Okada came to understand the vicious circle that accompanied the chemical farming systems. He warned people that applications of chemical fertilizers and pesticides resulted in the generation of harmful and destructive insects which necessitate the application of toxic pesticides that would often cause insects to develop even stronger resistance. Then, in turn, the application of still more toxic chemicals would ultimately lead to further deterioration of the soil, the growth of still more pests, and the production of unsafe food that could endanger human health. Some paragraphs in the original essays written by Mokichi Okada (1953) are presented as follows.

Though insect pests may not totally vanish when the nature farming method is used, it does reduce them to a fraction of what they are when fertilizers are employed. Farmers often say that too much fertilizer increases the number of insects that plague the crops. I have heard from experts that Manila and Havana tobaccos, which are used in the finest cigars and are famous for their superb aroma, are never troubled with insect pests, because the plants are never fertilized with chemicals. In particular, there is the fact that insects do not damage weeds; and the special fragrance of the wild parsley and that edible chrysanthemum picked in the country in springtime were never damaged by insects is due to the fact they have had no fertilizer.

2.5 Nutritional conditions favoring pathogens inside the plant body

Okada (1941) has indicated "the difference between resistant and susceptible plants is the existence of the nutrition favorite to pathogens". What is the nutrition favorite to pathogens? As being mentioned in later paragraphs in this book, this nutrition includes nitrogen metabolism intermediates, such as nitrate and amino acids. Several experiments have been done with powdery mildew resistant and susceptible varieties of cucumber.

2.6 Nature farming vegetables are more delicious

Okada (1941) has indicated, “Vegetables produced by nature farming are much more delicious than chemical fertilized ones”. Why are vegetables produced by nature farming more delicious? What accounts for the deliciousness? These are very interesting questions. To elucidate the questions, an experiment is conducted in greenhouse with two kinds of leafy vegetables. Growth of these two leafy vegetables at the early stage is weaker in organic than in chemical fertilization treatments, which is attributed to the lower available nutrients in organic fertilizers. However, at the later stages both vegetables in organic fertilization treatments grow better and result in a higher final total yield than those in chemical fertilization treatments, which is attributed to the high nutrient sustainability of organic fertilizers. Leaf concentrations of sugars (sucrose, glucose and fructose) and vitamin C (ascorbic acid) are significantly higher but nitrate concentration is lower in organic-fertilized than chemical-fertilized vegetables. High concentration of vitamin C and low concentration of nitrate are indications of high quality of vegetables. Similar results have been reported elsewhere (Wang et al., 1999; Stopes et al., 1988).

3. Okada’s other philosophy than nature farming

3.1 Life of Mokichi Okada (1882-1955)

Mokichi Okada was born in 1882 in Japan. At this time, western culture and civilization were in boom throughout the country, and in a consequence, a feudalistic Japan was transformed into a modern society. The revolution brought Japan new philosophies and technologies. At his childhood, Okada believed that he could be an artist as a painter and tried his best in the Tokyo School of Fine Arts (now the Tokyo National University of Fine Arts and Music). Due to his health problems, he abandoned his goal midway, but he already mastered the techniques of maki-e (maki painting), ware lacquer and Japanese traditional designs. In 1907, he started his jewelry venture, functioning as both designer and entrepreneur and became successful in the jewelry business. When he was young, Okada expressed great concern to poor people, financially supported many poor people in difficulties, and contributed a lot to social welfares. Okada believed the pragmatic philosophy proposed by William James that philosophy must be implemented and applied in everyday life. In order to practice and disseminate his philosophy, Okada founded a new religion in Tokyo, the Japan Kannon Society, which was the predecessor of later *Sekai Kyusei Kyo*.

3.2 Transformation of civilization

From the ancient ages to the present, many civilizations throughout the world have come and gone, leaving cultural inheritances of art and technology. Many pioneers realized humankind's needs and attempted to create an ideal world. Their various legacies have been handed down to the world of today. However, all civilizations to date, including the Western civilization of today, have faced some problems that obstruct the realization of the wish to lead humanity to happiness and fulfillment. Mokichi Okada has cited cosmopolitanism, or the transcending of limited local or national views through adoption of a global perspective, as one of the fundamental preconditions for the coming civilization. In other words, civilizations founded to date, regardless of place and time, have characterized by being identified with a specific region, race, and religion. Okada has once pointed out that the turmoil and confusion today is a direct result of lacking a truly global civilization. Okada has suggested that new civilization must be based on harmony between the material and the spiritual, which stems from his insight into histories of human progress.

3.3 Fundamental laws

Mokichi Okada proposed and worked for a new cosmopolitan culture that would guarantee the survival of human and the planet itself, which is derived from his concepts about the spiritual nature of the universe. Okada first noted that the universe, including this world itself, is composed of a visible, physical world, and an invisible, spiritual world. These two aspects are intimately and indivisibly related to each other, and further, there is a universal life force at work behind the harmony governing the universe. All livings in the world that include humankind are comprised of a visible body and an invisible spirit, and it is through the conjunction of spirit and body that physical life comes into existence and operates. Okada believed that the world exists because of the concord and indivisibility of spirit and body. Moreover, he determined a cause-and-effect, or dominant-subordinate relation between the spiritual and physical worlds, which governs all things in existence. In other words, the causes for all things in the universe can be found in the spiritual world, with the physical world being merely its concrete manifestation. Okada stated that the spirit is originally pure, but that impurities arise for a variety of reasons. He called such impurities "spiritual clouds." In Okada's view, for example, in the human body, blood is the physical substance that most closely corresponds to the spirit; he believed that the ingestion of substances other than healthy foods was counter to nature and polluted the blood. This pollution in turn is reflected back upon the spirit, causing clouds. He stated that the accumulation of such clouds on the spiritual body obstructs the spirit's natural functions, and therefore triggers an eradication process to re-establish the original state of purity, leading to the restoration of the spirit's functions. This he called the purification process.

3.4 Creating a true civilization by uniting East and West

Okada stated that the civilization should be a harmonious, integrated civilization that respects spiritual values and material abundance. The foundation of a true civilization would guarantee safety of life and imbue all with the harmony of beauty and art. The transitional period, as pointed out by Okada, is characterized by social conflictions, the impasse where doctrines, theories, and systems of principles all seem to have reached with confusions, and the fundamental imperilment of human health and life arising from disregard for the laws of nature. The foundations of civilization will undergo a transition from insularity and opposition to harmony and symbiosis, and the world will proceed toward the creation of a new civilization. Okada construed the theory of symbiosis as being the essence of the new civilization. He named this theory the *Izunome* principle, a reference to the god *Izunome*, who appears in the Kojiki, the very first transcription of history in Japan. The essence of Okada's theory lies in the emergence of a global civilization that encompasses the world's diverse races, nationalities and religions with full expression of the individual personal potentials. Okada emphasized that the new civilization needs the harmonious integration of Eastern and Western civilizations in both scientific and spiritual aspects. Okada also explained that the civilizations of East and West lack perpetuity and might be destined to merge as a matter of historical inevitability. The conjunction of the Eastern philosophy together with the rich spiritual traditions to the bountiful achievement of scientific technologies in the West absolutely favors the restoration of harmony between human beings and their environment.

3.5 In harmony with nature

3.5.1 Living in harmony and beauty

According to Okada’s philosophy about nature, the universe extends far beyond human’s knowledge and the scientific exploration and it is also beyond all time and space. We do not really know how it began or how it exists. Scientists have discovered that matter which seems to be standing still, contains small particles which are moving at tremendous speed – that matter is in itself energy. Although all things may seem separate, all that exists is a part of a great network of energy, an inter-woven web that is ever growing and evolving harmoniously. Okada compares the world to a great painting. The lines are drawn which mark the boundaries between countries. Then the pigments are added, which can be equated with the earth’s different races and nations. Each country fulfills its particular role and has its unique characteristics. It is the harmonizing unification of thought that gives knowledge, great vision and progress to civilization. It is therefore a mistake for one country in the world to consider their own color superior to all others and to try to paint a picture of the world entirely in that color. Human beings need to live in harmony peacefully with each other, with nature and with every living in the web of nature. Okada has suggested that it is important to put aside our prejudices and respect the differences, which exist among us in order to create a peaceful world, and each special characteristic will be enhanced and all will become greatly broadened and enriched as a result of each person's contribution.

Beauty is a part of nature. Referring to the importance of art beauty, Okada writes, "If you were taking a walk down the street, what if there were no trees, green gardens and shrubbery, no houses, stores and buildings? What if instead the streets were lined with straight gray walls like those of a prison? Most of us would not be able to bear walking more than a block". It is the infinite variety of objects, which catches our eye. The same is true of the countryside with its varying terrain of mountains, rivers, streams and endless variations of colors and textures that stimulate us and enrich our feelings. An art gives its beauty by harmonizing and combining together a variety of different forms, colors, and textures. In his poem, Okada has written:

" Ah, the great beauty,
The matchless beauty of nature!
Be aware always
That it's the voiceless,
Priceless teaching of the
Supreme God".

As a master artist himself, Okada filled his home and centers with calligraphy and flower arrangements and established two or more of the most highly respected art museums in Japan. The greatest manifestation of his commitment to beauty is the gardens he designed as "sacred grounds for all the world's exhausted ones", exquisitely landscaped parks still found today in the cities of Hakone, Atami and Kyoto.

3.5.2 Nature is the God

Mokichi Okada writing in one of his books explained, "Thus the principle of the nature farming method is an overriding respect and concern for nature. Nature can teach us everything." Okada wrote in somewhere else, "Nature is the God", "Respect for nature", "adaptation to nature" and "manifestation of the intrinsic power of nature". "Nature is beautiful; nature is harmonious; it has an intrinsic order and rules, and in certain ways it can be seen to have an ethical or moral dimension". These ideas are shaped by the belief that humankind exists within the order of nature.

3.5.3 Seven spiritual principles of the universe

As described in the followers' homepage, Okada's philosophy suggested seven spiritual principles of the universe, i.e., order, gratitude, purification, spiritual affinity, cause and effect, spiritual precedes the physical, oneness of the spiritual and the physical. The principles are described as follows.

Order. Everything in nature moves in order, such as the four seasons that always follow in exact order: spring, summer, autumn, winter. The cycle of birth, growth and death is maintained year after year. Knowing and honoring this principle and allowing everything to proceed smoothly and naturally, you can understand why certain situations fail and what to change so that it will not fail again and you can keep harmony in your life.

Gratitude. It is a basic truth that gratitude gives birth to gratitude, connects you to the Divine and positive energy. Knowing and practicing this principle, you can be grateful for everything that happens to you in your life, understand and overcome adversities, remember not to complain too much, enable yourself to stay connected with the law of nature that in turn helps you maintain balance, and make your life's experiences become positive.

Purification. Negative thoughts, words and actions create situations that manifest, as what are called, "clouds" on your spiritual body. These spiritual clouds can also make your body impure and cause your physical body to become toxic. When the density of these clouds reflected as toxins in the physical body, reaches a certain point, a natural purifying action – or elimination – occurs. In many cases, the purification manifests as an illness. Illness is a purifying process of the toxins that have accumulated in the physical body. The toxic area or affected spot is the outer or surface reflection of the spiritual origin of the condition. This is the spot where spiritual clouds have accumulated according to the Principle of Spiritual Affinity. When the clouds are dispelled, the physical toxins dissolve and are eliminated from the body, naturally restoring health and balance. Purification can also take the form of a mental, emotional and material cleansing in individuals and can also occur in the form of natural disasters. Knowing and following this principle, you can understand and be grateful for simple or acute illnesses that cleanse the body, understand why accidents, disasters, conflicts, monetary losses occur, and understand why other forms of purification happen to you and on the planet.

Spiritual affinity. The illnesses and misfortunes that befall us all correspond to our spiritual level and our past actions. You are also born into a family on the spiritual level that you require, in order to progress spiritually. Knowing and following this principle, you can realize that your spiritual level attracts the appropriate experiences to you for your spiritual growth, and be grateful to your parents and family members for the lessons they have taught you.

Cause and effect. Where there is an action, there is a reaction. You reap what you sow. Knowing and practicing this principle, you can focus on doing positive deeds for the benefit of others.

The spiritual precedes the physical. Everything that occurs in the physical world is a reflection of what has already occurred in the spiritual or in the consciousness. Modern material science has made great progress in the study of the visible and tangible, but it has left out the vital, inner element of matter that is invisible to the five senses. This is spirit, the primary component that is the very substance of all matter. Knowing and honoring this principle, you can solve any problem, personal or global because it directs to the cause rather than the effect, and understand that everything that happens is the material result of a spiritual cause.

Oneness of the spiritual and the physical. Your physical body belongs to the physical world and your spiritual body belongs to the spiritual world. The inseparable union of the spiritual and physical bodies, or the oneness of spirit and matter, generates life-force energy. Without spirit, the physical body has no life-force and without the body, the spiritual body has no physical vehicle. What occurs on the spiritual body reflects on the physical and vice versa. They are not separate and therefore a change in one affects the other. Knowing and practicing this principle, you can remember to honor your spirit and your body equally.

3.5.4 Now in harmony with nature

Now many scientists and policy makers and farmers have recognized the importance of living in harmony with nature. For example, Dr. John Ikerd, the famous agricultural economist, has done a lot of good work to develop the philosophy of living in harmony with nature on the basis of modern economic and agricultural situations (Ikerd, 1989-1994, 1999abc). Ikerd's idea on harmony with nature is consistent with Okada's philosophy about nature farming and environmental harmony. The following paragraphs cite Ikred's ideas that are appreciated by the nature farming followers in Japan.

Can human win battles against nature?

Human history has much been written in terms of ongoing struggles against nature. Human has been conquering nature to survive and prosper, killing the wild beasts, building dams to stop flooding, using medicines to fight diseases, and synthesizing chemicals to control the pests. In appearance, human has been winning battle after battle, but in fact, human has been losing the war against nature. Human has killed so many wild organisms that non-human species are becoming extinct at an unprecedented rate. When human remains as the only species on the earth, he cannot survive – nor might he want to survive. Human has built dams in streams and the sediment that once replenished the topsoil of fertile farmland through periodic flooding now fills the reservoirs of lakes instead. The typical case is the Yellow River in China. Chinese made the gigantic mistake of the overall engineering of the Yellow River into a multi-purpose river, centered on 46 dam projects varying from large to gigantic, and large land reclamation schemes, and many secondary storage reservoirs. By the time the Yellow River reaches Kaifeng, it runs 10 m above the surrounding plain, where the river bed is above the rooftops of the houses behind the levees. The levees on the Yellow River floodplain have already been rebuilt four times in forty years: in 1950, 1955, 1964, and 1977. Fish that once filled and throve free flowing streams have dwindled and disappeared. Floods may come less frequent now, but nothing on earth can control the floods when nature really flexes its muscles, especially for the Yellow River 10 m high above the roof. Human can never win the battles with Mother Nature. Human has wiped out plague after plague that has threatened humankind, and we now lead longer, presumably healthier, lives than ever before, owing to the modern medicines such as antibiotics. However, new, more sophisticated diseases always seem to come on the scene as soon as the old ones are brought under control. The typical cases are the bird influenza, SARS, AIDS, and BSE. Even if we may live longer, that does not mean we are healthier. Much of the medicine we take today is to treat the symptoms caused by the medicines we take. A wellbeing Chinese father used to ask the doctors to prescribe expensive good antibiotics when his son caught cold or had a fever. However, he could not save his life when the son had an infection but any antibiotics could not be effective anymore. Now, human can easily kill most insects, diseases, weeds, and parasites using chemical pesticides. The world still looses about the same percentage of crops to pests as in earlier times. In addition, excessive uses of pesticides have caused many problems such as environmental pollution and risks to animals, human and other organisms in the environment. Human continually develops new pesticides, to fight with nature over the biodiversity by using chemicals to kill insects and weeds. The nature fights back and makes incidences of weeds and pests occur. It is because human makes nature lose diversity. If human being continues fighting with nature, the situation gets worse. Therefore, nature farming suggests human establish a harmony and peaceful relation with nature instead fighting forever.

Harmony for sustainability

A new paradigm for living in harmony with nature is arising under the conceptual umbrella of sustainability. Movement of nature farming or organic agriculture is but one small part of a far larger movement that is transforming the whole of human society. Nevertheless, a society that cannot feed itself is not sustainable. Human civilization is moving through a great transformation from the technology-based industrial era of the past to a knowledge-based sustainable era of the future. Agriculture is moving through a similar transition. According to the industrial paradigm, the welfare of people is in conflict with the welfare of nature. People have to harvest, mine, and otherwise exploit nature including other people, to create more goods and services for consumption. Human productivity is defined in terms of one's ability to produce goods and services that will be bought and consumed by others. Life quality is viewed as a consequence of consumption. The more we produce, the more we earn, the more we can consume, and the higher our quality of life. The more we can take from nature, and each other, the higher our quality of life. According to the sustainable paradigm, people are multidimensional of physical, mental, and spiritual beings with a mind and soul as well as a body. The life quality is determined by the three dimensions - what we consume and we feel as well. The sustainable paradigm focuses on finding harmony among all three. Spirituality is not synonymous with religion although this word is disliked by some of the Japan government officers. Spirituality refers to a need to be in harmony with some higher unseen order of things. Religion is simply one means of expressing one's spirituality. Spirituality assumes a higher order to which humans must conform. Harmony cannot be achieved by changing the "order of things" to suit our preferences. Harmony comes only from changing our actions to conform to the "higher order". A life lived in harmony is its own reward. The fundamental purpose of agriculture is to convert solar energy into products for human food and fiber. Nature provides a means for things to come to life, protect themselves, grow to maturity, reproduce, and die to be recycled to support a future generation of life. However, if human demands too much to the nature, the nature system will be damaged or destroyed. Sustainable agriculture must be in harmony with nature and also must be in harmony with people. A socially sustainable agriculture must provide an adequate supply of food at a reasonable cost. Any system of agriculture that fails this test is not sustainable, no matter how ecologically sound it may be.

Principles in harmony for nature farming or organic agriculture

The following several principles in harmony are proposals from Japan Organic Agriculture Association and International Nature Farming Research Center to IFOAM (International Federation of Organic Agriculture Movements) for improvement of the standards. The ideas are basically in accordance with Okada's nature farming philosophy. They are Health Principle, Ecological Principle, Fairness Principle and the Principle of Consideration. The respective principles are expressed with clear explanation. All principles are to be related mutually and each is used interdependently as other principles are considered.

Healthy principle

The soil, plants, animals, and the health of humans are connected as one in organic agriculture. This principle describes the mutual interdependence of health among all lives from the smallest living being to human being. As the integration of all life functions, health is a sustainable process that accumulates and transmits the necessary substance. The role of organic agriculture is in the maintenance and improvement of this process of health in all aspects and at all levels regardless of production, processing, circulation and consumption. The necessary attention, care, affection, and love come only from lives in harmony -- among people and between the people and nature. For healthy wellbeing, diet is an important part of life. Organic agriculture shows the view of happiness including the health of the soil, the plants, the animals, the environment and the society. Improving food self-sufficiency will protect the health of the citizen, the country and its natural environment. Eating the food that was brought up with the natural features is connected to the human's health and associated with environmental protection. The concepts of "body and earth in one" and "right land for right crop" are related with the health of the soil, the plants, the animals and human beings.

Ecological principle

On the basis of ecological systems, organic agriculture must imitate and improve the systems. Physical nutrition and mental happiness are achieved via the ecosystem of specific production environments. Furthermore, the human should strive to bring out the function of harmony (adjustment) that exists mutually in natural environment and the living things. Appropriate organic management must be adapted to individual regional conditions, ecosystem, culture, and scale. Organic agriculture must not impose adverse impact to landscape, residence area, biodiversity outside its production area and other life systems such as water environment and general environment. Modern agriculture has deteriorated to be dependent on pesticides and chemical fertilizers on the conceptual basis with the living plants, animals and soil as materials. As a result, all components of nature, the soil, the plant and the animal (soil flora and fauna), become unhealthy and the mankind is affected and today is faced with the deteriorating unrecoverable environment. Originally, the soil, the plant and the animal existing in nature had natural self-sustaining functions such as various natural recycling functions and selfadjusting functions that are necessary for survival. Oriental philosophy emphasizes respecting nature and the laws of nature and living in harmony with nature, clearly in contrast with the modern philosophy represented by the technological civilization where the human confronts nature and tries to conquer nature. It is a task for world organic movement to combine the oriental view of nature in Asian monsoon zones with the western view of nature.

Fairness principle

Organic agriculture should be based on fair relationships in order to guarantee fairness in regard to the common environment and the life opportunity. This principle deals with interpersonal relations and the relations between humans and the other living things. It expresses that organic agriculture should be maintained and practiced in order that fairness is guaranteed. Equality, respect, justice, and stewardship are included in this concept. There should not be permanent social and ecological injustice in management of natural resources. In contrast, organic agriculture must show how production and consumption are socially and ecologically correct by developing relations based on the fairness. When there is a human relationship inside or in association with organic agriculture, fairness should be guaranteed at all levels and for all involved such as producers, farm workers, processors, distributors, trading companies, and consumers. With respect to the specific ecosystem and the natural resources, the property and use rights for all people concerned in organic agriculture and related parties are valid only in limited periods.

Principle of consideration

Organic agriculture must have the responsible attitude for the future environmental soundness and the happiness of the future generations. This principle emphasizes the approach of the organic agriculture to its strategy and present management. It is not a risk appraisal of the narrow concept based on restricted scientific and economic assessment, but must induce prevention measures and the sense of responsibility. Consideration, prevention measures and the sense of responsibility not only include scientific evidences and viewpoints, but also relate with moral sense and non-professional aspects that exceeds the category of science. This principle is a feature that influences the management, development and technical selection of organic agriculture. Organic agriculture itself is a living dynamic system and continues evolving and developing in response to internal and external needs and conditions. Efficiency should be discovered and improved, but this cannot result in sacrifices of environmental health and human happiness for the present and future generations. This principle is, therefore, similar to the fairness principle, dependent on the participation and representation of all parties.

4 Scientific proofs of nature farming philosophy

When chemical fertilizers spread in Japan more than 60 years ago, many farmers and agricultural scientists blindly believed in chemical fertilizers and pesticides that pests would become extinct and hungers would be exterminated by chemicals. Actually, the tragedy of human being caused by chemicals started from this time. At this moment, Mokichi Okada, an orient philosopher, warned people with an opinion contrary to others (Okada, 1993). Among his sharp opinions, four examples are selected here.

1) Fertilizers pollute the soil and weaken its power of productivity.
2) Pests would outbreak from the excessive use of fertilizers.
3) Nutrition favorable for pathogens causes disease susceptibility.
4) Vegetables and fruits produced by nature farming taste better than those by chemical farming.
5) Fertilizer poisons exist at various levels.

Up to today, because of large uses of chemical fertilizers and pesticides in the modern agriculture, environment degradations and food pollutions are leading to many serious problems in our society. Therefore, concerns over the food safety and environmental protection have prompted our scientists and policy-makers to re-evaluate the modern agricultural practices. In many countries over the world, many people suffer from difficult healthy problems and the financial input to medication increases steadily year by year. At this moment, many people may recall Okada's warning. However, it is important to show the people whether or not Okada's philosophy on nature farming can be proved with modern scientific theories and experiments. In this research, several scientific experiments were conducted in accordance with Okada's philosophy to prove some of his opinions on nature farming.

4.1 What is the power of soil?

4.1.1 The soil is living

Mokichi Okada defined the nature farming as the practice respecting nature, adjusting the providences of nature as norms, and displaying the great power or ability of the living soil. It is fundamental to grow crop by displaying the power of the soil itself. The earth, which has supported human beings and other lives and maintained beautiful orders in harmony for billions of years, is also living and breathing. With natural function and the like and billions of years of time, the soil has formed on the surface of the earth and is a life body with a mysterious living capacity. The soil is the necessity that maintains the biosphere on the earth in harmony. The soil foster the plant that becomes the basis of the food web of life. Therefore, it can be said that the continent biosphere exists on the base of soil. In comparison with the height of atmosphere, the thickness of the earth's rock mantle, and the depth of the ocean, the soil layer on the terrestrial earth's surface is very thin, merely 1 meter or thinner than that. However, the thin soil layer functions like the crucible of the terrestrial life, where many physicochemical and biochemical reactions and the consequent biological productivity are generated and sustained. The soil acts like a home of innumerable microscopic and macroscopic organisms. Simply a fistful of soil contains several billions of living bodies of microbes and those microbes perform vital biochemical functions.

4.1.2 The soil acts like a seething foundry for matter and energy exchanges

Another amazing attribute of the soil is its enormous internal surface area and sponge-like porosity. As for the same handful of soil may consist of a million square meters of active surface, where many physicochemical and biochemical reactions take place continuously (Hillel, 2005). For the scientists, the soil is like a seething foundry, where the matter and energy are constantly exchanged in fluxes. The radiant energy from the sun cascades through the ecosystem of soil and plants in the field, where heat is exchanged, the water percolates through the intricate passages of the soil, the plant absorbs the water and transmits it to the leaves, and the leaves transpire the water to the atmosphere. The leaf absorbs carbon dioxide from the air and synthesizes it with the water from the soil to produce the primary chemical compounds of life - the carbohydrate, the fat, the protein, and many others. The oxygen, produced in the leaf and emitted out, is used for breath of all lives on the earth (Hillel, 2005). The soil is a self-regulating biophysical factory with its own materials, water and solar energy for the products. The soil also determines the destiny and fate of the rain and the snow reaching the terrestrial surface. The rainwater flows through the soil surface maintains the steady flow of rivers and streams, or permeates to the storage space as underground water and as the flow of springs. Without the soil as storage buffer, rainwater falling over the continents would run off immediately, producing violent floods rather than sustained stream flow (Hillel, 2005).

4.1.3 It was the soil that produced the human civilization

The ancient human recognized the fact that the humankind depends on the earth completely, lived in contact with the soil intimately, and respected the soil much more than many of us today. The soil was not only the sources of their living, but also the materials from which they made their houses, containers and instruments. To tell the truth, the china, or ceramic, which was derived from the soil, was the first synthesized material in the history of technology. The splendidly shining old Chinese civilization was something born from the soil of the loess plateau. At the age of beginning, the lands other than the loess plateau are covered in the forest and the grassy plain, and the ancient Chinese people could only plough the soft loess because the metal tools had not yet been available. Waiting the harvest after sowing the foxtail millet, the people were playing the soil to shape it and heat to the china potteries. Thinking as moving the fingers, the development of their brains was promoted, and therefore, the art related with the pictures and letters was developed, making the Chinese civilization shining through the human history. The ceramic that is derived from the soil was given the same name, china, as Chinese country. Therefore, one can say that the soil of the loess plateau is the mother of the Chinese civilization. Of course, with the soil, other ancient civilization also developed in the same way. In the Bible, the name that is allotted to the first human was Adam, but it was from the letter "adama" that means soil. The name that is given to Adam's companion is Hava (transliterated as Eve) means life or life-giving. Together, Adam and Eve mean "the soil and life" literally.

4.1.4 The soil is the living filter for natural purification

The soil functions as a naturally living filter to prevent accumulations of toxins and pathogens, which might otherwise pollute the terrestrial environment, but rendered harmless and converted to the nutrient by the functions of the soil. Ever since ancient times, the human and the other animal have continued to die of various diseases, have been buried in the soil, and yet no major disease is transmitted by the soil because of its purification ability. The process of cleaning water by ion exchange is also the simulation of the properties of the soil, which was discovered by the soil scientists who investigated the paths of solutes through the clay. As indicated by Okada (1991, 1993), the soil has its warmth, its kindliness, and its own fondness and is the source of all lives. Accepting the fallen leaves, withered flora, the corpses of all animals, the soil purifies all these entirely, converted them into necessary nutrients, and then nourishes the new lives. The new lives grow, develop and fruit, and again die where they were born, keeping the great life cycling circulation on the earth. Thus, one can say that the soil maintains the roots of all lives on the earth in it and it owns magnificent energy. Since a long time ago, the soil, which possesses great love magnanimity, has been called as land mother and loved by many people as the symbol of motherhood love.

4.1.5 The soil mitigates the greenhouse effect

As described by Hillel (2005), the soil is not an isolated body and it is rather a central link in the larger chain of interconnected domains and processes comprising the terrestrial environment. The soil interacts with the atmosphere, the strata, and surface and underground waters. In addition to its function of regulating the cycle of water, it also regulates energy exchange and temperature. The soil enrichment with organic matter may help absorb dioxide from atmosphere and store carbon to an extent, resulting in mitigation of the greenhouse effect. Of course, the most important one of the soil's functions related with the greenhouse effect mitigation is the process of CO_2 uptake and O_2 emission through plants and some photosynthetic microbes that grow in the soil.

4.2 Why fertilizers pollute the soil and weaken its power of productivity

Here, "pollute" means the soil degradation that the original power of the soil is destroyed and the physicochemical and biological properties are declining due to the excessive uses of chemicals. According to the present experimental results, the soil nitrate concentration is higher in nature farming fields than in chemical farming fields (Table 1). This is one of the soil pollutions indicated by Okada. When the soil is polluted by excessive use of chemical fertilizers, the first thing that occurs is a reduction in microbial quantity (Table 1, Dehydrogenase activity (Casida et al., 1964)). At the original, nitrate-nitrogen is transformed to biomass state or ammonium state that are stored in soil of the ecological system if the nitrate-nitrogen is in excessive status, without excessive supply to the plant and without leaching from the soil (Roger et al., 1993). As Okada (1941) written in his articles, this is the natural power of the soil. However, the natural power of the soil loses because of long time of excessive uses of chemical fertilizers. Excessive supply of nitrate-nitrogen from the soil to the plant weakens the disease resistance of the plant (Table 1, Infection rate, Infection Intensity and Dead plant). Therefore, the nitrate-nitrogen is the nutrition favorable for pathogen propagation as indicated by Okada (Okada, 1993).

With the above experimental data, Okada's opinion on disease resistance is confirmed. However, it is necessary to elucidate the detailed mechanisms. The pathogen examined in this experiment is *Phytophthora infestans* and the disease is a serious problem for tomato production. The leaves, petioles and even the stem rotten very fast when the tomato plant is infected by the

Table 1. Phytophthora infection to tomato plants grown with different fertilization.

Fertil.	Infection (%)	Intensity (leaflet)	Dead plant (%)	Leaf NRase	Leaf Nitrate	Leaf Amino	Soil DHase	Soil Nitrate
Che	88.2 ±12.3	2.43 ±0.29	88.3 ±9.6	5.47 ±0.51	2.7 ±0.19	2.33 ±1.2	21 ±4.4	224 ±22
Org	60.5 ±7.2	1.57 ±0.17	63.7 ±8.2	7.34 ±0.53	1.9 ±0.08	1.64 ±0.09	81 ±5.6	174 ±5

Mean±SD. NRase, nitrate reductase activity; Amino, Amino acids; DHase, dehydrogenase activity.

phytophthora pathogen. Even now, it is not clear whether the phytophthora infection to tomato is associated with soil and plant nutrition. About 60 years ago, Mokichi Okada, a Japanese philosopher, warned people that the more the chemical fertilizers are used, the more the infections of diseases and pest insects. Now, the scientists have known that resistance of pathogens and insects to chemicals increase steadily and more poisonous chemicals are needed. However, it is not clear whether the imbalance of the plant nutrition metabolisms is associated with disease infections. From examinations on tomato plants and phytophthora infection, it is found that concentrations of nitrate and amino acids are higher in leaves of chemical fertilized tomato plants than in leaves of organic fertilized tomato plants. The high concentrations of nitrogen metabolism intermediates may be favorable to propagation and infection of the pathogens. It is necessary to understand the reason for the low concentrations of nitrate-nitrogen in leaves of organic fertilized plants. First in considerations is nitrate reductase in addition to the supply quantity of nitrate-nitrogen from the soil. The data show that nitrate reductase activity is higher in organic fertilized tomato plants. The high nitrate reductase activity accounts for the low nitrate concentration in the leaves. Not only in the leaves, but also in the soil, the nitrate reduction activity shown by the hydrogenase activity is higher in the organic fertilized plots. The nitrate-nitrogen, especially in excessive status, is reduced to ammonium nitrogen or organic nitrogen, resulting in a balanced supply of nitrogen nutrition to the plants and a stable storage of nitrogen in diverse status in the soil. Moreover, balanced nutrition including micro-elements would also contribute to the enzyme activities in organic fertilized plants and soil. However, the plant growth and photosynthetic rate before phytophthora infection are not lower in chemical plots than in organic plots (data not shown). This suggests that phytophthora resistance is not associated with plant physiological activities. The nitrogen nutrition metabolism is the ultimate reason for the infection resistance.

4.3 Why pests would outbreak from the excessive use of fertilizers

It has been observed in a fertilization experiment that aphids infect only the chemical fertilized cucumber plants even the plants are arranged in a Latin Square design. When an organic fertilized pot with a cucumber plant is placed in the chemical plot, the plant still keeps away the aphids. Examinations show that nitrate-nitrogen concentration is lower in organic fertilized cucumber plants (Xu et al., 1999). Usually, nitrogen metabolism mediates, such as nitrate, amides and amino acids, are favorite for growth and development of aphids (Cisneros and Godfreya, 2001). The Japanese philosopher, Mokichi Okada (Okada, 1941), has once warned people that “Pest insects would well up due to excessive fertilizer application”. Now many experiments have confirmed his words true. As reported, large populations of aphids were controlled on fababeans at an organic farm in Nova Scotia, Canada (Patriquin et al., 1993) in seven of the 10 years (1977-1986). Kowalski and Visser (Kowalski, 1983) reported lower levels of aphids and lower levels of free-amino acids in a field of organically fertilized winter wheat in comparison with a field with conventional fertilization. Soil nitrate concentrations were consistently lower in organically fertilized fields (Patriquin et al., 1986). It is also suggested that low soil nitrogen is one of the factors contributing to effective control of aphids. As a test of this hypothesis, they found as predicted that there were more plants infected and higher populations of aphids in chemical-fertilized than in control plots. An effect of nitrogen fertilization on pest infection has also been observed in soybean (Wilson and Stinner, 1984). Pest infection increase with increasing nitrogen fertilization in a soybean line that cannot fix nitrogen (Todd et al., 1972). Lower levels of free nitrogen result in less accumulation of pest metabolizable nitrogen, making the plants more resistant to pests and plants more dependent on nitrogen fixation are less attractive to aphids than plants that are less dependent on nitrogen fixation. It was found that the average per plant nodule weight of aphid-infested plants was significantly lower than that of uninfected plants (Patriquin et al, 1988). Many research cases suggest that insect incidences correlate positively with plant nitrogen concentration (Kerslake et al., 1998; Scriber, 1984; Scriber and Slansky, 1981). High nitrogen application to glasshouse milkweed resulted in high leaf nitrogen, consequently increased pest infestation, and prevalently increased diseases as necrotic tissue (La Voie et al., 2004). Other experiments have shown that a healthy soil grows crops that are resistant to pests and diseases and organic fertilizations or ecological management systems produce healthy soils, while excessive applications of chemical fertilizers decline soil health (Balfour, 1975; Howard, 1940; Pfeifer, 1947; Rodale, 1946). Excessive nitrogen (Kritsas and Garsed, 1985) with insufficient potassium makes crops more susceptible to pests by increasing concentration of free amino acids. Over-fertilization or imbalanced fertilization rather than under-fertilization or severe nutrient deficit is the cause of soil nutrition related disease and pest incidences under intensive management whether organic or conventional. Usually, over-fertilization is less under organic than under conventional management since the lower availability and slower release of nutrients, especially nitrogen from organic than from chemical fertilizers. This could explain why disease and pest pressure might be less under organic management. However, if large amounts of poultry manure or compost are applied, nutrient imbalances or excesses could also occur under this type of organic management (Patriquin et al., 1988). Likewise, nutrient imbalances and excesses could also be avoided under conventional management with careful monitoring of soil and plants and selective using of slowly released fertilizers such as coated urea (Lunt and Oertli, 1962). Experiments have shown that composts suppress plant parasitic nematodes (Thurston, 1992), but fresh or only partially decomposed residues can also be phytotoxic to crops or stimulate growth of deleterious organisms (Linderman, 1989). Culliney and Pimentel (Culliney and Pimentel, 1986) conducted an experiment to examine the hypothesis that organic farming methods promote crop-plant resistance to pest attack. Levels of herbivorous insects on collards were lower and plant growth higher in plots treated with manure or sewage sludge, than in NPK or no-fertilizer plots. Eigenbrode and Pimentel (1988) fertilized plots of collards with organic manures and chemical fertilizer and found that population of flea beetles, diamond back moth and imported cabbage worm were significantly lower in organic manure than in chemical fertilizer plots and the pest populations were positively correlated with nitrogen early in the season. Highly soluble fertilizer increased pest problems compared to the slowly released organic fertilizers.

Insects are usually considered to be nitrogen limited (Mattson, 1980; McNei and Southwood, 1978; White, 1993). Animal or insect tissue consists of 7-14% nitrogen by dry weight and a plant consists of only 0.03-7.0% nitrogen (Mattson, 1980). Herbivore insects must therefore consume large quantities of their host plants in order to accumulate enough nitrogen for growth and development. Thus, it is logical that plants with high nitrogen concentration are favorite choice of most insects. Insects prefer higher nitrogen plants (Wait et al., 1998) to help them meet their nitrogen nutritional requirements (Howe and Westley, 1988). For this reason plants with high leaf nitrogen often experience increased levels of herbivorous pests. Plants often respond to herbivore and pathogen damage with increased toxic chemical production, other plant defenses, or compensatory growth (Howe and Westley, 1988; Mattson, 1980). Compensatory growth often results in higher protein yields and leaf nitrogen contents. Therefore, if pest insects are controlled at lower levels by regulating the plant nitrogen metabolism, reduction in crop yield by pest can be maintained at negligible or acceptable level.

As Okada (1941) indicated 70 years ago, “Pest insects would well up due to excessive fertilizer application”. It was grating to hear his warning at that moment. However, now many experiments have confirmed his words true.

4.4 What are the nutrition favoring pathogens inside the plant body?

Okada (1941) has indicated, “The difference between resistant and susceptible plants is the existence of the nutrition favorite to pathogens”. What is the nutrition favorite to pathogens? As mentioned in the previous paragraphs in this book, this nutrition includes nitrogen metabolism intermediates, such as nitrate and amino acids. Several experiments have been done with powdery mildew resistant and susceptible varieties of cucumber. The resistant variety (*Cucumis sativus* L. cv. INFRC C-1) shows its lower concentrations of nitrate and amino acids and higher nitrate reductase activity than the susceptible variety 'Nankyoku-1' (Table 2). This resistant variety is bred and selected in strict field conditions of nature farming without any applications of chemical fertilizers and pesticides. The variety has adapted to low nitrate soils with a good fruit yield in organic conditions although the fruit yield is a little low in conditions of chemical fertilization. The high powdery mildew resistance of C-1 might be attributed to low nitrogen substance concentrations, which are due in turn to the high nitrate reductase activity (Table 2).

Table 2. Powdery mildew infection and nitrogen metabolism in organic and chemical fertilized tomato varieties with different powdery mildew resistance on fresh mass basis.

Variety-Fert.	------Infect---------		NO_3^-	Amino	NR-ase	Soil NO_3^-	Fruit yield
	(%)	Leaf pl^{-1}	(g kg^{-1})	(mmolkg^{-1})	(μmolkg^{-1})	(mgkg^{-1})	(kg m^{-2})
Nan 1-Che	100 ±0.0	7.6 ±0.89	2.9 ±0.19	2.1 ±0.11	6.5 ±0.49	119 ±18	1.487 ±0.171
Nan 1-Org	100 ±0.0	6.7 ±0.57	2.6 ±0.16	1.9 ±0.13	7.1 ±0.53	103 ±18	1.591 ±0.028
C1-Che	15 ±9.6	0.2 ±0.12	2.1 ±0.11	1.6 ±0.17	8.9 ±0.49	116 ±5	1.162 ±0.119
C1-Org	20 ±11.5	0.3 ±0.15	1.9 ±0.09	1.7 ±0.06	9.4 ±0.73	107 ±10	1.478 ±0.191

Vegetable crops such as cucumber are easier to be infected by pathogen when the nitrogen nutrition is high in addition to high humidity conditions. However, the mechanisms are not enough clear. The previous research with tomato shows that an unbalanced or disturbed nitrogen metabolism accounts for the phytophthora infection (Wang et al., 2000). Tomato plants with organic fertilization show higher phytophthora resistance than chemical fertilized plants. However, there is no big difference in resistance between organic and chemical fertilization if nitrate nitrogen is supplied to a similar level of chemical fertilizers, as shown by data in Table 2. In this case, the nitrate concentration in the leaves is also not much lower in organic fertilized than in chemical fertilized cucumber plants.

Rice blast (caused by *Pyricularia grisea*). Excessive nitrogen fertilization, aerobic soil and drought stress are favorite conditions for rice blast (Ou, 1987; Webster and Gunnell, 1992; Ziegler et al., 1994). High nitrogen rates and nitrate nitrogen increase rice susceptibility to the disease. Ammonium nitrogen is converted to nitrate when fields are drained and aerated. This may explain why rice is more susceptible on non-flooded aerated soil. Extended drain periods encourage the disease by aerating the soil, converting ammonium to nitrate and by causing drought stress to rice. Nitrate-nitrogen is more conducive to disease development than ammonium nitrogen. An optimal rate of nitrogen fertilization results in a high yield in rice crop, but excessive use over the optimum causes diseases that can decrease the crop yield or increase the cost (Norman et al., 1992). It is well known by the plant pathologists that beyond the optimum amount, nitrogen may increase the incidence and severity of several common diseases that can reduce yield and quality. The interaction between nitrogen fertilizer and disease is true for almost all rice diseases, especially the blast, sheath blight and kernel smut. Therefore, scientists believe that there exists an optimum application rate and timing that can give each rice variety the best yields without stimulating incidence of diseases (Norman et al., 2002). A larger pre-flood application gives rice a shot of early growth that helps build carbohydrates to improve yield, but it increases diseases that could rob yields or add to input costs for control if the optimum amount is exceeded. The mechanisms of this nitrogen-disease interaction are largely unknown, but it is well known that higher nitrogen makes the plants lusher and more susceptible to diseases. The plants grow taller, faster and leafier, filling in the canopy early, so resulting in higher humidity that promotes more growth of sheath blight. This disease uses excess nitrogen in the plant tissues for its own growth. Excessive nitrogen also delays maturity of the panicle, increases the length of time that the grain is tender and results in kernel smut (Slaton et al., 2003). Therefore, the urgent work is to search for each crop or variety the optimum nitrogen rate for better yields without kicking in the disease.

The nutritional condition inside the plant that favorites with disease incidences, as indicated by Okada, is the accumulation of nitrogen intermediate metabolites, mainly caused by excessive supply of nitrate nitrogen.

4.5 Why nature farming vegetables are much more delicious

Okada (1941) has indicated, “Vegetables produced by nature farming are much more delicious than chemical fertilized ones”. Why are vegetables produced by nature farming more delicious? What accounts for the deliciousness? These are very interesting questions. To elucidate the questions, an experiment is conducted in greenhouse with a Brassica leafy vegetable. Growth of the leafy vegetable at the early stage is weaker in organic than in chemical fertilization treatments, which is attributed to the lower available nutrients in organic fertilizers. However, at the later stages Brassica vegetable in organic fertilization treatments grow better and result in a higher final total yield than those in chemical fertilization treatments, which is attributed to the high nutrient sustainability of organic fertilizers. Leaf concentrations of sugars (sucrose, glucose and fructose) and vitamin C (ascorbic acid) are significantly higher but nitrate concentration is lower in organic-fertilized than chemical-fertilized vegetables (Table 3). High concentration of vitamin C and low concentration of nitrate are indications of high quality of vegetables. Similar results have been reported elsewhere (Wang et al., 1999).

In developed countries with sufficient food supply, the people want a good health and a long life. This is not wrong and the desire has started with human being from the old time. In oriental areas, quite a lot of people live a long life inside the mountains eating wild vegetables and unpolluted food. However, many difficult diseases and health problems occur in the modern society even in the developed countries with good medical conditions. As indicated by Okada (1941), if one wants to live long healthy life, he needs to eat unpolluted natural food. That is why many scientists and policy makers have tried to re-evaluate our modern agriculture and adopt organic or nature agriculture.

Table 3. Concentration of vitamin C and nitrate in leaves of a Brassica (*Brasscica campestris* L. cv. Kairyo) leafy vegetable

Fertilization	Sugars ($g\ kg^{-1}$)	Vitamin C ($mg\ kg^{-1}$)	NO_3-N ($g\ kg^{-1}$)	Vitamin C/NO_3
Organic	5.8	190	4.8	39.6
Chemical	3.9	130	6.3	20.6

4.6 What is "fertilizer poison"?

Okada mentioned many times about "fertilizer poison" in his works on nature farming philosophy. It is written as "*hidoku*" in Japanese, meaning that fertilizers are harmful or poison. Now it is well known there are many side-effects of excessive fertilization. However, it is still needed to elucidate where the fertilizer poisons exist. Actually, the "fertilizer poison" can exist in different scales of environment, at the level of the macro-environment and ecosystems, the level of living body, and at the micro-environmental or molecular levels.

4.6.1 Pollutions of waters and food by nitrate

Excessive uses of nitrogen fertilizer in the agricultural systems cause pollutions of nitrate to surface and underground waters and also degrade the quality of agricultural products. The degraded quality of food can be confirmed by the nitrate concentration of soilless cultured spinach from a US market. It reaches 6500 mg kg^{-1} on fresh mass basis (Muramoto, 1999. Center for Agroecology and Sustainable Food Systems, University of Calfornia, Santan Cruz, CA. Internet Materials). However, the spinach produced with EM inoculated organic fertilizer in the nature farming system contains nitrate at a concentration of only 540 mg kg^{-1}. The two data of nitrate concentration suggest that nitrate pollution to the food, especially to the fresh vegetables, can be avoided by using EM bokashi in nature farming crop production. The author has once examined drinking wells in an agricultural area in Shandong Province of China. The concentration of nitrate in the drinking water reaches 242 mg kg^{-1} for a well and 124 mg kg^{-1} for another well (Table 4). The villagers drinking this kind of water have many health problems, such as skin allergy, pains here and sores there. One will be surprised if he compares the nitrate level to the UN criteria of the drinking water with nitrate lower than 10 mg kg^{-1}. The well in Wang Village was dug in a place close to the vegetable field. The soil was very deep and no rock was touched in the bottom of the well. The resource of the water is the leaching from soil. Actually, the villagers are drinking their soil solution.

Table 4. Nitrate concentration (mg kg^{-1}) in different waters in the world

Country	Location/Site	Nitrate	Conditions
Severely Polluted Waters			
China	Xilin Village/Irrigation well	66	20 m deep, in a conventional vegetable field
China	Cangshan /River Yi	25	Drainage from the field
China	Cangshan/River Wu	106	Polluted by paper and food processing mills
China	Lutang Village/Irrigation well	224	40 m deep, in an intensive vegetable field
China	Wang Village/Drinking well	124	7 m deep, near a pigpen and vegetable field
Canada	Quebec/Drainage canal	40	Drainage from field
USA	Nebraska /Well in corn fields	30	Conventional corn fields
Japan	Akahori-Machi/Irrigation well	35	Conventional vegetable field
Not Polluted Waters			
China	Gansu/Yellow River Upper	1	Without agricultural field
China	Linyi/ Yi River	2	Separated from field by large embankments

4.6.2 Blue baby syndromes

Nitrate can be carried by rain or irrigation water down through the soil and into the groundwater. If the well draws water from this groundwater, the well water may contain nitrate. Nitrate can affect red blood cells and reduce their ability to carry oxygen to the body. However, the blood cells of infants can take much longer to return to normal. As a result, infants, who are given water with high levels of nitrate or foods containing nitrate, may develop a serious health condition due to the lack of oxygen. This condition is called methemoglobinemia or “blue baby syndrome” (Donovan, 1990; Ziebarth, 1991). An infant with moderate to serious “blue baby syndrome” may have a brownish-blue color due to the lack of oxygen. This condition may be hard to detect in infants with dark skin. In mild to moderate cases, babies may have the same symptoms as when they have a cold or another infection (fussy, tired, diarrhea, or vomiting). In most cases of adults and children, the affected blood cells rapidly return back to normal. Babies under the age of 6 months old are most at risk and babies under the age of 3 months old even more so. Infants who are formula fed and live on farms or in highly agricultural areas may also be at greater risk. Nitrates used in farming, and the excess not taken in by the crop itself, easily run-off and may seep into water tables, contaminating water supplies.

The nitrate is naturally occurring nitrogen-oxygen chemical found in almost every vegetable that we eat. Nitrate can also be laboratory formulated and used in fertilizers, such as $NaNO_3$ and NH_4NO_3. Nitrate is taken up either from vegetables or drinking water. Nitrate or nitrite has been found to be responsible for "Blue Baby Syndrome." Adults are not much affected by nitrate or nitrite because their stomachs produce acids that depress the bacteria that help convert nitrate into nitrite. This conversion, and the consequent nitrite, is what causes nitrate poisoning or “Blue Baby Syndrome”. The name “Blue Baby Syndrome” stems from the fact that the cells of the baby’s body become oxygen deprived and the skin shows a color of blue or purple without proper oxygen saturation in the blood because the nitrites hinder proper oxygen transportation in the red blood cells. Once in the blood, nitrite oxidizes ferrous iron in the hemoglobin of red blood cells to form methemoglobin, which lacks hemoglobin's oxygen-carrying ability (Ziebarth, 1991). This oxygen deprivation may lead to the slow asphyxiation of the person poisoned.

The most obvious symptom of nitrate poisoning is a bluish color of the skin, particularly around the eyes and mouth. This is called cyanosis. The high concentration of nitrates is found in water, root vegetables and leafy vegetables such as spinach, lettuce and other green vegetables. The concentration of accumulated nitrate varies depending on the type of vegetable, the ambient, the sunlight, soil moisture and the soil nitrogen concentration. Vegetables that tend to accumulate large amount of nitrate include spinach, lettuce, beets, cabbage, broccoli, and carrots. Leafy vegetables such as spinach, cabbage and kale contain more nitrates than root vegetables such as carrots and beets and flower vegetables like broccoli. Proper preparation and immediate use or cool storage help eliminate this risk in leafy vegetables. Boiling vegetables in water cannot eliminate nitrates, and nitrates may seep into the water used for cooking. It is best to not use that water as the liquid to make your food. Because the intake of nitrates from foods such as green beans, carrots, squash, spinach, and beets can be as high as or higher than that from well water, these vegetables should be avoided for infants before 6 months of age. If you prefer to make your own homemade baby vegetables, an alternative is to choose organic produce. Organics do not use commercial nitrate fertilizers and thus the risk of nitrate contamination is minimized, but not eliminated. The best way to prevent "blue baby syndrome" is to avoid giving your baby water that may be contaminated with nitrate. Infants under one year of age should not drink water exceeding the drinking water standard of 10 parts per million (ppm) of nitrate. Boiling water will kill bacteria that are in well water, but it will not reduce the level of nitrate.

4.6.3 Nitrate as a cause of cancers and other chronic health problems

Fertilizer poisoning at micro or molecular level is explained by the long-term exposure to endogenously formed carcinogenic N-nitroso compounds (NOC), a group of genotoxic compounds, most of which are animal carcinogens. NOC are potent animal carcinogens, inducing tumors at multiple organ sites including the esophagus, stomach, colon, bladder, lymphatics, and hematopoietic system (Bogovski and Bogovski, 1981). NOC cause tumors in every animal species tested, and it is unlikely that humans are unaffected (Lijinsky, 1986). The number of well-designed epidemiologic studies with individual exposure data and information on nitrosation inhibitors and precursors are few for any single cancer site, limiting the ability to draw conclusions about cancer risk. Nitrate is a precursor of N-nitroso compounds. The commensal bacteria possessing nitrate-reducing activity convert nitrate into nitrite and other bioactive nitrogen compounds. Nitrate is readily absorbed from the upper gastrointestinal tract. Up to 25% is actively excreted in saliva, where about 20% is converted to nitrite by bacteria in the mouth (Spiegelhalter et al., 1976). Nitrate can also be converted to nitrite at other sites including the distal small intestine and the colon. Under acidic conditions in the stomach, nitrite is protonated to nitrous acid (HNO_2), which in turn spontaneously yields dinitrogen trioxide (N_2O_3), nitric oxide (NO), and nitrogen dioxide (NO_2). N_2O_3 is a powerful nitrosating agent capable of donating NO+ to amines to form carcinogenic N-nitrosamines (Leaf et al., 1989). HNO_2 can also be protonated to H_2NO_2, which then reacts with amides to form N-nitrosamides. At neutral pH, nitrite can be reduced by bacterial activity to form NO, which can react with molecular oxygen to form the nitrosating compounds N_2O_3 and nitrogen tetroxide (N_2O_4). In addition to the acid-catalyzed and bacterial-catalyzed formation of nitrosating agents, inducible NO synthase activity of inflammatory cells can also produce NO (Ohshima and Bartsch, 1994). These three mechanisms of endogenous nitrosation account for an estimated 40-75% of the total human exposure to NOC (Tricker and Preussmann, 1991). Many studies support a direct relationship between nitrate intake and endogenous formation of NOC. Populations with high rates of esophageal and gastric cancer excrete high levels of N-nitrosoproline (Kamiyama et al., 1987). Nitrate intake at the acceptable daily intake level (3.67 mg/kg body weight, 0.84 mg/kg as nitrate-N) results in increased urinary excretion of NOC, particularly in combination with increased intake of dietary nitrosatable precursors (Vermeer et al., 1998).

Nitrate intake from drinking water and eating fresh vegetables, both derived from the fertilizers in crop production is one of the main causes of the fastest growing cancer in the world. Researchers have studied the link between nitrate-rich fruit and vegetables and gullet cancer, which claims the lives of more than 3,000 people in the UK every year. McColl and his research team have investigated the link between high levels of nitrate and cancer around the gastro-oesophagael junction, where the oesophagus joins with the stomach. He also said organic food would not prove to be a healthier option because it also contained substantial levels of nitrate, some of which came from natural fertilizers such as compost. "It appears that the mass production of vegetables in the western world since the last world war may be the underlying factor that has led to such huge increases in this form of cancer," McColl said. He said research so far had showed that green and root vegetables contained the highest levels of nitrate. The scientific literature reporting studies on possible associations between nitrate and cancer risk are as follows: 1) Stomach cancer associated with nitrate in drinking water and vegetables (Armijo and Coolson, 1975; Clouph, 1983; Morales-Suarez et al., 1995; Barrett et al., 1998; Sandor et al., 1998; Yang et al., 1998; Hartmann, 1983; Forman et al., 1985; van Loon et al., 1998; Knekt et al., 1999; Moriya et al., 2000); 2) A positive correlation between mortality rates of bladder cancer and nitrate levels in drinking water and vegetables (Morales-Suarez et al., 1993); 3) Increased risk for non-Hodgkin's lymphoma associated with nitrate levels in drinking water and vegetables (Weisenburger, 1993; Ward et al., 1996; Ward et al., 1998); and 4) Other cancers in association with nitrates in drinking water and vegetables (Hagmar, 1991; Cantor et al., 1997; Barrett et al., 1998).

The scientific literature on the associations between nitrate and chronic health problems are as follows: 1) Hyperthyroidism (goiter) linked to exposure to nitrate in drinking water (Seffner, 1995; van Maanen et al., 1994); 2) An increased risk for central nervous system malformations in newborns whose mothers had consumed private well water equal to or greater than 26 ppm

NO_3-N (Arbuckle et al., 1988); 3) Genotoxic effects at the chromosomal level in persons consuming water with very high nitrate levels (Van Maanen et al., 1996; Tsezou et al., 1996); and 4) An increased risk of developing insulin-dependent diabetes associated with 2 to 8 ppm NO_3-N in water supplies (Kostraba et al., 1992).

4.6.4 Eutrophication and the consequent green and red tides

Eutrophication is the natural process by which surface waters, such as lakes, rivers and seas, become excessively enriched with nutrients, typically nitrogen and phosphorus (Ryther and Dunstan, 1971; Rosenberg, 1985). If naturally, eutrophication takes thousands of years to progress. However, humans have greatly accelerated this process through their various cultural activities. Man-made eutrophication is the water pollution caused by activities such as farming, forestry, road-building, industry and waste treatment that cause nutrients to enter watercourses. The sources of the excessive plant nutrients, primarily phosphorus, nitrogen, and carbon, added to streams, rivers, reservoirs and lakes include runoff from agricultural fields, urban lawns, and golf courses, and untreated or partially-treated sewage, especially the urban sewage containing phosphorus from detergents (Vollenweider, 1968; Seki and Iwami, 1984). Eutrophication often results in population explosions of algae and other aquatic plants. The most serious problems are caused by the massive growth of single-celled algae. As algae respire at night, when they are unable to produce oxygen via photosynthesis, the concentration of oxygen in water can be depleted. Bacteria breakdown the dead algae and cause decreases in the dissolved oxygen. In addition, aquatic plants, including algae, influence the oxygen and pH of the surrounding water. The excessive growth of algae enhances the fluctuations in dissolved oxygen and pH, which upset metabolic processes in organisms and result in disease or death. For example, fish are asphyxiated when dissolved oxygen is in low concentration. Blooms of blue-green algae produce algal toxins, killing feeding animals and poisoning freshwater supplies in reservoirs.

The eutrophication induces abnormalities of the ecosystem, such as the green tide and red tide in particular hydrodynamic zones. Green tide is a type of harmful algal bloom and an accumulation of green macroalgal biomass in eutrophicated waters (Raffaelli et al., 1998). A quantity of biomass as high as up to 27 kg fresh mass per m^2 are casts up or drift in water bays (Fletcher, 1996). Deleterious ecological effects of green tide include the uncoupling of biogeochemical cycles in sediments from those in water columns (Valiela et al., 1997), negative impacts on seagrass beds due to shading, and disruption of feeding by wading birds (Raffaelli et al., 1998). The eutrophication is also responsible for the red tide that corresponds to a massive proliferation of microalgae until concentrations of several million cells per liter of water led to a red-brown color in sea waters. Red tide is a phenomenon where vegetable plankton called whorl flagellum algae appear in an abnormally large quantity. The red tide is red-brown or brown, depending on the particular species of vegetable plankton. The principal cause of red tide is the eutrophication of the sea, especially most often in inland seas in the north hemisphere, where there are intensive industrialization and dense population (Okaichi, 1989). Large amounts of nutrients are generated from the organisms contained in domestic drainage. The whorl flagellum algae multiply rapidly with these nutrients. When red tide occurs, fish and shellfish die since their gills are filled with the red tide plankton, robbing them of oxygen (Anderson, 1989). Recently, the phenomenon has spread throughout the world. Some of whorl flagellum algae secrete toxins and poison people eating shellfish, which have fed on this type of plankton. In the Philippines, for example, the red tide plankton contain a paralyzing poison that accumulates in the flesh of fish and shellfish and the poison is passed on to the humans who eat fishes.

Ultimately, the excessive uses of fertilizers account for the eutrophication and the consequent red tides and green tides, which impose harmful effects on the lives in the water and on the whole aqua-ecosystem. Therefore, eutrophication is one aspect of the fertilizer poisoning indicated by Mokochi Okada.

4.6.5 Global warming and greenhouse effect

Global warming is the gradual increase in the temperature of the earth's lower atmosphere as a result of the increase in greenhouse gases. The temperature of the atmosphere near the earth's surface is warmed through a natural process called the greenhouse effect. Visible, shortwave light comes from the sun to the earth, passing through a blanket of thermal gases composed of water vapor, carbon dioxide, methane, nitrous oxide, and ozone, which are called greenhouse gases. The thermal blanket stops down the infrared radiation reflected off the planet's surface towards space, some of which is trapped and reflected downward, keeping the planet at an average temperature suitable to life. Industry, agriculture, and transportation have produced additional quantities of the natural greenhouse gases plus chlorofluorocarbons and other gases, augmenting the thermal blanket. Some longer-term results of global warming include melting of polar ice, resulting in rise of sea level and coastal flooding, profound changes in agriculture due to climate change, extinction of species as ecological niches disappear, more frequent tropical storms and increased incidences of tropical diseases.

Each of the greenhouse gases has a different global warming potential that takes into account the effectiveness of each gas in trapping heat radiation and its longevity in the atmosphere. One kilogram of methane (CH_4) is estimated to have the same warming potential as 21 kilograms of carbon dioxide (CO_2), and one kilogram of nitrous oxide (N_2O) has an equivalent impact to approximately 310 kilograms of CO_2. According to the Organization for Economic Cooperation and Development (OECD), CO_2, CH_4 and N_2O emissions in agriculture at global level are estimated to account for 14% of the total emission of greenhouse gases. All forms of nitrogen fertilizers may lead to N_2O emissions. Agricultural practices that increase nutrient use efficiency and diminish nitrogen leaching are appropriate for minimizing N_2O emissions. Adequate use and management practices, matching the nitrogen supply to crop requirements and integrating animal manure and crop residue management into crop production, result in a net reduction in N_2O emissions. The practice of reduced tillage and prevention of leaching through improved drainage are the agricultural practices that minimize nitrogen losses. Nitrous oxide (N_2O) has a greenhouse effect and is considered detrimental to the ozone layer. According to experts of the Intergovernmental Panel on Climate Change, N_2O is responsible for 7.5% of the calculated greenhouse effect caused by human activity. The concentration in the atmosphere is increasing at a rate of about 0.2%.

4.6.6 Heavy metal contaminations

As one of the fertilizer poison, heavy metal pollution has received more and more attention as many health problems are caused by heavy metal contaminations to food and water. Chemical fertilizers, especially phosphorus fertilizers, often contain variable amounts of heavy metals (see Table 5) (Cavallaro et al., 1993). Long-term application of chemical fertilizers is an important source for soil heavy metals (Li, 1995). According to the investigation, average contents of Zn, Ni, Cu and Cr in 20 samples of phosphorus fertilizers from China are 298, 16.9, 31.1 and 18.4 mg/kg (Xiong, 1993). Cd in vegetables exceeded the threshold of Chinese National Standards after the application of phosphorus fertilizers containing more than 250 mg/kg of Cd. Taylor (1997) also reported Cd accumulation derived from fertilizers in New Zealand soils. Soil acidification, which is caused by excessive fertilization, increases metal solubility and crop uptakes.

In the original principles of nature farming, animal manure and human toilet sewage are not allowed to be used as fertilizers. Now, it is well known uncomposted animal manure and urban toilet sewage cause soil pollutions because many kinds of chemical, such as medical drugs, growth hormones, and heavy metals may be contained. Cu and Zn in poultry wastes reach as high as 1500~2500 μg/g (Wong, 1985). Han et al. (2000) also reported the enhancement of soil heavy metals after the application of poultry manure. Organic fraction of municipal solid waste can be reused for soil conditioning after composting, as a source of organic matter and nutrients to the soil. However, frequent application of such composts to soil systems may lead to the accumulation of

Table 5. Typical heavy metal concentrations (mg kg^{-1}) in farmyard manure and phosphate and nitrate-fertilizers (Cavallaro et al., 1993)

	Phosphate fertilizers	Nitrate fertilizers	Farmyard manure
Cd	0.1-170	0.05-8.5	0.1-0.8
Cr	66-245	3.2-19	1.1-55
Cu	1-300	-	2-172
Hg	0.01-1.2	0.3-2.9	0.01-0.36
Ni	7-38	7-34	2.1-30
Pb	7-225	2-27	1.1-27
Zn	50-1450	1-42	15-566

heavy metals in soils (Veeken and Hamelers, 2002), contaminations to ground water and the food chain (Cala et al., 2005). It is sure that soil properties are improved and nutrients are supplied after sludge application (Sommers, 1977; Khaleel et al., 1981). However, the application of sludge may lead to accumulation of harmful components, such as heavy metal, organic compounds, salts, and pathogens, in soil and crops, resulting in such components entering the food chain. Heavy metals are of particular importance (see Table 6) (Lopez-Mosquera et al., 2000; Moreno et al., 1996). In a sandy Ultisol soil in southeastern Nigeria subjected to 40 years disposal of sewage wastes, the mean concentrations of Zn, Cu, Cd and Pb in the top- and sub-soil horizons of sewage soil were 79.3, 32, 0.29 and 1.15 mg/kg, respectively. These levels were high enough to constitute health and phytotoxic risks.

Table 6. Characteristics of the sewage sludge composts (Moreno et al., 1996)

	Sample 1	Sample 2	Sample 3
PH	7.10	7.24	7.04
EC(dS/m)	3.94	3.73	4.15
TOC(g kg^{-1})	268.5	276.2	260.9
Total N (g kg^{-1})	23.2	22.5	27.9
C/N	11.57	12.28	8.99
Cd (mg kg^{-1})	2	760	830
Zn (mg kg^{-1})	776	755	1640
Ni (mg kg^{-1})	105	101	525
Cu (mg kg^{-1})	275	214	995
Fe (mg kg^{-1})	2600	3100	2800
Mn (mg kg^{-1})	241	245	216

High concentration of heavy metals in soil can directly damage human health. Children are even more susceptible to environmental Pb. High Pb concentration in soil can lead to the rise of Pb in their blood and hinder their growth. The studies indicated that, compared with children exposed to soil lead levels of 100 ppm, those exposed to levels of 1000 ppm had mean blood lead concentration 1.10-1.86 times higher and those exposed to soil lead levels of 2000 ppm had blood lead concentrations 1.13-2.25 times higher (Jin et al., 1997). High concentrations of most metals, regardless of being essential or non-essential, are toxic to living cells. High concentrations of heavy metals in soil are phytotoxic and result in reduced plant growth and/or enhanced metal concentrations in plants and then enter the food chain, especially in low pH soils (Chaney, 1994). Plants growing in a polluted environment can accumulate metals at high concentrations, causing a serious risk to human health when the plant enters the food chain (Qian et al., 1996; Wenzel and Jockwer, 1999). As well known, high concentrations of metals in plants can interfere with physiologically important functions of the plants, cause imbalance of nutrients and have detrimental effects on synthesis and functioning of biologically important compounds, such as enzymes, vitamins, hormones, etc. (Vangronsveld and Clijsters, 1994; Luo and Rimmer, 1995). John (1973) reported that among the edible plant parts, the highest Cd levels were found in lettuce and spinach. Other investigators have agreed that leafy vegetables tend to accumulate higher metal concentrations than root, grain or fruit crops (Moir and Thornton, 1989; Alloway et al., 1990). The amount of metal uptake from soils is influenced by (1) soil factors including pH, redox potential, organic matter content, fertilizer application, the presence of Mn, Fe and Al oxides and hydroxides, cation exchange capacity, texture and amounts of other metals, and (2) plant factors including plant species, cultivars and age (Koeppe, 1977; Alloway, 1990; Jung and Thronton, 1996). Heavy metal entry into the food chain can do great harm to human health. Zn, Cu, Pb and Cd are generally the metals of greatest concern. Cd can accumulate in the body over a lifetime. The first biochemical signs of Cd toxicity are kidney disorders. The itai-itai disease in Japan caused by Cd-accumulated rice and soybean growing in a soil heavily polluted by Cd from nearby mine and smelter is well known (Kobayashi, 1978).

Accumulation of heavy metals in soil can also cause ecological toxicity and damage biodiversity in soil. Soil enzyme activities are involved in nutrient cycling and availability to plants and can be used as an index of soil functioning, and also effective indicators for microbial activities in soil. Several microbial indicators (SIR, total fungal length and biomass, and FDA bacterial biomass) were correlated with enzyme activities to a statistically significant extent (Gadd, 1993). The negative effects of heavy metals on soil enzyme activities have been recognized. For example, Cd, Cu and Hg ions act as inhibitors of pure phosphatases in vitro (Blum and Schwedt, 1998). Enzyme activities are useful for detecting altered microbial community structure caused by environmental impact such as heavy metal pollution (Kandeler et al., 1996). All the enzymes tested are appropriate for detecting heavy metal pollution in soils, as directly interactions between enzymes and heavy metals (Gadd, 1993). Many studies indicate significant reductions (10- to 50-fold) in enzyme activities because of the increase in heavy metal concentrations in soils. These results demonstrate that heavy metal contamination of soil has adversely affected the abundance and activity of microorganisms involved in organic matter decomposition and nutrient cycling in the soil (Kuperman and Carreiro, 1997).

Similar to excessive nitrate as a fertilizer poison, heavy metals are poisoning the whole ecosystem at the macro level and the human body at the micro and medical molecular levels. Heavy metal contaminations can be caused by both chemical and organic fertilizations. However, in the organic farming systems, the application of well-composted organic manure can improve soil pH to above 7, making heavy metals less available to crops. In addition, increased humus in soils by organic amendments can chelated heavy metals, and decrease crop uptake.

4.7 What are proof-tested for Okada's nature farming philosophy?

With above-mentioned data from several experiments, the theories of Okada's philosophy are perfectly proof-tested in scientific ways. This suggests that Okada's philosophy is of extractions from the nature. The most important theories on nature farming of Okada are summarized as follows.

1) Fertilizers pollute the soil and weaken its power of productivity. For example, scientific data show that the excessive nitrate pollutes the soil and decreases soil microbial quantity and quality.
2) Pests would outbreak from the excessive use of fertilizers. Experimental data show that disturbed metabolism makes nitrogen intermediate compounds, such as nitrate, amino acids and amides, to accumulate in leaves, weakens the leaves morphologically and consequently results in pest invasions and pathogen infections.
3) The difference in disease incidence between resistant and susceptible plants is attributed to nutritional conditions inside the body. The data show that the susceptible varieties contain more nitrogen mediate metabolites than the resistant ones even under the same soil nutrition. The nitrogen mediate metabolites are favorable for pathogens.
4) Vegetables and fruits produced by nature farming taste better than those by chemical farming. The data shows that vegetables and fruits

contain more soluble sugars, organic acids and vitamin C, which account for the deliciousness.

5) Fertilizer poison exists at different levels: at the medicinal or molecular level, nitrates from excessive fertilization induce cancers and cause other health problems such as blue baby syndromes; at the macro ecological level, nitrogen and phosphorus from excessive fertilization pollute surface waters and cause eutrophicatoin and the consequent green and red tides; and at macroclimatic level, greenhouse gases from excessive fertilization cause global warming by the greenhouse effect.
6) Of course, fertilizer poisoning consequences can be listed in many other aspects.

5 Technologies in nature farming systems

5.1 The technology of effective microorganisms or EM

5.1.1 The basic understanding of EM

The spread speed of EM around the world is amazing as it grows exponentially. Now in about 160 countries, EM is being used in agriculture and environment management. One can get by surfer on internet lots of information about EM. The quality of the research happening in Germany and Holland is high. Top scientists from universities and government research organizations have worked on EM and showed both positive and neutral results. Effective Microorganisms (EM) is a kind of microbial materials in the range of beneficial microorganisms. Beneficial microorganism is a term for a large group of microorganisms that contribute beneficially to human body, used as drinks or food starters such Lactobacillus in yogurt and yeast in bread, to animals such as feed additives, and to soils such as Rhizobium, Actinomycetes and mycorrhiza. The effects of these beneficial microbes are shown as nitrogen fixation, nutrient mineralization, humus formation and decomposition, and disease suppression. EM is a mixed culture of beneficial microorganisms containing about 80 different species. The main species included in EM are as follows. 1) Lactic acid bacteria: *Lactobacillus plantarum*, *Lactobacillus casei, Streptococcus lactis*; 2) Photosynthetic bacteria: *Rhodopseudomonas palustris*, *Rhodobacter sphaeroides*; 3) Yeasts: *Saccharomyces cerevisiae*, *Candida utilis*; 4) Actinomycetes: *Streptomyces albus*, *Streptomyces griseus*; 5) Fungi: *Aspergillus oryzae, Mucor hiemalis*; and 6) Others: some microorganisms that are naturally-occurring and introduced into EM in the manufacturing process which can survive in EM liquid at pH 3.5 and below. The concentration of most of these microorganisms in the liquid phase range from 1×10^6 to 1×10^8 per ml. According to Xu et al. (2000), Hornick and Parr (1987), and Li and Ni (1996), EM applications with both organic and chemical fertilizers promoted plant growth and increased grain yield. This was attributed to increased photosynthetic capacity and nutrient availability. The root quantity shown by root number and root length and the root quality shown by the respiration rate were increased by EM applications. Senescence shown by declines of photosynthesis was delayed by EM applications. Many observations of growth promotions, yield increases, and quality improvements are reported by farmers without strict scientific controls. Research on the individual species contained in EM have been thoroughly investigated and conducted over times. Some phytohormones and the derivatives are synthesized by soil microbes including some species contained in EM (Arshad and Frankenberger Jr., 1992). Barea et al. (1976) found that among 50 bacteria isolated from the rhizosphere of various plants, 86, 58, and 90% produce auxins, gibberellins, and kinetin-like substances, respectively. Kampert et al. (1975) reported that 55% of bacteria and 86% of fungi isolated from the rhizosphere of *Pinus silvestris* could produce gibberellins and the derivatives. *Actinomycetes* and *Streptomycetes* produce auxins and similar substances (Purushothaman et al., 1974; Mahmoud et al., 1984), gibberellins (Arshad and Frankenberger Jr., 1992), and cytokinins (Bermudez de Castro et al., 1977; Henson and Wheeler, 1977). Some fungi like *Aspergillus niger* produce gibberellins (El-Bahrawy, 1983). It has been observed that root development and activity are promoted by EM applications and it is speculated that the effect is due to plant growth regulators produced by inoculated microbes. Some of the plant growth regulators produced by microorganisms contained in EM are presented in Table 7. The successive chapters will elucidate in details the applications of EM technology in nature farming crop production.

The EM technology is but one tool in nature farming system. It includes the series of organic matter management, farm design, and natural pest control practices to not only organic agricultural systems but also other sustainable systems using chemicals. Combined with cover cropping, green manuring, reduced tillage, organic matter mulching, crop residue covering, composts, microbial inoculants, permanent bed vegetable growing, hedgerows, mixed- and inter- cropping, farmscaping, biological pest control, it makes up nature farming as a whole. EM can be used separately from nature farming by any farmer or gardener, and in environmental purification at any scales. Of course, nature farming can also be practiced with or without the use of EM. Because some of Okada's followers who promote EM technology are not scientists, and some activities and propositions diverge from modern scientific principles. This makes it difficult for these people to collaborate with scientists in universities and national research institutes. This phenomenon is especially reflected in the research and applications of EM technology (Higa, 1994).

The necessary fundamental research on this technology has been inadequate. Many benefits were claimed and conclusions reached about this technology without valid scientific support. This has resulted in aversion and criticism of the technology by scientists. Nevertheless, the microbes involved in this technology have demonstrated their effectiveness on ecosystem improvement of the soil microflora (Fujita, 1995; Liebl et al., 1992), promotions of crop root development (Xu et al., 1998), and recovery of polluted environments (Li and Ni, 1996). Research is needed to elucidate the mechanisms or modes-of-action that elicit these beneficial effects.

Table 7. Plant growth regulator (PGR) producing microorganisms contained in the microbial inoculant used in the present study

Microbe	PGR produced	Document
Actinomycetes spp.	IAA, ICA	Larsen et al., 1962
	IAA, ICA	Kaunat, 1969
	IAA	Purushothaman et al., 1974
	IAA	Clark, 1974
	IAA	Barea etal., 1976
	GLS	Panosyan et al., 1963
	GLS	Kampert et al., 1975
	Cytokinins	Bermudez de Castro et al., 1977
	Cytokinins	Henson and Wheeler, 1977
Streptomyces spp.	IAA, IPyA	Mahmoud et al., 1984
Aspergillus spp.	IAA, GLS, GA	El-bahrawy, 1983
	IAA, GLS, GA	Dvornikova et al., 1968
Mucor hiemalis.	Ethylene	Lynch, 1974
S. cerevisiae	Ethylene	Thomas and Spencer, 1977

5.1.2 The basic use types of EM

EM-1. With the basic mixture of Effective Microorganisms (EM-1), several different preparations can be produced. The most widely used preparation is EM extension solution which stands for ‘Active EM’, produced by mixing 5 % of original EM-1 liquid together with an equal volume of sugar cane molasses and keeping it at a constant temperature around 30^{o}C in a sealed container during one to two weeks. Then you have to check the pH of solution. If the pH is below 3.5 and the smell is sweet and sour that means the EM fermentation process has been completed and succeeded. In a good equipped fermenting tank at a temperature of 37^{o}C, the fermentation can be completed and succeeded in 24 hours. EM extension solution can be diluted again with water and used for a variety of purposes. The most effective use is applications as additives to the feed or drinking water for animals to maintain them in good health; the second is application for elimination of bad odors in husbandry or garbage and sewage treatments; and then the vast use is applications in agriculture to help activate germination, flowering, fructification and maturity, as well as improving growth and quality.

EM-Bokashi. This is made by mixing EM-1 with a fresh organic material such as oil mill cake, rice bran, wheat bran or fish meal etc., depending on what you can get locally. The organic materials are then left to ferment for up to two weeks in a sealed container. The final product can be used for the purposes as 1) accelerator or starter for the fermentation and anaerobic decomposition of organic waste materials when making compost and 2) additive to animal feed for improvements in general health and natural immunity.

EM-Compost. Animal dung, organic kitchen waste, garden cuttings and leaves are fermented with a quantity of EM-1 mixed with a spray and left covered for an anaerobic fermentation. The anaerobic fermentation can breakdown the chemical residues in the raw organic materials. Then, if needed, aerobic fermentation is added to the processing period and results in the production of good compost.

EM-5. It is a mixture of EM-1, molasses, vinegar, distilled alcohol and water, which is then fermented in a sealed container for more than 30 days until it produces no more CO_2 gas. Natural herbs such as garlic, red pepper, neem, Sichuan pepper and other pest repelling plant materials can be added before the fermentation process. EM-5 can prevent invasions of pest insects as well as strengthening the natural immune system against diseases.

EM-X. It is a special version of the EM liquid which has been certified for human consumption. As a daily dose over a period of time, it reduces free radicals in the body greatly improving the immune system.

5.1.3 Composting for biofetilizers

Composting is to decompose plant remains and other once-living materials to make an earthy and crumbly substance. It is used to recycle crop residuals, yard and kitchen wastes, and animal manure. In natural, composting is what happens as leaves pile up on the forest floor and begin to decay, and the rotting leaves are returned to the soil, where living roots can finish the recycling process by reclaiming the nutrients from the decomposed leaves. Actually, organic wastes are broken down through a combination of biological and chemical processes. Biological agents like worms, insects, fungi, bacteria and other micro-organisms "chew up" the materials, which are further transformed by oxidation, reduction and hydrolysis. Composting organic wastes into a valuable resource is popular in agriculture both conventional and organic. There are many kinds of composts and composting methods according to the materials and conditions (Rynk, 1992; Ndegwa and Thompson, 2001; Palm et al., 2001).

EM Bokashi- a living biofertilizer. Here introduced is a kind of biofertilizer composted using oilseed sludge, rice bran and fish meal with a microbial material inoculated. This microbial inoculant is called EM (Effective Microorganisms) in Japan and widely used in nature farming as mentioned in previous paragraphs. This kind of compost or biofertilizer is called EM Bokashi. EM bokashi was prepared by adding 8 ml molasses, 800 ml water and 8 ml EM inoculant into the mixed materials of 1.5 kg oil mill sludge, 3.5 kg rice bran and 1.0 kg fishmeal in a closed container. Anaerobic fermentation occurs in the closed container under a proper temperature. The fermentation can be performed well if the temperature is in the range from 20-40^{o}C in only two or three weeks. *Lactobacillus spp*. and yeast dominate in the biofertilizer. The *Lactobacillus spp*. population reaches 10^{8} CFU g^{-1} in seven days and yeast populations reaches 10^{8} CFU g^{-1} in three weeks (Yamada and Xu, 2000). The pH inside the biofertilizer can reach as low as 4.5. Therefore, other aerobic microorganisms cannot thrive in this condition and so the biofertilizer can be kept for a long time without decaying and losing nutrients. The quality parameters of the commonly used EM bokashi are characterized by a 4.5 pH, an EC of 4.9 mS cm^{-1}, 1.01 g kg^{-1} NH_4^{+}-N, 0.09 g kg^{-1} NO^{-}_3-N, 9.9 g kg^{-1} available P, 445 g kg^{-1} total C, 45 g kg^{-1} total nitrogen and a carbon to nitrogen ratio of 10.3. Therefore, the nutrients, especially the nitrogen, are not really available after the anaerobic fermentation. The EM bokashi needs to be aerobically fermented again before used, ether in processing place or in field mixed with soil. If the EM bokashi used at the same time as sowing or transplanting, it may cause burn to the seeds or the young root. It is better to mix the EM bokashi with the 5 cm surface soil layer in the field with an optimum soil moisture one or two weeks before sowing or transplanting. Then the EM bokashi will be aerobically fermented in the field conditions and the nitrogen will be mineralized. Fig. 1 shows the fermented soil surface with EM bokashi applied. Then the surface soil can be mixed deeper again as needed. As shown in Fig. 1, the biofertilizer brings the soil microbial enrichment in addition to fertilization.

As in the materials used, there are no pesticides and chemical residues in the biofertilizer. If there were chemical residues in the materials, the anaerobic fermentation would breakdown these residues. Therefore, EM bokashi is an ideal biofertilizer for organic crop production. As shown by experimental results in Table 8, vegetables grown with EM bokashi shows higher quality than those by chemical fertilizers (Xu et al., 2000).

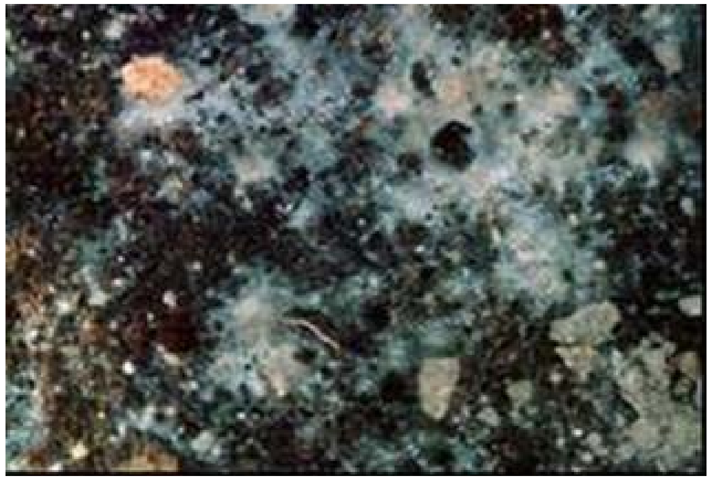

Figure 1. The biofertilizer, EM bokashi, applied on the soil surface, fermented aerobically with many microorganisms thriving.

Table 8. Sugars and organic acids in the ripe tomato fruit grown with a biofertilizer, EM bokashi, and chemical fertilizer.

Fertilizer	Sugars (g kg^{-1})				Organic acids (g kg^{-1})			
	Sucrose	Glucose	Fructose	Total	Citric	Malic	Total	Vitamin C
Bokashi	1.70 ±0.55	29.5 ±1.8	29.1 ±1.1	60.3	6.96 ±1.35	1.69 ±0.03	8.65	0.14 ±0.007
Chemical	0.24 ±0.11	25.1 ±3.7	25.2 ±2.1	50.5	6.57 ±1.06	1.48 ±0.25	8.05	0.11 ±0.004

Expanding active EM solution. The therapy for EM (Effective microorganisms) has secretly kept by one or two companies. Farmers used to buy the EM inoculant at a quite high price. Now Dr. Higa who proposed EM technology suggests farmers to expand the inoculant to active EM solution at on-farm level. Therefore, now farmers only need to buy the original inoculate and use it as starter. To make 10 L of active EM solution, one can add 300 ml of EM-1 original inoculant and 300 ml of molasses into 9.4 L of tape water in a container. Then the container is closed and the anaerobic fermentation occurs. Everyday the cap of the container needs to be opened for release of the gas from the fermentation. Otherwise, the container would be on the strain of high pressure imposed by the gas released from the fermentation. One or two week of time is needed for the fermentation to be performed. The indication is the pH, which must reach below 3.5. At this condition with such a low pH, only lactobacillus and yeast can be detected and it is not easy for other microorganisms, especially the aerobic fungi, to survive this low pH. That is why EM inoculant or active EM solution can be stored for a long time instead spoiled. Some active EM solution with botanical pesticide materials added will be introduced in next paragraphs. The preparations are similar to the abovementioned active EM solution. For example, the power of neem fruit, Ginkgo leaves, dry flowers of *Chrysanthemum cinerariaefolium*, Sichuan pepper, or hot peeper is added into the solution before the fermentation starts at an appropriate rate. The powder can also be first enclosed in a net of gauze and then the net was placed into the solution in the fermentation container so that the filtration for the powder residuals is omitted.

Composting kitchen garbage with EM. In the modern daily life, human disposes a large quantity of fresh garbage from family kitchens and restaurants. It can be a good resource of organic fertilizer used to crop production. However, some harmful substances might be mixed into the garbage and would pollute the environment if appropriate treatment is not performed. Anaerobic fermentation with EM added as inoculant can breakdown some chemicals in the garbage. Therefore, a fermentation with EM added is suggested for fresh garbage composting before it is used as organic fertilizer. The schedules are very easy to remember. EM bokashi or active EM solution is mixed into the fresh garbage. The water content is adjusted by adding some dry fallen leaves, straws and soils. Then the mixed materials are filled into a container, which is then closed with a cap. Stirring and mixing should be made again two to three days after the fermentation starts. It takes a month in summer and two or three months in winter for the fermentation. This is an anaerobic fermented compost. Much of the materials are not yet mineralized. It cannot be used together with seeds or immediately before sowing and transplanting. Otherwise burns on roots or seeds would occur. The compost should be used first to the soil surface for several days of aerobic fermentation and the mixed to deeper soil layer, one or tow weeks before sowing or transplanting.

5.1.4 Cleaning the environment with EM technology

EM has been widely used in environment management, including odor control of garbage and landfill, processing of waste into organic fertilizer, leachate treatment as well as urban and animal wastes treatment (Higa, 1994).

Uses in daily life. EM can be used in daily lives in many different ways, as 1) pouring EM down to the toilet to eliminate bad smells; 2) cleaning our kitchens and bathrooms with EM as the detergent; 3) making compost from kitchen waste with EM as starter; 4) washing our clothes with a little of EM added; 5) improving the quality of drinking water; 6) improving the health of our household pets; and 7) keeping our gardens in a natural and healthy conditions.

Sewage treatment. Research group led by Walter (Walter et al., 2003) have added extended EM using molasses and dairy wastewater in vitro and in field pond systems to assess the effect on dairy shed wastewater quality. Addition of extended EM solution to anaerobic dairy effluents reduced the offensive odor in laboratory and in field experiment. It was observed that the crusts that had formed on the water surface of the ponds were degraded by EM extension solution. Addition of extended EM increased suspended solids by increasing biological flocculation and decreased COD rapidly. Pond management and then quality of the discharge were improved by application of EM.

Help to reduce methane production. Methane is the second most important greenhouse gas and farm animals produce significant quantities in their rumens, so contributing to the greenhouse effect. Methane production also reduces the energy available to the animal. Silage, which is made from fermented grass, is a major component of the feed of dairy cattle. It has been thought that manipulating the microorganisms responsible for that fermentation process may be a way to reduce methane production from the cows' rumens. Experimental work in The Netherlands has shown that grass silage treated with an EM inoculant (predominantly lactic acid bacteria and yeasts) can alter the production of volatile fatty acids, propionic acids and acetic acid (Feed Innovation Services, 2003). This resulted in a decrease in methane production, which is an exciting development. The increase in the production of propionic acids has positive effects on milk protein production, meaning that EM may not only have the potential to reduce the effects of climate change but boost dairy cattle efficiency.

EM bokashi ball. Active EM solution or EM bokashi can be used to treat wastewater or polluted water and can also be applied to paddy field. However, good effectiveness cannot be expected if the solution or powder is applied into running water. Therefore, EM bokashi ball is suggested. EM bokashi is mixed into soil at a ratio of 1:3 with a little active EM solution added. Balls are made at the size a little larger than an egg. After air dried, that EM Bokashi can be stored for application. Balls are spread and deposited into the soft muddy layer under the running water in a river or surface water in a lake. Microbes, mainly lactobacillus and yeast are alive with bokashi nutrients in the mud and function for leaning the water. The active EM bokashi balls can also be applied to the paddy field. In a similar way to the case of river, EM bokashi balls are deposited into the soft muddy layer under the water in the paddy field and the leaching of nutrients are avoided.

5.1.5 Animal husbandry with EM.

EM is used in swine in a type of a fermented additive called bokashi using common feed material like oilseed cake, rice brain, corn or barley flour with EM inoculated. EM bokashi is added into feed at 3% first and 1% later.

Feeding of piglets with EM additive begins at the age of 4 months. As recorded by Pham (2002), the highest weight gain was obtained in the third month of feeding, the growth was 250.0g per day more than control, and total gain per day reached 750 g. During the following months the difference in gain remained the same and became some lower as the age and weight of animals increased. In poultry farming, EM bokashi was added to feed at the age of 10 days and effect showed 20 days after application as a steadily increasing gain. The principal gain in chickens is attributed to protein formation both in white muscles and red ones. This improves the quality and the value of produce. On the other hand, the protein increase in spleen is perhaps one of ways promoting the activation immune system. With EM application, protein increases in blood, which is considered as one of the positive factors. In a study with irradiation treatment in Vietnam (Pham, 2002), EM application allays the negative effect by irradiation in blood. EM application prevents decreases in lymphocytes that play paramount role in organism's immunity. The organs of immunogenesis, spleen and thymus, increase the mass in response to the injury by irradiation and EM application allays the injuring effect of irradiation on the function of these organs. The injury of animal organs caused by the irradiation conditioned the increase of spontaneous proliferation as seen in case of content of neutrophils in blood and EM application lowered this effect. EM application preserved the activation ability of T-lymphocytes in response to the action of injuring factor inhibiting their function. The analysis of proliferation ability of T-lymphocytes in response to their stimulation with concovaline and phorbolacetatemiristate has shown protective effect. The proliferation ability of T-lymphocytes remains higher in animals which have obtained EM-1. EM-1 exerts an expressed effect on the function of interleukine-2 which plays an important role in the activation of inactive T-lymphocytes. The interlcukine-2 function has been assessed by the stimulation of its reception on lymphocytes. Thereby the activation ability of interleukine-2 lowers under the effect of injuring factor on organism, and the EM-1 application promotes the preservation and even the increase of it. EM application activates super oxide dismutase and increases antioxidant activity in liver. In general, EM application to animals improves many functions and system such as immune, system of lipids per oxidation, mineral exchange, and protein formation.

EM was introduced to India in 1999 and proved particularly effective in dairy husbandry (Correa, 2002). For example, at Discipline farm, where allopathic medicines had failed to cure cows of a necrotic fungus, with EM addition to feed, the cows not only returned to full health, but also remained healthier and showed fewer flies and ticks. Other dairies that fed EM to their animals noticed that the milk production increased, and that the milk products improved their taste. EM was also effective in their vegetable gardens, paddy fields and fruit trees. One of the successes observed is the eradication of the rhinoceros beetle in coconut trees. Research by Li and Ni (1996) showed that quality of eggs was improved by EM addition to the feed. In EM eggs, protein increased and fat and cholesterol decreased. Quality of broiler was also much improved. Because of no need of antibiotics, the broiler is free of chemical residues and certified as Green Food (safe food) in China. Quality of pork produced with EM addition to the feed was also improved and certified as Green Food.

5.2 Intercropping for a healthy crop

Sustainable agriculture seeks to use nature as the model for system design. Since nature consistently integrates the plants and animals into a diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity. When early humans replaced hunting and gathering of food with domestication of crops and animals, the landscape changed accordingly. Since then, humankind has greatly reduced biological diversity by a limited selection of crop plants and animals. Annual crop monoculture represents a typical example. In response to this man-made biological simplification, nature has struggled to restore diversity. For example, the weed and pest incidence is the effort of nature to restore the biodiversity from the monoculture. However, the human has continued to fight with nature over the biodiversity by using chemicals to kill insects and weeds. Why the nature makes incidences of weeds and pests occur? It is because humankind makes nature lose diversity. If humankind continue fighting with nature, the situation gets worse. Therefore, we should realize the benefits of diversity, for example, planting mixtures of different crops or intercropping with green manure and non-crop plants. There is much more cooperation than competition among species in nature (Grossman et al., 1993; Laster and Furr, 1972). There exist mutually beneficial relationships between species within a community. Intercropping is one of the efforts made on the restoration of the natural biodiversity. In addition to a healthy crop from the beneficial relation among species, another reason to grow two or more crops together is the improvement in productivity per unit of land. Intercropping also reduce the ability of the pest insects to recognize their host plants. For example, thrips and white flies are attracted to green plants with a brown soil background, ignoring the vegetation-covered or mulched areas. Some insects recognize their host plants by smell. Onions planted with carrots mask the smell of carrots from carrot flies. The author observed in the field that cabbages intercropped with tomato were sheltered by the tomato smell from the butterflies laying their eggs. Another advantage for intercropping over monoculture is disease control.

5.2.1 Two varieties of rice mix-cropped together

In conventional crop production, monoculture of rice enables pathogenic fungi to easily attack the crop. One of the solutions in organic agriculture to breed resistant varieties, but it is not so easy as to get a variety both good in yield or quality and strong in disease resistance. Moreover, pathogens can soon overcome and be adapted to resistant crop varieties. In addition to breeding of resistant variety, increases in crop diversity by planting several varieties, including resistant and susceptible ones, in a mixture can provide a physical or biological barrier for pathogen to the fungal spores. Scientists and farmers in Yunnan Province, China changed from planting their typical pure stand of a single rice variety to planting a mixture of two or more different rice varieties (Zhu, Y. et al., 2000), aiming at reducing the incidence of rice blast. When intercropped, the susceptible plants are separated by non-host plants that can act as a physical barrier for the disease to spread and the susceptible variety will suffer less disease infection.

5.2.2 Tomato mix-cropped into leafy brassica

Intercropping can also adjust the supply of nitrogen from the soil to the crops. As usual, tomato will be easily infected by several fungal pathogens if the seedling absorbs too much of nitrogen. When a brassica leafy vegetable was sown before greenhouse tomato seedlings were transplanted (Xu et al., 2004), the leafy vegetables absorb the mineralized nitrogen when the young tomato seedlings do not need so much of it. Therefore, the nitrogen metabolism is smooth and makes the tomato crop healthy. As a consequence, the tomato plant were less infected by leaf blight and yield more fruit at the later growth stages (Table 9).

5.2.3 Peanut intercropped under tomato or cucumber

Intercropping legume crop, peanut, into tomato crop increased tomato fruit yield by decreasing leaf blight infection (Table 10). The key point here is to smooth the nitrate nutrition metabolism and reduce the concentration of nitrogen intermediate compounds in the plant tissues (Xu, 2004).

Table 9. Fruit yield of tomato intercropped with brassica leafy crop

Harvest period	Brassica intercrop	Fruit yield (g pl^{-1})	---------Leaf blight index (%)------- Infected plant	Infection index
Before Aug 25	No	976	77	8.3
	Yes	501	54	4.6
Before Aug 25	No	495	91	17.6
	Yes	906	66	10.7

Index = ∑(Number of infected leaves to a certain degree × Degree constant) × 100/(total leaf number × highest degree constant).

Table 10. Fruit yield and blight infection of tomato intercropped with peanut plants.

---------Treatment---------		Total fruit	Yield increase	Blight index
Fertilizer	with peanut	(kg pl^{-1})	(%)	(%)
Organic	No	1.22±0.20		6.5
Organic	Yes	1.38±0.09	13.2	3.4
Chemical	No	1.45±0.17		11.9
Chemical	Yes	1.62±0.09	11.7	8.2

5.2.4 Pumpkin and cucumber intercropped with bean

The most common disease incidence for pumpkin, cucumber and other *Cucumis spp* is powdery mildew. The pathogen is from the soil. When the pumpkin or cucumber is intercropped with bean crop, the vines can extend through over the vine of bean so that the leaves of pumpkin or cucumber leave a little farther away from the soil. The strip intercropping can prevent *Cucumis spp* from infection by the soil-born pathogens, in addition to the benefit of nitrogen fixation by the legume crop (Xu et al., 2002).

5.2.5 Tomato intercropped with turfgrass

Vegetables can also be intercropped with grasses or green manure crops. Field tomato intercropped with turfgrass, Kentucky blue grass (*Poa pratensis*), striped near each other or mixed planted, showed high resistance to Phytophthora and blight and improved fruit quality (Table 11). The nitrate concentration was lower in the tomato leaves intercropped with grass and consequently decreased the risk of fungal infection (Xu et al., 2005). Other research has also found that crop health is achieved by intercropping on the basis of biodiversity (Wolfe, 2000).

Table 11. Fruit yield, disease resistance and fruit quality in tomato plants intercropped with turfgrass.

Plot	Fruit yield (kg m^{-2})	Mal-Fruit (%)	Disease index (%)	Fruit Vc	Fruit Ca	Leaf NO_3^-
				----------------	(mg kg^{-2}FM)	----------------
In grass	3810	4.9	0	294	94	221
Near Grass	4618	4.0	13	285	101	269
No grass	5344	9.3	29	279	82	339

5.3 Mulching with crop residuals to avoid diseases and increase biodiversity

Mulching enriches and protects soil, helping provide a better growing environment. Mulches can either be organic, such as grass clippings, straw, tree leaves, bamboo slices and bark chips or inorganic, such as plastic, stones, and brick chips (Fujita and Fujiyama, 2000, 2001ab; Norgrove et al., 2004). Both organic and inorganic mulches have numerous benefits. Here the author focuses on the organic mulches as crop residuals. Mulching with crop residuals protects the soil from erosion, reduces compaction from the impact of heavy rains, conserves moisture, reducing the need for frequent irrigation, maintains a more even soil temperature, prevents weed growth, and keeps the plants from infection by the soil-born pathogens. Organic mulches also improve the condition of the soil as the mulches slowly decompose and they provide organic matter which helps keep the soil loose and promotes aggregation. This improves root growth, increases the infiltration of water, and also improves the water-holding capacity of the soil. Organic matter is a source of plant nutrients and provides an ideal environment for earthworms and other beneficial soil organisms. Research has shown that mulching with organic materials also effectively suppressed weeds.

5.3.1 Mulching with crop residuals to avoid diseases

The author has tried in situ wheat residuals as mulch to suppress weeds in the successive cropping (Xu et al., 2003). The wheat was harvested by cutting the spikes only with the straws left, which were then woven down as pigtail shape on the soil surface. The straws in pigtail shape were closely mulched on the surface and suppressed weeds effectively (Fig.2).

Figure 2. Wheat straws were woven onto the soil surface (Lower left: without woven mulch and weeds thriving; Upper left: pumpkin growing over the mulch).

5.3.2 Mulching with crop residuals to control weeds

Another experiment was done on a small wasteland where weeds were thriving and a thin layer of mulch with clipped grasses suppressed the weeds effectively as shown in Fig. 3. Many research has confirmed the effect of mulching with residual in weed control (Liebl et al., 1992). Although mulching is a useful technique, the thickness required to suppress weed germination varies with the density of the mulch material. Mulch should be thick enough to prevent light penetration and transmission to suppress photosynthesis of weeds. Applying a sufficient thickness for effective weed suppression is often an expensive option. Soil surface can be mulched after the weeds have germinated and the weeds die and ferment under the mulched organic materials as shown in Fig. 3. Mulch layers insulate the soil from high summer temperatures allowing roots to grow to the surface of the soil. Other advantages of the mulch layer include improved soil moisture retention, soil structure and soil fertility.

Figure 3. A thin layer of mulch with clipped grasses suppressed the weeds effectively.

5.3.3 Mulching with crop residuals to increase biodiversity

In organic agriculture, pests can be controlled by enriching populations of natural enemies. The author has tried enrichments of biodiversity and populations of natural enemies, such as spiders, by mulching with crop residuals and organic materials along the walls of a soil-based greenhouse. The spiders predate the insects in the decomposed organic materials such as crop residuals before the field insects reach the dense populations. This practice effectively controlled insects of brassica leafy vegetables in greenhouse (Fig. 5).

5.4 No-tillage to enrich biodiversity and improve soil properties

Any agricultural production system that contributes to constantly reduce organic matter content of the soil is not sustainable. Intensive and repeated tillages mineralize organic matter at rates greater than those in undisturbed conditions, resulting in decreasing organic matter in the soil and diminishing crop yields over time. Intensive and repeated tillages will generally damage the soil structure with negative effects on root growth, soil flora and fauna and soil moisture and nutrition (Sorrenson et al., 1998; Warren, 1981). In addition, soil carbon is lost very fast to the atmosphere as carbon dioxide when the soil is intensively tilled, resulting in unacceptable CO_2 emissions into the atmosphere that contributes to the greenhouse effect and the consequent global warming. Therefore, no-tillage or conservative tillage has received more and more attentions in the sustainable crop production. No-tillage farming avoids the use of tillage for seedbed preparation or weed control (Baker et al., 1996; Derpsch, 1998; Gazziero, 1998). Soil disturbance only occurs with seeding. Since 1987, the no-tillage technology has experienced a 59-fold increase only in Latin American from 670000 ha to 40.6 million ha and reached 90 Million hectares over the world in 2004. No-tillage or conservative tillage offers benefits as reduced labour and machinery, time and fuel savings, improved surface water quality and long-term productivity, reduced soil erosion, greater soil moisture retention, improved water infiltration, decreased soil compaction, improved soil tilth, increased biodiversity or more wildlife, and reduced release of carbon gases and consequently reduced air pollution (Derpsch and Moriya, 1998). In order to maintain and improve soil properties and achieve a sustainable crop production, it is necessary to stop mechanical soil preparation and keep a permanent cover of the soil with adequate quantities of plant residues added to the system. No-tillage with green manure cover crops and crop rotations is the only truly sustainable production system in most forms of agriculture, including nature farming systems. However, many reports show that no-tillage practices decrease crop yields compared with conventional tillage practices, which might be true at the stage of the first few years. At the International Nature Farming Research Center, experiments were conducted in comparison between several tillage regimes, till or no-till with or without green manure plant mulching. The soil animal density in no-tillage field was significantly higher over the 3-year period. In spring of the third year, the species number and density of earthworm increased in no tillage field. The aboveground biomass of sweet corn and green soybean increased steadily from first to third year in no-tillage field, and at the third year, reached the same as in conventional tillage field. Physical and chemical properties were improved in the successive no-tillage field.

A layer of crop residues accumulate on the soil surface in no-till systems. At the first few years, this residue layer may depress yields because of its negative effects on surface-applied nitrogen and the low soil aeration (Kelly, 1983). Nitrogen is cycled through mineralization (release) and immobilization (tie-up). Nitrogen in the organic form is unavailable and that in inorganic form (nitrate and ammonium) is available to growing crops. The surface residue in no-till systems may lead to significant immobilization of surface-applied nitrogen and surface applied nitrogen may also be lost by escaping as a gas. This loss is not related to surface crop residues but related to no-tillage practices. Populations of soil microbe increase with accumulation of surface residue, resulting in a greater potential for nitrogen immobilization. Immobilized nitrogen is just temporarily unavailable and then mineralized available to a growing crop. Soils in no-till systems tend to be moister than plowed soils. Soil moisture ultimately affects nitrogen management. A layer of crop residuals on the soil surface reduces evaporation from the soil surface. Usually, about 75% to 90% of the soil surface should be covered at all times and the more is better in the no-tillage field. Rotations of crops including high biomass crops can produce more residuals. Mulching the soil with residuals can also reduce weeds by depriving the weeds already germinated and sheltering weed seeds from the sunlight necessary for germination. With several seasons of no-tillage and residual mulching, weed seeds present in the surface layer may be significantly reduced.

5.5 Enrichment of symbiotic relationships in crop plant by inoculating mycorrhiza and rhizobia

It is well known that soil microbes play an important role in increasing nutrient availability and uptake, especially in nutrient-poor soils. N-fixing systems, including free-living, symbiotic or associative organisms, contribute significant amounts of fixed N to cropping systems. Rhizobia-legume systems fix N at rates of 50-300 kg N/ha/year. Cyanobacteria fix 15-25 kg N/ha/year and azospirillum-grass associations fix 10-30 kg N/ha/year. The symbiotic relationships of rhizobia with legumes and soil microbes, such as mycorrhizal fungi, are important components of biological farming systems (Bethlenfalvay and Schuepp, 1994). Several experiments have been conducted at the International Nature Farming Research Center to assess the responses of plants to rhizobial inoculation as regards of growth, nodulation, and mycorrhizal root colonization in organically fertilized soils. Rhizobia inoculation increased the shoot dry mass in the organically fertilized plants due to improved nodulation in the room (Aryal et al., 2003). Mycorrhizal Inoculation to bean plants increased root infection rates and frequency of arbuscular formation and consequently increased absorption, by the root, and translocation, to the shoot, of nitrogen and phosphorus. In another experiment, arbuscular mycorrhizae (AM) were inoculated into phosphorus deficient soil fertilized with either organic or chemical fertilizer with cucumber as the first crop and lettuce as the second crop but without additional fertilization and AM inoculation. AM inoculation increased fruit yield of cucumber significantly in the unfertilized, organic-fertilized and P-deficient plants compared with the fully chemical-fertilized plants. AM inoculation increased the available phosphorus in plant and soil by 30% for all treatments except for those chemically-fertilized (Table 12). The residual effects of AM-inoculation to cucumber were evident for lettuce in all pre-treatments that were unfertilized and un-inoculated for the second cropping.

Table 12. Effect of AM inoculation on available phosphorous (P) in cucumber plants and pot soil fertilized with organic fertilizer and chemical fertilizer.

Treatment	P in plant (mg g^{-1})	P in soil (mg kg^{-1})	Plant DM (g pl^{-1})	Fruit yield (g pl^{-1})
No Fertilizer	43.0 ± 5.7	6.5 ± 1.0	11.8 ± 0.2	0.0 ±0.0
No Fert +AM	58.9 ± 4.4	7.3 ± 1.5	13.3 ± 0.3	0.0 ±0.0
Organic	121.1 ± 21.8	8.0 ± 0.9	33.5 ± 0.9	103.1 ±6.3
Organic +AM	114.7 ± 19.3	9.0 ± 0.8	40.0 ± 0.7	158.0 ±14.2
NK	56.7 ± 2.4	4.9 ± 0.8	14.2 ± 0.3	0.0 ±0.0
NK+AM	62.0 ± 2.4	7.9 ± 1.0	16.9 ± 0.3	0.0 ±0.0
NPK	127.2 ± 26.5	12.0 ± 2.0	31.2 ± 0.7	92.9 ±8.1
NPK+AM	130.4 ± 6.1	10.4 ± 1.8	32.8 ± 0.7	112.9 ±8.5

Research has shown that enhanced AM association with crops through growing mycorrhizal crops in the previous season showed significant growth and yield promotion on soils with high P fixation capability (Thompson, 1991; Arihara et al,. 2000). Experiments at the Internatinal Nature Farming Research Center have shown that arbuscular mycorrhizal fungi colonized the roots of all the plant species except *A. caudatus*. The percentage of colonization ranged from 36 % to 76 % in the roots collected during full flowering. The abundant amount of mycorrhizal fungi in different crops grown in the nature farming field indicated that these fungi could be managed and manipulated to improve growth of plants in the organic soils (Mridha et al., 1999).

5.6 Integrated weed control by intercropping and applying organic materials

Weed control is one of the most important practices in addition to disease and pest managements in nature farming or organic farming crop production. In pest and disease managements, natural or plant materials, predator insects can be used as alternatives of chemical pesticides to suppress the pathogens or kill the pest insects (Basdow, 1995; Keel and Defago, 1997). However, for weeds control there is no alternatives of herbicides. Integrated weed control practices combined with cultivation measures have been tried and adopted in organic agriculture (Liebman and Gallandt, 1997). Integrated weed control should have a broader focus than weed control alone and should be integrated with other crop production practices that affect the ecosystems (Walker and Buchman, 1982). These measures including planting time (Davies et al, 1997), crop residual mulching (Rasmussen and Ascard, 1995), intercropping (Swanton and Weise, 1991; Swanton and Murphy, 1996.), rowing spacing (Malik et al., 1993.) and mechanical weeding (Stonehouse et al., 1996). Cover crops have been introduced, not only improving water infiltration, adding nitrogen to the soil if they are legumes and reducing soil erosion, but also providing good weed suppression. Ducks have been used in paddy fields and orchards weed control and also for snail control. Geese are natural born grass eaters and can do a good job of weed control in orchards. Although cost and maintenance exceed the cost of herbicides, these are the alternatives for the organic growers. Various companies have introduced fabric mulches such as cloths and papers. Weed germination is surely inhibited under this cloth or paper, but soil temperature was lower, especially in the early spring. Use of crop residual mulches provides good weed control, which have also shown to improve soil structure, keep soil cooler during high summer temperatures, conserve water and even aid in the suppression of root rotting fungi. It has been reported that surface application of a microbially fermented organic fertilizer called ‘EM bokashi’ depresses weeds germination in paddy fields (Iwaishi and Umemura, 1999). Here, EM means effective microorganisms containing many species of beneficial microbes and EM bokashi means an organic compost anaerobically fermented using materials such as rice bran, oil mill sludge and fish processing by-product with EM inoculated to the materials before fermentation. However, it is not yet known whether EM bokashi is effective in weeds suppression in dryland field. In the present research, EM bokashi was applied to the soil surface before soybean seeds were sown and effects of EM bokashi on weeds population and on crop yield were examined. Another alternative practical measure is to use crop residual on the soil surface to smother weeds (Swanton and Weise, 1991). In Japan, crop residual mulch is often used in vegetable production for weed control in both conventional and organic agriculture systems. The benefits of it are not only in weed control but also include preventing crops from infections by soil-born pathogens, reducing soil erosion and nutrient leaching, and improving soil structure, soil properties, biological diversity, soil water conservation, and the consequent growth and yield (Barnes and Putnam, 1983; Putman and De-Frank, 1983; Mohler, 1991; Liebl et al., 1992; Ateh and Doll, 1996: Swanton and Murphy, 1996). Mulch using crop residuals that are moved in from outside is widely used for production of pumpkin and other *Cucurbita spp.* Application of raw organic materials at appropriate time shows effective control on weeds in both upland and paddy fields, through injuring the germinating seeds of weeds.

5.6.1 Weed control in upland field by applying organic biofertilizer

In the research station of International Nature Farming Research Center, many field experiments were conducted for weed control. In the first experiment, EM bokashi, a bioactive organic fertilizer was applied 300 g m^{-2} and a compound fertilizer (N:P:K=15:15:15) was applied 60 g m^{-2} as control. Three weeks after soybean seeds sown, weeds and soybean seedlings were examined. Then the field was ploughed to mix the organic fertilizer deeper than before. Soybean was sown once more and weeds were examined again three weeks after the second sowing.

EM bokashi, the bioactive organic fertilizer, aerobically re-fermented when applied into the surface soil layer. Weed population decreased more than 50% by the soil surface fermentation. Many microbes including fungus and actinomyces thrived in the surface soil layer one week after the bioactive organic fertilizer was applied (Fig.1). As shown in Table 13, 20 days after soybean seeds were sown, the density of weeds was reduced to half of the control and the biomass of weeds was reduced to a quarter of control. About 5 weeks after seeds were sown, density of the weeds maintained the same as at the time of 20 days after sowing, i.e., half less dense in organic plot than in chemical plot, but the weed biomass in organic plot increased from a quarter to half of the control (Table 14). This was attributed to the increased biomass per plant because of the lowered density. In the experiment of the second time of sowing, both density and biomass of weeds were reduced more than 30% compared with the chemical fertilizer control (Table 15). This means that seeds of capable to germinate are reduced by the organic fertilization. The examined microbial quantity and the soil respiration rate were much higher in organic plots than in chemical fertilizer plot. However, crop seeds cannot be sown immediately after application of the organic fertilizer, and if so, crop seeds will also be damaged (Table 16). Sowing is suggested after the aerobic fermentation of the organic fertilizer in the surface soil layer is completed and the surface soil containing the decomposed organic fertilizer was incorporated into the 0-20 cm soil layer. With this kind of application manner, not only weeds were suppressed but also the nutrients in organic fertilizer were mineralized and became available for crops. Such an organic fertilizer is also used to control weeds in paddy field in Japan (Iwaishi and Umemura, 1999). This organic fertilizer ferments and decomposes continuously in the surface soil layer of the paddy field and a layer of soft mud forms as a consequence. Weed seeds cannot stay in this layer, sink down to the deeper layer and loses their germination potential. Moreover, applications of this organic fertilizer promote populations of earthworms, mainly *B. sowerbyi* BEDDARD, which disturb the weed germination and establishment by their activities in the mud layer. Although mechanisms of weed control in dryland field by application of organic fertilizer are completely different from the case of paddy field, it may

Table 13. Weeds in plots of soybean with chemical and organic fertilization 20 days after the first sowing

Weed name	Weed density (Plant m^{-2})		Weed dry mass (g m^{-2})	
	Chemical	Organic	Chemical	Organic
Portulaca oleracea	280.0 ±25.0a	116.0 ±35.4b	27.0 ±1.9A	7.3 ±3.0B
Digitaria ciliaris	55.3 ±22.4a	44.7 ±20.7a	8.3 ±3.3a	3.1±0.1a
Echinochloa crusgalli	32.7 ±8.7a	56.7 ±1.3 b	0.6 ±0.03a	0.5 ±0.1a
Senecio vulgaris	68.0 ±13.3A	7.3 ±3.7B	6.0 ±1.4A	0.1 ±0.1B
Amaranthus lividus	1.3 ±0.7A	0.0 ±0.0 B	0.2 ±0.2A	0.0 ±0.0B
Equisetum arvense	0.7 ±0.7A	0.0 ±0.0B	0.1 ±0.1 A	0.0 ±0.0B
Total	438.0	224.7	42.2	11.1

Values followed by different capital letter are significantly different at P≤0.01 and those followed by different lower case letters are different at P≤0.05. The same for tables below.

Table 14. Weeds in plots of soybean with chemical and organic fertilization 37 days after the first sowing

Weed name	Weed density (Plant m^{-2})		Weed dry mass (g m^{-2})	
	Chemical	Organic	Chemical	Organic
Portulaca oleracea	290 ±7 a	123 ±23 b	249 ±86 A	178 ±27 B
Digitaria ciliaris	53 ±7 a	63 ±23 a	127 ±40 a	112 ±4 a
Echinochloa crusgalli	14 ±1 A	17 ±29 B	3 ±1 a	3 ±9 b
Senecio vulgaris	80 ±29A	7 ±3 B	97 ±33 A	4 ±1 B
Amaranthus lividus	1 ±1 A	0 ±0 B	10 ±6 A	0 ±0B
Total	439	210	486	329

Table 15. Weeds in plots of soybean with chemical and organic fertilization 20 days after the 2nd sowing

Weed name	Weed density (Plant m^{-2})		Weed dry mass (g m^{-2})	
	Chemical	Organic	Chemical	Organic
Portulaca oleracea	598 ±66a	426 ±10b	221 ±35.6a	141 ±59
Digitaria ciliaris	32 ±7a	41 ±14a	7 ±5.2a	7 ±3a
Echinochloa crusgalli	13 ±2a	47 ±12b	0 ±0a	1 ±1a
Total	643	514	228	149

be adopted as one of the integrated weed control practices in organic farming systems. Usually, an organic fertilizer produced from animal manure and plant materials contains weed seeds and makes problems of weed seeds introduction and disperse in crop field (Mt. Pleasant and Schlather, 1994). However, EM bokashi, the organic biofertilizer, does not contain any weed seeds and there is no such a problem. The bioactive organic fertilizer was anaerobically fermented with lactic bacteria and yeast inoculated and the organic materials, oil cake, rice bran and fishmeal, are maintained fresh and raw before used. When the organic fertilizer is applied into the surface soil layer, aerobic fermentation occurs. Many fungi thrive fast and the mycelia spread in this surface soil layer. The surface soil layer is blocked and become hard (Fig.4) so that oxygen might be cut from the outside the soil by hard surface layer and used up by the organic decomposition inside the soil. In a consequence, the seeds of weeds were damaged or kept from germination because of oxygen shortage. Moreover, the fungi might be the pathogens of the weed seeds as mentioned by Kremer (1993), who isolated fungi from rotting weed seeds. Other research has also shown that fungi infect weed seed and decrease weed seedbank and fungicides increase weed seed survival (Longsdale, 1993; Fellows and Roeth, 1992). EM bokashi promotes fast propagation of fungi, many of which may infect weed seeds. The mechanisms for the organic fertilizer in weed control should be examined more in details.

Table 16. Effect of chemical and organic fertilizers on growth and seed development of soybean plants

---------Treatment-------		Emerg	Dry mass	Nodule	--Nodule fresh mass---	
Experiment	Fertilizer	(%)	(g/plant)	(/plant)	(mg/plant)	(mg/nod)
First sow	Chemical	75.2 A	0.50 a	24.7 a	32.0 a	1.30 b
	Organic	33.9 B	0.40 b	21.2 a	32.6 a	1.54 a
Second sow	Chemical	75.0 b	0.87 a	10.8 a	13.3 a	1.23 b
	Organic	81.3 a	0.91 a	7.5 a	11.7 a	1.56 a

First sowing, 1 June 2000; Second sowing, 5 July 2000.

Figure 4. Soil surface application of EM bokashi biofertilizer depressed weeds (Left: before sowing).

5.6.2 Weed control in upland field by mulching with crop residuals

In this experiment, Rye (*Secale cereale* L. cv. INFRC R-1) was sown in October and pumpkin was intercropped between rye rows two weeks before the ears of rye were harvested. The space was 2.0 m between rows and 0.4 m between plants. Ears of rye were harvested with the stalks remaining in the field, and the stalks were braided onto the ground in pigtail style as mulch. Density and biomass of weeds were much less in mulched plots than in bare field plot as shown by the pictures in Fig. 4. The weeds could not thrive for whole summer even when the pigtailed mulch rotted. Moreover, compared with the bare field cultivation, pumpkin crop with residual mulch was less infected by powdery mildew and other fungi. Rye plants before harvest protected pumpkin seedlings from infection of aphids. More soil fauna were found in plots of residual mulch, especially under the pigtail-shaped residuals. Therefore, the final fruit yield in mulched plots was higher than in bare tillage plots. Soil respiration beneath the mulch was higher than in the bare fallow soil and this might be due to high activities of soil microorganisms. During the growth of pumpkins, the vine sprawled onto the mulch (Fig. 2), which not only separated fruits from the soil, but also suppressed weed emergence and the latter affect positively the fruit production. Although the operation of mulching has to be improved, residual mulching treatment as done in the present work can be a good practice to suppress weeds and prevent from disease infection and is suitable for organic agriculture.

Using plant residues on soil surface to smother weeds has long been adopted as one alternative approach to the uses of chemical herbicides (Swanton and Weise, 1991; Dyck and Liebman, 1994). Residues can be the remaining of the preceding main crop or the preceding cover crop and moved-in residues from outside the field. Residues are widely used in the conservative tillage systems. In these cases, residues play multiple roles in reducing soil erosion and nutrient leaching, improving soil structure, and increasing soil organic matter in addition to suppressing weeds (Ateh and Doll, 1996; Barnes and Putnam, 1983; Putnam and Defrank, 1983; Mohler, 1991; Liebl et al., 1992; Swanton and Murphy, 1996). In Japan, rice straw is usually moved in as soil surface mulch from outside to vegetable field or apple orchard. It costs money and labor to store and move the rice straw for vegetables. In the present research, rye, or wheat in another case, was grown in the wintertime as one of the main crops and also as a cover crop. Pumpkins were sown between the rye rows before the rye were harvested. Ears of rye were harvested with the stalks remaining in the field. Then the stalks were braided onto the ground in pigtail style. It would be more effective if some organic fertilizer or fresh grass residues were spread under the pigtailed mulch. The pigtailed mulch tightly attached to the soil surface and weeds could not emerge from under the mulch. The mulch also maintained soil moisture and provided a good environment for soil biota, i.e., the soil fauna and soil microorganisms. This was reflected by the soil respiration under the mulch. For a large scale of production, it is possible to use mechanic tool with the farm machine to make the mulch in pigtail type. As one of the practices in integrated weed management, the pigtailed mulching may be expected with a good effect in organic farming crop production.

5.6.3 Weed control in upland field by intercropping a smother crop

In this experiment, peanut, as smother crop, was intercropped into tomato. One row of peanut was intercropped between two rows of tomato. Tomato fruit yield and weed incidence were observed and examined. As shown in Table 17, the accumulated fruit yield up to 74 days after sowing was higher in tomato plants with peanut intercropped. The yield increasing was more than 10% in both organic and chemical fertilization treatment. The yield increasing was attributed to enlarged fruit size and there was no difference in fruit number per plant between treatments. The economic income from peanut was not calculated in the present research because it is not the main crop. Although the biomass of weeds was not examined, weeds were clearly smothered by peanut plants in the intercropping plots. Different from other plants, peanut is a legume crop and it is able to fix nitrogen from the air. In addition to the weed smothering effect, peanut might interact in nitrogen nutrition with the main crop tomato, at least the peanut might not compete with tomato plants for nitrogen nutrition. Similar nitrogen release and supply by legume green manure crops were confirmed by Stute and Posner (1995) in cornfield. Peanut plants covered the soil surface between tomato row and suppressed weeds as found by McLenaghen et al. (1996). Dyck et al. (1995) have once conducted a field study using crimson clover (*Trifolium incarnatum*) as green manure in sweet corn field and confirmed the contributive effect of legume green manure in weed management. Boydston and Hang (1995) have obtained weed suppressive effect and potato yield increase by a non-legume plant, rapeseed (*Brassica napus var. napus*), as green manure. With their research results, many scientists suggest that allelopathic interaction between the green manure plants or the plant residues and the main crop may have been responsible for the weed suppressive effect of green manure (Dyck and Liebman, 1994; Gallandt et al., 1998; Liebman et al., 1995; Ohno and Doolan, 2001; Westoby et al., 1996; White et al., 1989). Combination of tomato and peanut, which covers the horizontal space together over the soil surface with different vertical canopy structure, minimized the invasion of weeds. As mentioned by Cardina et al. (1999) and Reader (1991), the cover crop can be selected to provide habitat for weed seed predators that are capable of reducing weed seed survival and elicit allelopathic chemicals that are capable to inhibit weed emergence and establishment. Smother crops, such as peanut used in the present experiment, have also been used in crop rotation between two main croppings to suppress the growth of weeds and break cycles of weed infestation associated with the production of the specific main crops (Robbins et al., 1942). A smother crop shades out weeds by its rapid growth and thick canopy. Often used smother crops are alfalfa (*Madicago sativa*), buckwheat (*Fagopyrum esculentum*), foxtail millet (*Setaria italica*), and rye (*Secale cereale*).

Table 17. Fruit yield of tomato plants with peanut intercropped.

Treatment		Red Fruit		Green fruit		Total Fruit	
Fertilizer	Peanut	kg/plant	No./plant	kg/plant	No./plant	kg/plant	No./plant
Organic	No	0.68 ±0.12	6.3 ±0.8	0.54 ±0.15	6.8 ±1.7	1.22 ±0.20	13.0ab ±1.7
Organic	Yes	0.81 ±0.04	6.3 ±0.3	0.56 ±0.04	7.3 ±0.3	1.38 ±0.09	13.5 ab ±0.3
Chemical	No	0.85 ±0.12	5.8 ±0.6	0.60 ±0.20	6.8 ±1.9	1.45 ±0.17	12.5 ±1.6
Chemical	Yes	0.89 ±0.14	6.0 ±1.1	0.73 ±0.11	7.3 ±0.3	1.62 ±0.09	13.3b ±0.9

5.6.4 Weed control in paddy field by applying organic materials

In the rice production, the beneficial organisms such as photosynthetic bacteria, earthworms even the unwanted weeds, pests and pathogens, all are related with the recycling of organic matter. It is expected that pests can be depressed by increasing the tolerance and competition of rice under an appropriate conditions favorable for the decomposition and utilization of organic matter in the soil. In nature farming rice production, it is expected that rice growth be promoted while weeds are depressed (Iwaishi and Umemura, 1998). Actually, undecomposed organic matter accumulates on the soil surface, decomposes during rice growth period and increases the organic mater in the root layer. This is why there should exist ideal paddy fields where weeds are not easy to propagate due to the cultivation practices. It is possible to control weeds by returning the rice crop residuals to the paddy fields and producing a condition for the residuals to be decomposed, as practiced by some farmers. In the research at INFRC Agricultural Experiment Station, the actual conditions of nature farming practitioners and the good experiences were analyzed and possibility of the practical use as a technique was confirmed. In 26 paddy fields from central to eastern parts of Japan there existed paddy soils whereby the growth of rice was promoted while the weeds were controlled by cultivation practices. The dominance of rice over the weed (*M. vaginalis*) or the weed over the rice and the damages by pest (*L. oryzophilus*) changed with alternations of the application depth of rice straw with different decomposing extent and quantity. The adverse effects from the raw materials was overcome by mulching organic materials on the soil surface with positive effects of promoting activities of earthworms, improving soil structure and depressing weeds. Moreover, applications of organic materials confirmed the growth promotion from weeds control by earthworms and activities of photosynthetic bacteria. A long-term experiment conducted in the fields with *M. vaginalis* as the main weed and without any pesticide applications also confirmed that there exist paddy soils whereby rice growth is promoted and weeds are depressed. It is possible to adjust the soil nitrogen concentration and earthworm population by applying organic materials and changing puddling methods in addition to soil water management for weeds control. In addition, organic materials with high nitrogen content, such as oilseed mill sludge, fishmeal and rice bran, mix fermented with microbial inoculant, can applied to the soil surface in the paddy field to control weeds. The fermentation of the organic materials occurs in the soil surface layer and produces a soft muddy layer, where the weeds deposit into the deeper layers without germination and establishment. For a better fermentation and establishment of the soft muddy layer, the water should be shallow enough and the temperature should be high, so that the fermentation of the organic materials could perform well.

5.7 Integrated organic management of orchards

Orchard management is difficult without pesticides and chemical fertilizers. This is especially true in Japan, where the appearance and color of fruit are very important, and the fruit will not be marketable if there is even a small blemish or scar on the surface or if the fruit is less than standard size (Fukuda, 1994). The consumer demand for these fruit quality parameters forces growers to use pesticides and fertilizers to ensure a large size and attractive appearance. Therefore, an integrated management is adopted in organic orchard production. The most common management of organic orchards in Japan is sod culture, fruit trees strip-intercropped with turfgrass. The original purposes to use sod culture are mainly the prevention of soil erosion and replenishment of organic matter. The roots deeply penetrating into the soil function as "the natural deep plowing machine" with soils undisturbed for small animals and microbes to thrive. In the opposite direction, killing grass with herbicide is called “clear culture”, where the soil surface is ploughed and then exposed. Recently sod culture is managed with multiple purposes, such as enriching biodiversity especially the natural enemies, controlling the nitrogen metabolism to lower risks of diseases, minimizing soil erosion, increasing soil aeration and permeability, and supporting workers’ equipment movement through the orchard during wet weather. The management practice involves use of a grass alley with a vegetation-free strip mulched by crop residuals in the tree row out to the drip line of the trees. This vegetation-free strip can be established and maintained by mulching rice and wheat straws or barks and wood pieces. The vegetation-free strip will help to minimize soil moisture and nutrient competition of grasses in the alley with trees, resulting in optimum tree growth. The vegetation-free strip may help minimize tree damage or loss from voles during the dormant season.

5.7.1 Principles and practices in orchard floor management

Orchard floor under trees or sod culture has long been adopted in both conventional and organic fruit productions (Fujii, 1985; Ito, 1982; Matsui and Sasaki, 1979). Orchard floor is usually maintained with a planted cover crop of grasses such as Kentucky bluegrass, or legume such as clover (Kitaguchi and Yoshioka, 1988). Bluegrass is expected to form a thick sod. Clover is a low creeping legume and grows along the surface of the soil. Clover is an excellent nitrogen-fixing legume and releases nitrogen to the fruit trees. Estimates of nitrogen fixed by white clover in grass pastures are reported as high as 225 pounds per acre. Both Kentucky bluegrass and clover flower early in the spring and if left undisturbed should remain relatively dormant through the summer, minimizing competition with the fruit trees for moisture and nutrients. The common style of sod culture is a combination of a sod band between two tree rows with a weed-free zone within the tree rows. The weed-free zone is usually maintained with rice or wheat straw mulch.

Sod culture offers several advantages over both complete tilling and chemical weed control. The permanent cover allows accesses to the orchard for cultural practices such as pruning, thinning, and spraying with machines easily passing through. The amount of dust in the orchard is also reduced, which is particularly important at harvest to prevent the fruit from being dirtied. Soil erosion caused by water run-off is reduced in sloping blocks. Sod culture is less costly than tilling or herbicides for weed control. Management of the sod orchard floor is difficult in practice because the orchard systems need to optimize all of the following objectives: 1) preserve soil structure, 2) maintain adequate soil organic matter levels, 3) enhance the biodiversity, 4) control weeds and other pests, 5) Allow efficient and effective irrigation of the tree crop, 6) allow efficient nutrition of the tree crop, and 7) allow access for orchard traffic. The main one of these objectives in organic fruit production is the biodiversity whereby pests are controlled. In organic orchards, frogs and many other natural predators thrive in the sod canopy and earthworms in the soil under the sod or under the straw mulch. The author has once visited organic orchards of viticulture in South France, where some orchards have been managed for 50 years without pesticides and fertilizers both chemical and organic. Although the farmers could not answer the questions about the nutrient budget in the orchard system, they just know that only the grapes produced in this organic way can be used to make the high quality wine. A unique ecosystem including the nutrient cycling might be formed in this kind of orchard. The author has also once visited the organic apple and grape orchards managed by Mr. Furukawa in Nagano, Japan. He keeps not only the sod but also many kinds of wild flowers under the trees. He keeps hens with chicks hatched naturally in the orchards, geese wandering around under the trees, and pigs confined under some of the threes. Pest insects are eaten by the chicks and soft weeds other than the hard sod are eaten by the geese. The orchards are fertilized by droppings of the birds and applications of big manure and composts. The unique organic amendment used by Mr. Furukawa is seaweeds. He buys or receives free some failed products of seaweeds, a kind of algae called *nori* in Japanese and applies the seaweed product to the orchards of apples and grapes. Wherever he grasps up a handful of surface soil, he can find some earthworms. The fruits are produced without any pesticides and herbicides and chemical fertilizers and clearly more delicious than the marketed conventional products. It is usually impossible in the climate of Japan but it becomes possible in Furukawa's orchards.

Sod culture, as a no-till farming, results in changes including enhanced soil biodiversity, increased soil organic matter and improved nutrients cycle in the soil (Kitaguchi and Yoshioka, 1988; Layne and Tan, 1988; Matsui and Sasaki, 1979; Toshio and Watanabe, 1982). This conservative system offers advantages as 1) reduced labor requirements, machinery wear and fuel cost, 2) reduced soil erosion, 3) enhanced soil moisture retention and improved water infiltration, 4) decreased soil compaction and improved soil tilth, and 5) reduced release of carbon gases and air pollution. As a consequence of enhanced soil biodiversity, sod grasses enhance the network by VAM hyphae, expanding into the soil and connecting roots of fruit trees and grasses (Cruz et al., 2000). This network made by VAM interconnections brings benefits to the soil plant system by extending root longevity (Tommerup and Abbott, 1981) and providing channels to allow nutrient transfer between plants (Martins, 1993; Martins and Cruz, 1998). VAM hyphae increase efficiency of nutrient utilization and nutrients are maintained in the plant system without leaching away. This interconnection involves not only a direct link between plants through hyphae, but also a complex of hyphae which are able to branch and link with other hyphae of the same species of VAM fungi distributed in the soil. The competition between the fruit tree and the grass for nutrients and water is minimized when a great network system is formed by VAM hyphae between these plants. Sod grasses have a shallow root system, which greatly protects against soil erosion (Ishii et al., 2000). The major disadvantages to sod culture are additional water and nutrients that must be applied to maintain both the fruit trees and the sod crop. Growth of the sod crop should be curtailed before active growth of the trees begins, as there is evidence to suggest sod crops compete for water and nutrients to the detriment of the trees. Sod grass is usually mowed leaving the cuttings on the soil surface in the three rows.

5.7.2 Leaf-scorch avoidance by integrated organic management

Actually, even in conventional agriculture, chemicals cannot solve all of disease and pest problems. Some diseases and pests must be controlled with integrated organic management. For example, in the pear production areas of Japan, a severe problem in orchard management is leaf-scorch and/or anomalous defoliation before harvest, which affects fruit yield and quality in both the current and future years by reducing photosynthate accumulation (Nagano Prefecture, 1987). This problem is attributed to leaf tissue dehydration caused by the unbalance between excessive transpiration and water uptake on hot-dry days, even under ideal soil conditions. To date, there has been no effective chemical practice to prevent or alleviate this problem. Therefore, scientists are prompted to elucidate the mechanism of leaf-scorch and to devise suitable cultural management practices that would prevent this problem. Some farmers have suggested that sod culture, or grass floor management, with nature farming or organic farming practices could minimize or eliminate this and other disease and pest problems (Fukuda, 1994). With farmers' collaborations, the author examined one organic orchard in comparison to a conventional orchard. Leaf scorch or leaf-burn was not observed in the pear orchard under integrated organic management but was severe in the orchard subjected to chemical farming practices. The leaf-scorch showed the symptom with the whole leaf dead and dried. This is a special local problem in the Central Japan mountain areas with a high evapotranspiration demand in the summer. There have been very few documents explaining the mechanism of this leaf-scorch problem. Some suggestions on causative effects were found in a booklet entitled "Fruit Production Guidance" published by Nagano Prefecture (1987). This problem is due to the sluggish stomatal regulation in response to suddenly increased transpiration. When it is hot and dry in the summer, especially after a rain, the leaf transpiration increases in response to the evapotranspiration demand. In such a case, the stomata usually close to adjust the balance between water influx to the leaf and transpiration water loss from the leaf. If the physiological activity associated with stomatal function decreases, the stomata cannot adjust in response to increased evapotranspiration demand so that transpiration water loss is greater than water influx to the leaf and the leaf dies because of sudden water loss and desiccation. Since no leaf-scorch was found in the pear trees managed by organic farming, it is suggested that physiological activity associated with stomatal function was higher in leaves of pear trees with integrated organic farming management than leaves of pear trees subjected to chemical farming practices. The author also examined the leaf water relations and stomata related variables to support the observation of leaf-scorch avoidance. The laboratory test using excised leaves (Quisenberry et al., 1982; Xu et al., 1994) showed that the stomata of pear leaves from integrated organic farming could adjust the opening aperture in response to decreasing leaf water content so that more tissue water was retained as water was lost by transpiration. Water relation analysis (Jones, 1992; Robert et al., 1997; Xu et al., 1997) showed that the concentration of cell sap solute such as sugars, ions and other soluble substances was higher in leaves of pear trees under integrated organic farming than in those under chemical farming. Moreover, leaves of pear trees under organic farming hold more active water in symplast, where most metabolic reactions take place. Improved leaf water relations and cell water compartmenting might, at least in part, account for the leaf-scorch avoidance of pear trees under organic farming practices. As a consequence of leaf-scorch avoidance, fruit yield was 62% higher in the organic farming orchard than the conventional pear trees, which were severely affected by leaf-scorch.

5.7.3 Aphid control in an apple orchard by integrated organic management

Actually, massive use of chemicals often induce the outbreak of several secondary pests such as mites, aphids, leaf miner due to shortages of natural predators in the apple orchard ecosystems (Andow, 1998). Recently, the importance of natural enemies, predators or parasites, in agro-ecosystems has received more and more attentions (Altieri, 1991; Bayram and Luff, 1993; Corbett and Rosenheim, 1996; Luck, 1990). Conservation and augmentation have been adopted for several natural enemies in apple orchards and adjacent farms and show good effects of the conservations in pest management apple orchard ecosystems. Yu et al., (2003) once conducted an experiment with two apple orchards. The two orchards were adjacent, each with acreage of one ha. In the crop-covered system, Alfalfa, *Medicago sative* L., was grown between the rows and white flower lagopsis, *Lagopsis supine* Labiatae, was grown under the tree canopies. The clean cultivated system was maintained free of ground vegetation during growing season, and managed with 9 applications of insecticides and miticides against aphid (*Aphis spriecola* Patch), apple leaf blotchminer (*Linthocolletis ringoniella* Mats), leaf roller (*Choristoneura rosaceana*) and acaridae. Another experiment of predator conservations both in the orchard and in adjacent farm field was conducted in an apple orchard surrounded by wheat field. The effects of the migrated natural enemies from the wheat field to apple orchard were examined. In the crop-covered apple system, populations of natural enemies, such as the predator *Orius sauteri*, Conellidies and parasitic wasps of leaf miner, were enriched compared with the clean-cultivated ecosystem. The peak stage of the beneficial enemies in the crop-covered apple system appeared 1 week earlier than in the clean-cultivated apple system, and both average densities and maximum densities of the natural enemies in the crop-covered apple ecosystem were higher than that in clean-cultivated system. Populations of aphid, mite and leaf miner maintained at very low levels, and the outbreak of those insect pests never happened in the crop-covered apple ecosystem. However, the insect pests occurred heavily in clean-cultivated apple system, and pesticides had to be sprayed several times to control aphids and mites. Around the time of wheat harvest, a great quantity of predators migrated from the wheat fields surrounding apple orchard into the apple orchard, the population of predators of aphids increased quickly and the population of aphid soon decreased rapidly on the apple trees after wheat harvest. The research results suggested that an optimum ground cover vegetation was favorable to augmentation of natural enemies in the apple system and conservations of insects' natural enemies around the orchard enriched the predators and the parasitoids in the apple system. Both practices mentioned above increased the natural efficacy of biological control of insect pests and stabled the apple ecosystem.

5.8 No-tillage in nature farming systems

5.8.1 Implications and benefits of no-tillage farming

No-tillage or no-till farming has been adopted in both conventional and organic crop productions. No-tillage is usually defined as planting of crops in previously unprepared soil by opening a narrow slot, trench, or band only of sufficient width and depth to obtain proper seed coverage, without other soil preparations (Derpsch, 1998). No-tillage and reduced tillage have been used since ancient times in indigenous cultures, simply because man has not the muscle force and a tool strong enough to till any significant area of land to a significant depth by hand. The ancient Chinese on the loess plateau, the ancient Egyptians and the Incas in the Andes of South America used a stick to make a hole in the ground and put seeds by hand into unprepared soil. It was the no-tillage or reduced tillage that protected the land on the loess plateau, where the people saved time for activities such as pottery making. It is the china pottery making technology that laid the foundation of the Chinese culture. Thus, you can say the china made China instead China making china. In those days, a plough was nothing else than a branch from a tree that scratched the soil surface without mixing the soil layers. Ploughs that inverted the soil layers and thus gave a good weed control were not developed until the 17th century. It is this plough that avoided famine and death at the end of the 18th century by effectively controlling quack grass (*Agropyron repens*), a weed that had spread all over Europe. Therefore, the plough became a symbol of "modern" agriculture. Back to the 1940s, Edward Faulkner advocated no-tillage and reduced tillage in his famous book "Plowman's Folly" (Faulkner, 1943). No-tillage trials in Latin America were first started in 1971 in Brazil in cooperation with a German aided project (Derpsch, 1998). Herbert Bartz is the first farmer to apply the no-tillage technology to his soybeans in 1972 and has used no-tillage continuously until the present. Although no recorded documents are available, it is well known that Chinese have grown soybean and other legume crops under no-tillage after wheat harvest with exception of some kinds of soil surface weed deleting practices. Time and the soil water loss do not allow the seeding of soybean or other legumes after the soil is ploughed. Seeds are sown by riding the wheat stubble residues immediately after wheat harvest. Otherwise with plowing, the legumes would grow much weaker because of the time delay and soil moisture loss.

Now, about 90 Million hectares of farmland is managed under no-tillage practices in the world and this technology has experienced a 59-fold increase since 1987 in Latin America from 670000 ha to 40.6 million ha in the year 2004. The advantages of no-tillage farming are considered as 1) labour and time are reduced, 2) costs for machines and fuels are saved, 3) soil tilth, moisture retention, and soil water infiltration are improved, 4) soil erosion, gas release and water pollution are reduced or prevented, 5) biodiversity in soils and fields are enriched, and 6) long term productivity and sustainability are maintained. Derpsch (1999) has listed the new paradigms in agriculture in comparison with the old one. According to new paradigms, tillage is not necessary for crop production. The main differences between conventional tillage (CT) and no-tillage (NT) practices are summarized as follows: 1) burying of plant residues with tillage implements in CT, but in NT crop residues remain on the soil surface as mulch; 2) soils are left bare for weeks and months in CT but soils are permanently covered in NT; 3) Burning crop residues is allowed in CT but prohibited in NT; 4) CT emphasizes soil chemical processes but NT emphasizes the soil biological processes; 5) chemical pest control is first option in CT but biological pest control is the first option in NT; and 6) green manure cover crops and crop rotations are optional in CT but compulsory in NT. As consequences, 1) wind and water erosions of the soil are unavoidable in CT but are near zero in NT, 2) water infiltration into the soil is reduced in CT but increased in NT, 3) available soil moisture is low in CT but high in NT, 4) the soil organic matter is reduced in CT but in NT, 5) soil carbon is lost as carbon dioxide into the atmosphere contributing to global warming in CT but avoided in NT, 6) soil is degraded in chemical, physical and biological properties in CT but improved in NT, 7) fertilizers are largely used with high costs of crop production in CT but fertilizers are reduced in NT, and 8) at last, the farms are threatened by lower yields, low profits and low income in CT but survival of the farm family on the farm is insured through a good profitability and high and sustainable crop production in NT.

The key problem of conventional agriculture is the steady decline in soil fertility due to soil erosion and the loss of organic matter associated with intensive tillage practices, which leave the soil bare and unprotected in heavy rainfall and wind. Soil degradation does not only makes the farm land to go out of production, but also increases inputs and investments to maintain high levels of productivity (Stocking, 1986). Soil erosion is the most important factor causing soil degradation. Consequently, sustainability can only be achieved if soil erosion is stopped completely. When soil losses are higher than natural soil regeneration rates, sustainable agriculture is not possible. Recent studies show that soil erosion is a selective process, with the most fertile soil particles taken away. Eroded soil sediments usually contain several times more nutrients than the soils they originated from (Stocking, 1988). Applied fertilizers are also transported by erosion to surface and underground waters. Soil cover is the most important factor that influences water infiltration into the soil, thus reducing runoff and erosion (Mannering and Meyer, 1963). Soil organic matter has an overriding importance to soil fertility. Soil organic matter is probably one of the most important characteristics in relation to soil quality, due to its influence on soil physical, chemical and biological properties (Cannel and Hawes, 1994). Organic matter helps store nutrients and efficiency of fertilizers is greatly reduced if soil organic matter is not enough. Any agricultural production system without sufficient soil organic matter to an adequate level will result in soil degradation. Soil tillage results in rapid mineralization of soil organic matter stored, lead to an increase in yield during a few years. Once organic matter has been mineralized and consumed, more nitrogen cannot be liberated and yields of crops remain low. It is difficult to raise soil organic matter once it has fallen (Rasmussen and Smiley, 1989). Especially in tropical climates, organic matter reduction is processed much more quickly, and reductions below 1%, sometimes as low as 0.2%, can be reached in only one or two decades of intensive soil preparation. In other hand, no-tillage positively affects chemical, physical and biological soil properties, with erosion drastically reduced and organic matter maintained (Kochhann, 1996). Under no-tillage, soil organic matter, nitrogen, phosphorus, potassium, calcium, magnesium, pH and cation exchange capacity are high and aluminum is low (Lal, 1976; Lal, 1983; Sidiras and Pavan, 1985; Crovetto, 1996). As improved physical soil properties under no-tillage, the soil infiltration rate is high and erosion is thus reduced, soil moisture is high, soil temperatures remains relatively constant, and aggregate stability is high (Derpsch et al., 1988; Kemper and Derpsch, 1981; Roth, 1985; Sidiras and Pavan, 1986). Biodiversity is high under no-tillage because no mechanical implements are used that destroy the nests, channels and habitat built by microorganisms and different soil fauna, organic substances at the surface supply them with food, and in many cases pesticides are prohibited in combination with other organic practices. As consequences, more earthworms, arthropods, (acarina, collembola, insects), more microorganisms (rhyzobia, bacteria, actinomicetes, micorrhyza) are found under no-tillage conditions (Kemper and Derpsch, 1981; Kronen, 1984; Voss and Sidiras, 1985). As benefits to the environment from no-tillage, surface and underground water quality is improved, and greenhouse gases are reduced. Intensive soil tillage accelerates organic matter mineralization and converts plant residues into carbon dioxide, contributing to the green house effect and to global warming. Soil carbon is lost very fast as carbon dioxide within minutes after the ground is intensively tilled, and the amount is directly related to the intensity of tillage. It is reported that total losses of carbon from ploughed wheat fields in the early few weeks were up to five times higher than for unplowed fields (Reicosky, 1997). While fossil fuels are the main producer of carbon dioxide, the widespread adoption of conservation tillage could offset as much as 16% of worldwide fossil fuel emissions (CTIC, 1996).

Without mixing of the soil and crop residue by tillage, the no-tillage system accumulates a layer of crop residues on the soil surface. This residue layer may depress grain yields because it may result in significant immobilization of surface-applied nitrogen. When nitrogen fertilizer is applied as urea to no-tillage surface, the nitrogen may also be lost by escaping as a gas into the atmosphere. The availability of fertilizer nitrogen for crops also depends on the amount immobilized by soil microbes, which tend to increase with surface residue. On the other hand, the immobilized nitrogen is not lost from the soil but just temporarily unavailable. Immobilized nitrogen must be mineralized to be made available to a growing crop. Soils under no tillage tend to be more compact and moister than plowed soils and thus populations of anaerobic bacteria, particularly in the upper 3 inches of soil, are increased, resulting in greater potential for denitrification and a greater nitrogen requirement. As reported, some diseases of crops increase under no-tillage (Igarashi, 1981; Homechin, 1984; Reis, 1985; Reis et al., 1988) if no-tillage is practiced in monoculture. A well-balanced crop rotation with the use of green manure crops is sufficient to neutralize this negative effect of no-tillage. No-tillage can have positive or negative effects on pest insects, depending on the specific pest and the prevailing climatic conditions. In general, the diversity of insects, spiders, and other fauna leads to a better biological equilibrium, where pests may be controlled by predators.

5.8.2 Case studies on no-tillage farming

Mycorrhizal root colonization, growth, nodulation and photosynthesis of soybean plants in response to tillage

As reported, conservative tillage, especially no-tillage (NT), leads to enhanced symbiosis of arbuscular mycorrhizae (AM) to the root systems (Evans and Miller, 1988). This experiment was conducted in an Andosol soil with a soybean crop to evaluate the effects of no-tillage (NT) and conventional tillage (CT) on plant growth, nodulation, root colonization and photosynthesis. Results showed that the number and fresh weight of nodules were increased by NT (Table 18). AM root colonization and shoot P and N concentrations were also significantly higher in NT compared with CT (Table 19, 20 and 21). Electrical conductivity, NH_4-N, available P and K in the 0-10 cm soil layer were found higher in no-tilled soil. Results in this study suggested that NT improved nodulation and AM root colonization as well as the plant nutrition in the soybean crop. Significant reduction in AM colonization due to soil disturbance in CT than in NT was also observed by Evans and Miller (1988). Soil tillage may markedly reduce the rate of AM establishment by breaking up the living AM fungal mycelium in the soil, into which roots of small plant seedlings can be rapidly connected. When mycelium is broken, the AM formation will mainly depend on the slow growth of infective hyphae from spores and colonized root fragments (Kling and Jakobsen, 1998). With a low degree of soil disturbance, like in no-till and reduced till management, the extra mycelium already existing in the soil can provide soil mineral nutrients at an earlier stage of plant development (Miller et al., 1995). Physical disturbance of AM mycelium by soil tillage would reduce its P gathering efficiency early in the season, before restoration of the network (Hamel, 1996). The presence of arbuscule in the infected roots indicates the dependence of the plants on mycorrhizal fungi. Although there was no significant difference in shoot and root dry weights, the mean values were greater in NT than in CT that may be partly linked to positive effect of increased mycorrhizal infection on plant growth. Higher levels of shoot P and N with higher AM colonization of plants under NT underscore the role of AM fungi in soil exploration by soybean roots. Higher concentration of shoot P in NT than in CT is in accordance with the results of Kabir et al., (1998), who reported higher P absorption by field grown corn under NT than under CT. AM fungal spore numbers were not related to the abundance of AM infection. This indicates that spore in soil is not only dependent on percentage of AM infection, but also depends on the edaphic factors such as high aeration and optimum moisture or the undisturbed soil conditions, which allowed sufficient time for the build up of mycorrhizal spores. Plants under NT contained significantly higher nodule number and nodule fresh weight than plants under CT. This might be due to improved P nutrition (Lynd et al., 1985). Similar results have also been reported for soybean in different agricultural soils (Jackson et al., 1972). The concentration of Ca, Mg and K were not changed significantly. These elements move towards the root largely by mass flow (Tisdale et al., 1985). They also move by diffusion but are much more mobile than P and therefore, plants rely less on AM hyphal extensions to take them up (Kabir et al., 1998). NT generally leads to greater retention of SOM than CT. Higher soil nutrient status in NT might be due to more retention of SOM. The content of SOM at the surface of soils under NT is greater than under CT (Havlin et al., 1990). Changes in frequency and intensity of tillage practices alter soil properties and affects availability of nutrients for plant growth, crop production and soil productivity (Hossain et al., 1999). Lower soil pH in no-tilled soil than in tilled also suggests more organic matter in NT.

In conclusion, the optimal utilization of AM fungi is important for the maintenance of sustainability in plant production. The benefit of AM fungi on nutrient uptake and growth of plant will depend on the characteristics of the fungal population as well as growth conditions. AM fungi may not function at its optimum in such agricultural fields that are frequently disturbed by management practices. Conventional tillage noticeably reduced AM root colonization, nodulation and plant uptake of P and N in the present study compared to no-tillage. Reduction of the intensity of tillage could promote the favorable effects of AM fungi.

Table 18. Per plant shoot and root dry mass, nodule number, nodule fresh mass, pod number and fruit fresh mass of soybean under NT and CT at harvest

Treat.	Shoot DM(g)	Root DM(g)	Pod number	Pod Fr. Wt. (g)	Nodule number	Nodule Fr. Wt. (g)
NT	35.8a	3.51a	48.8a	107.4a	56.3a	2.43a
CT	33.6a	3.13a	43.2a	102.5a	49.6b	1.98b

Table 19. Mycorrhizal colonization of roots and soil spore of soybean plants under NT and CT at the time of harvest.

Treat.	-----Spore per g of dry soil-----			Infection
	F	C	A	(%)
NT	40.2a	38.9a	15.8a	46.8a
CT	31.9b	25.8b	13.4a	41.7a

Table 20. The concentration (mg g^{-1}) of shoot nitrogen, phosphorous, potassium, calcium and magnesium of the plants under NT and CT at the time of harvest.

Treat	P	N	K	Ca	Mg
NT	5.18a	45.2a	46.6a	18.56a	1.38a
CT	4.56b	39.4b	43.9a	15.55a	1.23a

Table 21. Chemical properties of soil under NT and CT at the time of harvest

Treat.	pH	EC	T-C	T-N	C: N	NH_4-N	NO_3-N	Av-P	CaO	MgO	K_2O
			--- (g kg^{-1})---			-------(mg Kg^{-1})------			--------(g kg^{-1})---------		
NT	5.42a	0.11a	59.2a	4.3a	13.8	28.3a	48.7a	0.37a	2.98a	0.31a	1.26a
CT	5.72a	0.09a	56.3a	4.0a	14.1	20.2b	37.8b	0.21b	2.95a	0.28a	0.81b

Effect of no-tillage on growth and mycorrhizal colonization in maize plants

No-tillage, by keeping the hyphal networks in soil intact, increases mycorrhizal symbiosis and activity in soils and thus increases nutrient uptake by plants. Roots infection by *G. graminis* changes the uptake of P, Ca, and K. The changes in nutrient concentration in plants under no-tillage might be due to factors related to changes in the activity of nonmycorrhizal fungi colonizing the plant roots, which change soil's physico-chemical properties. In this study examined was the influence of tillage intensity on the nutrient concentrations in mycorrhizal host maize plants and the colonization of roots by mycorrhizal and other soil fungi. Three factors including fertilizer (F), tillage (T) and green manure (M) were designed with 2 levels. Italian rye grass and red clover were used as the green manure crops. The treatments had significant effects on shoots fresh weight of maize plant (Table 22). Number of ears per plant was also significantly higher in NT than in CT but the ear fresh weight per plant was not significant statistically. The concentrations of P and Ca were affected by soil tillage intensity. Shoot N, P and Ca concentrations were higher in NT compared with CT. Soil pH was lower in no-tilled and green manure mulched plots than in tilled and no green manure mulched plots but higher in organically fertilized plots than in chemically fertilized plots (Table 23). Soil EC was higher in NT plots, organically fertilized plots, and green manure mulched plots than in CT plots, chemically fertilized plots and no green manure mulched plots respectively. Soil NO_3-N and available P were high in NT, organically fertilized soils and green manure mulched plots. Mg in NT, organically fertilized plots and green manure mulched plots was significantly higher. Ca was significantly different between fertilizer treatments. K and CEC were not different statistically between treatments. Overall results indicated that mineral N, available P and K in soil were significantly reduced in tilled soil compared to no-tilled soil. Available P in NT (16 mg/100g) and green manure (16.2 mg/100g) was noticeably higher than in CT and no green manure treatments. No-tillage treatment significantly increased the colonization of maize roots by mycorrhizal fungi but there was no significant difference in the frequency of AM root infection. There were also no consistent relations among hyphae, arbuscule and vesicles. Nevertheless, no-tillage positively influences mycorrhizal root colonization.

In the same experimental fields, Fujita et al. (2000) examined the effect of no-tillage practices on soil macro-and meso-fauna. The sampled spoil fauna included earthworms, spiders, centipedes, and Coleoptera (Carabidae, gold beetles, Melanotus). The populations of the soil fauna were steadily higher in no-tillage plots (NT) than in conventional tillage plots (CT) from 2002 to 2004. The soil properties including the soil infiltration ability were improved by no-tillage practices. Cultivations under no-tillage for three years improved the ecosystem functions and increased the populations of the beneficial fauna including the predators and decomposers. The final goals for organic agriculture to reach are not refusals of chemical fertilizers and pesticides but the improvements in field ecosystems and buildup of a crop production ecosystem, whereby crops can be easily produced without dependence on chemical fertilizers and pesticides.

Table 22. Analysis of variance significance levels for grain yield and shoot fresh weight of maize plants in response to tillage, fertilizer and green manure.

Source of	-------Grain Yield (g/plant)--------				-----Shoot Fresh Weight (kg/a)---			
Variation	‘02	‘03	‘04	‘05	‘02	‘03	‘04	‘05
NT	351	470	450	404	356	579	485	509
CT	386	526	465	432	491	634	507	498
	NS			NS	*	NS	*	NS
OF	330	492	445	408	368	568	474	481
CF	408	504	470	428	479	645	519	525
	*	NS	**	NS	*	NS	**	NS
NM	---	504	455	409	---	655	494	492
GM	---	492	460	427	---	558	498	515
	---	NS	NS	NS	---	NS	NS	NS

NT: no-tillage, CT: conventional tillage, OF: organic fertilizer, CF: chemical fertilizer, NM: no intercropping green manure, GM: intercropping green manure. * and ** mean significance at P≤0.05 and P≤0.01.

Table 23. Chemical properties of soil under no-tillage and conventional tillage at the time of harvest.

Treat	pH	EC	NH_4-N	NO_3-N	Av-P	K_2O	CaO	MgO	CEC
O	MgO	CEC							
O	CEC								
C									
			------------------(mg/100g D.S.)--------------------						
15	0.13	0.93	2.78	16.0	101	427	74.3	24.5	
32	0.12	0.93	1.59	15.2	94	447	66.0	23.9	
S	NS	NS	NS	NS	NS	**	NS		
33	0.13	0.89	2.77	15.7	94	465	84.2	24.6	
14	0.12	0.97	1.61	15.5	101	409	56.2	23.9	
7	1.61	15.5	101	409	56.2	23.9			
5.5	101	409	56.2	23.9					
409	56.2	23.9							
	23.9								
S	NS	NS	NS	NS	NS	**	**	NS	
	6.28	0.12	0.80	1.97	15.1	89	430	70	23.8
	6.20	0.14	1.06	2.41	16.2	106	444	70.3	24.6
S	NS	NS	NS	NS	NS	NS	*	NS	

(dS m^{-1}), CEC (cmol kg^{-1})

5.9 *Aigamo* paddy rice (rice-duck mutualism) farming systems

5.9.1 Concept and practices of *aigamo* technology

What is the aigamo rice faming technology? A method of rice farming that relies on ducks to eat insects and weeds has been practiced in Japan. It is so-called *aigamo* paddy farming. The *aigamo* is a crossbreed of *kamo* (wild duck) and *ahiru* (domestic duck) (Asano et al., 1999a). Because *kamo* is migratory, it was believed that using *ahiru* would be better for agriculture. According to some experts, though, *aigamo* have come to be used because they produce a large amount of tasty meat and are easier to obtain than *ahiru*. The *aigamo* method of growing rice involves releasing two-week-old *aigamo* ducklings into a rice paddy about one or two weeks after the seedlings have been planted. About 200 of birds are needed for one ha of farmland. A shelter is needed where the ducklings can rest and take refuge from rain. The field is usually surrounded by net fences to protect ducks from dogs, cats, weasels, and crows.

5.9.2 Ecological benefits from the *aigamo* rice farming technology

Combined with organic fertilization, rice grown with *aigamo* method is more resistant to typhoons, lower temperatures and other adverse environmental problems.

Weed and pest controls. The ducks help the rice plants grow by eating both insects and weeds in the paddy fields (Zhu et al., 2004). Pesticides including herbicide are not needed. Total weed biomass was controlled in *aigamo* plots better than in plots applied with agrochemical (Furuno, 1996; Manda, 1992; Wei et al., 2004). It was observed by Cagauan (1997) from on-station research in the Philippines that the total weed biomass in the paddy field was reduced by ducks at rates ranging from 52% to 58 %. The mechanism of weed control by ducks is direct consumption of plant parts and seeds and disturbance of weed germination and growth through the feeding activities. It was observed in Japan that the hoppers in rice paddy field were depressed by *aigamo* during the early growth stage of rice (Manda, 1992; Furuno, 1996). In the Philippines, ducks have effectively controlled the herbivorous golden apple snail (Basilio, 1989; Rice IPM Network, 1991; Rosales and Sagun, 1997; Vega, 1991). According to Liu et al. (2004), releasing about 250 ducklings with body weight of 150 g into one ha of rice paddy reduced sheath blight by 56.0% and the disease control effect was even higher than applications of antibiotics. Wang et al. (2005) reported that rice-duck mutualism suppressed weeds by 99.4%, reduced pest insects and diseases, increased soil nutrition and dissolved oxygen, and consequently improved the rice yield and quality. Releasing 300-450 ducklings with 200-400 g body weight postponed the incidence peak of the *Chilo suppressalis* larva for 9-14 days and reduced the second generation of *Chilo suppressalis* larva by 53.2-76.8% and the third generation by 62.2%.

Fertilization and soil improvement. The ducks' droppings become an important source of natural fertilizer. In addition, the ducks stir up the soil in the rice paddy fields with their feet and bills, disturb the weed seeds from germination, increase the oxygen concentration in the soil, and make the soil more nutritious for the seedlings (Choi et al., 1996). Furuno (1996) observed on his farm that movements and feeding activities of ducks in the paddy fields disturb the soil resulting in improvement of soil physical property, and the consequent better rice root systems and enhanced tillering. Yu et al. (2004) reported that rice-duck system improved paddy rice canopy with fewer non-productive tillers, consequent improved canopy light transmittance, increased green leaf area and chlorophyll content, enhanced root activity and leaf photosynthetic capacity, consequently resulting in a 5% yield increase.

Improvements in biodiversity and natural harmony. It is said that some practices similar to *aigamo* paddy farming have been done in Japan for 500 years. However, modern agriculture looks at a single answer to a specific problem, a very analytical approach that can destroy the parts of the ecosystem with rice, weeds and insects, ducks and fishes as its components. Originally, the duck or *kamo* was also a component of the system. The inhabitants of the paddy field are not only the ducks. The duckweed, an aquatic fern (Azolla), which harbors a blue-green bacterium as symbiont, is also grown on the surface of the water. The azolla is very efficient in fixing nitrogen, attracting insects for the ducks and feeding ducks by itself (Alejar and Aragones, 1989). The plant is very prolific and grows fast so that it can be harvested for cattle-feed as well. In addition, the plants spread out to cover the surface of the water, providing hiding places for another inhabitant, the roach. The roach grows well in the paddy fields and feeds on duck feces, daphnia and worms, which in turn feed on the plankton. The fish and ducks provide manure to fertilize the rice plants. The rice plants in turn provide shelter for the ducks. It is very interesting that the “stimulation effect" of duck activities around the young rice plants leads to stockier rice stems and actually changes the way the rice grows. Before the *aigamo* technology was adopted by thousands of farmers throughout Japan and eastern Asia, a Japanese farmer who used to watch wild ducks floating on his paddy fields and doing the same as weeds and pests predation had already imaged the idea that a similar system would be artificially successful on paddy farms. Nature is able to live with itself. These animals and plants including ducks, fishes, insects, weeds and rice plants can live in harmony and nature gives them the power to interact and live together. This principle is being brought back into agriculture.

Prevent of global warming by reducing methane emission. Methane contributes about 19% of the greenhouse effect and CO_2 about 64%. However, on unit volume basis, methane contributes to greenhouse effect by a factor of 20 to 25 over CO_2. Rice paddies release 12% of all methane to the atmosphere. Without a doubt, controlling methane from rice paddies is of great importance in slowing the greenhouse effect. It is interesting that ducks can do the job. Theoretically, in a rice paddy, methane is mainly produced by methanogens that consume hydrogen and acetic acid in the paddy soil, where ferric iron (Fe III) is constantly changed to ferrous iron (Fe II) by Fe III-reducing microorganisms, or so-called iron reducers, which also consume hydrogen and acetic acid in the process of conversion. The consumption of iron reducers is faster than that of methanogens. Therefore, as long as Fe III is provided regularly, development of methane is controlled. Once the Fe II moves into water from the soil, it is oxidized to Fe III. Fe III goes back to the soil and everything starts over again. The Fe II is stuck in the soil and spreads in the water very slowly. Morii and his team set up a small experimental environment similar to a rice paddy at a lab and were mixing up the water for different periods of time in order to help promote Fe II that is stuck in the soil in the water (http://home.att.ne.jp/kiwi/AptNo7/furuno.html). As a result, when the water was mixed for two hours, the development of methane was controlled over the following 24 hours. When mixed for 7.5 hours, it was controlled for the next three days. Morii got confident in his theory and experimental work, but the biggest issue was how his experimental work could be applied to rice paddies outside a lab. Later, he found that the ducks could do the job through a local news program on TV reporting duck-rice farming. Actually, ducks are constantly paddling the water with their legs and paddles in the paddy fields, helping spread Fe II stuck in the soil and promote the circle from Fe III to Fe II and back to Fe III. Later, Morii conducted experiments in paddy fields in co-operation with Furuno, the *aigami* rice farmer (http://home.att.ne.jp/kiwi/AptNo7/furuno.html). Morii established a control area surrounded by a 25 cm-height iron frame, which prevented water in the control area from being contaminated by muddy water. A net was attached to keep the area free from ducks. One month later, concentrations of Fe III in the water and soil in both plots were measured and it was found that the Fe III concentration in water was 267 times higher in the plot with the ducks than in the control, while the Fe III concentration in soil in the duck polt was only 9% of that in the control plot. Since iron reduction in the process of change from Fe III to Fe II is much faster than the fall of soil particles including Fe III in the muddy water down to the soil, the amount of Fe III in the soil may not increase as it does in water. Therefore, it is suggested that ducks in the rice paddy suppress the release of methane from the rice field. Recent years, active experiments are also conducted in China. Gan et al. (2003) reported that methane emission was much lower, the dissolved oxygen concentration in rice-duck paddy fields was 38.4-44.7% higher, the soil redox potential was 11 and 18 mV higher, and the concentration of reduced matters such as Fe II was higher in rice-duck paddy field than in the control field. Similar results were obtained in other repeated experiments (Huang et al., 2005). By using anaerobic incubator technology, Deng et al. (2004) found that rice-duck complex remarkably reduced the methanogens in the rice paddy soil and especially reduced the methane emission at rice heading stage corresponding to the peak time of methane emission.

5.9.3 Financial benefits from the *Aigamo* rice farming technology

In fact, many Japanese farmers released ducks into their paddy fields in the 1940s, when the agricultural machineries are not so available at that time. However, the main reason for ducks to be used today is to optimize rice cultivation and produce rice with high quality, while in the past, the main reason was reducing costs and labors. *Aigamo* farmers do not only benefit just from rice, they also get profit from ducks at the same time in the same field. By combining two completely different things farmers can come up with wonderful results. The rice, duck meat, and other items, such as duck eggs and fish are available to contracted families through a Teikei system (a direct selling-consuming system from farmers to consumers). When it comes time to harvest the rice in the fall, the ducks have grown fat and can be sold for meat. Farmers can grow rice and produce duck meat and this suggests that the *aigamo* method really does kill two birds with one stone. *Aigamo* paddy farming allows for the production of healthy and delicious rice while relying on less labor than conventional methods. In Asian countries, where people are aware of the overuse of chemical fertilizers and pesticides, the *aigamo* method is attracting more and more attentions for it can raise healthy and delicious rice. This method is beneficial from a cost down by quitting purchases of expensive chemical fertilizer or pesticides, and also from the extra income by selling the fully grown ducks. Reported improved rice grain yield from duck raising in paddy fields can be attributed to the benefits previously discussed. Higher grain yield and reduced labour costs due to weeding, spraying and fertilizing contribute to better economic benefits derived from rice-duck farming. In South Korea, the increase in income derived from rice-duck farming ranged from 73-77 % compared to conventional rice farming (Kang et al., 1995; Kim, 1997). Duck raising in paddy fields leads to organic farming with the benefits of reducing costs of fertilizers, pesticide and labour. ‘Organic rice’ has a higher price than conventional rice in Asian countries. As shown in Table 24, agronomic characteristics and yield were improved and better than other weed control methods in organic rice production. The profit of rice-duck system was twice to several times higher than those of other weed control systems (Table 25). Data from Japan suggest that, compared with conventional rice production, the higher profit of the rice-duck system is attributed to both the income from duck meat selling and the higher price of organic rice (Table 26).

5.9.4 Social benefits from the *aigamo* rice farming technology

Environmental pollution and food quality degradation caused by excessive uses of agricultural chemicals have received more and more attentions from the world. Organic movements also spread throughout the world. In addition, in many Asian countries, population pressure has been a fact of life for many years. The arable land is limited and the land area per capita is much less than it is in Latin America, Africa, and Australia. The most important is the control of disease and pest insects. At this moment the so-called "re-discovery of traditional rice farming practices in Asia" or

Table 24. Growth and yield of the rice (cv. Tai-keng 9) as affected by treatments of weed control under organic farming (AES, NCHU; 1st crop, 2002).

Treatment	Plant height (cm)	Panicle number	Panicle grain no	Grain weight (g)	Grain set rate (%)	Yield (kg ha^{-1})
Control	90.0f	12.5ef	83.0c	24.2e	86.0a	2744e
Paper	94.8cde	14.7de	84.3c	26.1d	85.4a	4066cd
Soybean (m)	101.5a	21.5b	96.2ab	29.8bc	85.9a	5789ab
Hull(s)	92.4ef	11.8f	88.5bc	25.5d	84.8a	3022e
Azolla	94.3de	14.5de	95.0ab	26.2d	86.8a	5000bc
Rice bran	99.3ab	14.4de	97.7a	28.8c	87.0a	4922bc
Duck (100/ha)	97.5bc	15.2d	90.8abc	29.5c	86.1a	5033bc
Duck (200/ha)	97.3bc	24.6a	97.1a	30.8a	86.2a	6556a
Duck (300/ha)	97.0bcd	17.4c	95.7ab	30.6ab	85.0a	5189b

According to Chen S.H and Wang S.M. 2004. Weed Control in Organic Paddy Field. National Chung Hsing University, Taibei,China. Means in the same column followed by the same letter are not significantly different at α= 0.05 by Duncan's

Table 25. Cost and profit analyses for measures of weed control in the organic rice farming.

Treatment	Cost (1000NT$) Weeding	Cost Others	Cost Total	Yield (kg ha^{-1})	Income (kNT$) Rice	Income Duck	Income Total	Profit (kNT$)
Paper mulch	15.3	80.3	95.6	4066	130.1	0.0	130.1	34.6
Soybean meal	27.0	71.3	98.3	5789	185.3	0.0	185.3	87.0
Rice bran	20.0	71.3	91.3	4922	157.5	0.0	157.5	66.3
Smoked hull	0.0	80.3	80.3	3022	96.7	0.0	96.0	16.5
Azolla	0.0	80.3	80.3	5000	160.0	0.0	160.0	79.8
Duck	14.9	80 .3	95.3	6556	209.8	60.0	269.8	174.6
Control	0.0	80.3	80.3	2744	87.8	0.0	87.8	7.6
Manpower	25.0	80.3	105.3	4500	144.0	0.0	144.0	38.8
Herbicide	1.3	64.3	65.4	5865	105.6	0.0	105.6	40.2

(According to Chen S.H and Wang S.M. 2004. Weed Control in Organic Paddy Field. National Chung Hsing University, Taibei, China). Control: without any weeding measure. Manpower: weeding by human labor.

Table 26. Comparison of the economic incomes of the *aigamo* rice farmers with those of chemicals-reduced conventional farmers (in Japan, 1998)

	Conventional	*Aigamo*
Crop area (m^2)	8000	7800
Practiced year	7	6
Duclings per ha	0	170
Duck Survival (%)	--	81
Rice yield (kg ha^{-1})	4500	4150
Gross income (1000JPY ha^{-1})	125.6	195.3
Income from duck meat	--	13.8
Labor time input (h ha^{-1})	289	456
For ducks	--	204
Cash input (1000JPY ha^{-1})	50.6	61.1
For ducks	--	26.0
Profit (1000JPY ha^{-1})	75.0	134.2
Per day per labor	18.1	21.6

"recalling the wisdom of traditional rice farming in Asia" becomes especially correct and important. Rice-duck mutualism is one of the wisdom in Asia. Takao Furuno, a Japanese farmer has promoted rice-duck farming method and other organic practices for more than 30 years. Organic farmers face many difficulties, one among which is time-consuming labor. Weeding, in particular, requires long hours. Many farmers, wondering whether or not organic farming was worth the trouble, are advised to try rice-duck systems. It is convinced that the ducks do a good job removing weeds and pests and improving conditions in paddy fields. The results of the study co-operated with professors clearly indicate that the paddy with ducks provides several advantages in rice production. A report on the study was published and helped promote *aigamo* rice technology with an NGO called the Japan *Aigamo* Duck Association. Furuno has visited many Asian countries and shown his technology to the farmers. As talked by Furuno, agriculture has evolved from human power to animal power, and then to fossil fuel power, and ducks represent a "reconsideration of animal power". Over the last thousand years, the people of Asia have been devising the means of producing more food in smaller areas under limited conditions. Crop rotation and cash crop methods require time to be effective, but farming with ducks is effective at once. In 1996, as an expert, Furuno visited Tanzania and transferred his rice-duck technology at the Kilimanjaro Agriculture Training Center. By using ducks and fish to rice-farming systems, it is expected that Tanzanian farmers could produce rice more effectively as well as increase their menu of high-protein dishes. Furuno has been invited as a guest lecturer by China mainland and Taiwan, Korea, Indonesia, Vietnam, Cambodia, and the Philippines, where he found opportunities to build a network of rice-duck organic rice production. Several books have already been published and some are translated into Korean and Chinese and Vietnamese. The rice-duck farming technology optimizes the power of nature in rice cultivation and promotes the food self-sufficiency of each farmer, particularly those in developing countries, thus tackling both global issues effectively. In fact, the ducks are so good at weeding that Third World farmers who have adopted the method now have time to sit and chat instead of spending up to 240 person-hours per hectare in manual weeding every year. Besides, weeds and other pests have been miraculously transformed into resources. The paddy field with ducks is really a complex, well-balanced, self-maintaining, self-propagating ecosystem. The only external input is the small amount of waste grain for the ducks, but the outputs are delicious, nutritious organic rice, duck and roach. This *aigamo* method also explodes the myth that organic farming always requires intensive labour. Actually, organic farming need not be labor intensive. This is also consistent with Okada and Fukuoka's nature farming philosophy let nature do and you do nothing (Fukuoka, 1978, 1985, 1987ab).

5.9.5 History and development of rice-duck farming in Japan and other Asian countries

An estimated 10,000 farmers use this *aigamo* rice system in Japan, which has now been spread to the rice-growing countries such as Korea, China, Vietnam, the Philippines, Thailand, and India, where this technology is especially important for people still weeding and working much by hand.

Japan. Actually, raising ducks in paddy fields is not a new idea. A book that was published 1000 years ago in China advocated the use of ducks in rice paddy fields. The agricultural method releasing ducks in the paddy field has been employed since approximately 1,000 years ago from the Chinese Yangtze River to the Asian monsoon zones. It is introduced to Japan about 500 years ago and handed down in Kinki district. It was used throughout Japan after the Word War II in difficulty of obtaining food. Hideyoshi Toyotomi, the first Shogun who ruled Japan about 500 years ago, recommended releasing ducks in paddy fields to improve rice cultivation according to the Chinese legend (Manda, 1992). In 1980s, the practice was revived to fit modern agriculture by Takao Furuno, a farmer in Fukuoka Prefecture, who integrated rice farming with *aigamo* duck. Two months old *aigamo* ducks are released into paddy fields at a rate of at 400 birds per ha about two months after rice seedlings were transplanted. *Aigamo* ducks help control weeds and insects and lead to the non-application of pesticides

(Furuno, 1996; Manda, 1992). Recently, the *aigamo* rice farming has been involved in organic agriculture in Japan. Here, the topic is about the rice farming with ducks involved. Actually, from beginning, the duck husbandry is closely associated with paddy rice farming (Farrell, 1997). The traditional practice of duck production in paddy field in the South-Eastern Asian countries involves herding the birds in paddy fields after the rice is harvested. Duck herders transfer their flocks from one farm to another depending on food availability. Herders house their flocks in sheds usually along irrigation canals where water is available for the duck. Duck pasture in paddy field after rice is harvested helps economize the high cost of feed. Ducks are introduced in paddy fields to get rid of weeds and insects during the rice growing season (Quisumbing, 1983). In some areas, duck raisers contract with rice farmers for caring their ducks (Chandrapanya and Pantastico, 1983) and the duck raisers come back and pay the farmers for their services after months. Ducks are also released in paddy fields to control mud snails (AICAF, 1988; Basilio, 1989) since the herbivorous snail *Pomacea canaliculata* Lamarck has once been a big problem as an exotic pest during the early 1980s.

China. In the recent two years, China Ministry of Agriculture has widely promoted the movements of environment-friendly ecological agriculture. The rice-duck system is then popularized in middle and lower reaches of Yangtze River, which becomes a typical representative technology in organic production. It is called “rice-duck mutualism” in China and the widely confirmed advantages are 1) reducing uses of agricultural chemicals because the ducks controlled weed and animal pests, 2) increasing yield by about 200 kg per ha, and 3) increasing farmer’s incomes by extra production of 150 ducks per ha and by cost-down from reduced input of chemicals. The farmers have summarized four keys in the paddy duck technology: 1) suitable rice varieties with optimum medium or large plant height, well-distributed canopy, thick stalk and high tillering ability, 2) appropriate timing and space for rice-duck mutualism with about 180 ducklings per ha released two weeks after rice transplanting, 3) good rice management with sufficient fertilization, and 4) proper timing of driving ducks out of the paddy field just before the rice spikes sagging down to prevent the rice grain from being eaten by the birds (Asano et al., 1999b).

Korea. Korean Rice Farming Association has promoted the rice-duck system in organic agriculture movements. The rice produced by rice-duck systems is sold 40-60% higher than the rice grown with chemicals. The number of rice-duck farms and the areas showed an steady increasing trend from 1993 (Kim, 1997). Farmers raise ducks for meat at a density of 200-350 birds, which feed on *Azolla* growing naturally in the paddy fields and sometimes the supplements in forms of commercial feed, rice bran, vegetable scraps, and kitchen scraps. The duck meat is sold well in the autumn and winter.

Vietnam. In addition to the ducks raised throughout the year in backyards of farm households, most others are seasonally raised in integration with the growing paddy fields and the paddy fields after rice harvest (Men, 1997). One week old ducklings are driven into the paddy field 20 days after rice seedlings are transplanted. Feed supplements such as rice by-products are supplied depending on the availability of food in the paddy fields. When rice plants start to flower, the ducks are driven out of the paddy fields to canals, ditches, lakes, and swamps. After the rice is harvested, ducks are herded in the paddy fields, where they forage on left-over rice grains, insects, fish, shrimps, snails and water plants during the day, and then driven to pens or sheds in the evening for night stay (Basilio, 1989). The paddy fields are efficiently used for duck raising during the fallow period between rice harvest and next transplanting.

Indonesia. More than 30 million ducks are raised each year in Indonesia, one of the largest duck producing countries in the world. Ducks contribute more (25%) to the total poultry egg production than chickens (15%) although the improved breeds of chicken contribute 60% (Setioko, 1997). The rice-duck herding systems similar to the Philippines are widely employed in Indonesia.

The Philippines. Ducks rank next to chickens for egg and meat products (PCARRD, 1991). More than 10 million ducks were raised in the Philippines in 1991 (Anonymous, 1991). Ducks requires only inexpensive and non-elaborate housing facilities, little attention and less space compared with chickens. These animals are hardy and resistant to common avian diseases and feed on a variety of foods. Duck eggs are larger and more nutritious than chicken eggs.

5.9.6 Challenges and perspectives in rice-duck paddy farming systems

There exist many limitations and disadvantages to the duck-rice systems (Bird, 1986). Even though the paddy field is managed organically, ducks can be affected by pesticides applied from neighbor farms, particularly when water comes from communal irrigation canals. The use of agro-chemicals in modern rice farming are threatening the traditional rice-duck farming (Manda, 1996; Farrell, 1997). Manda (1996) observed that there is a rapid decline in traditional rice-duck farming in Southeast and East Asia due to the introduction of herbicides, other pesticides and chemical fertilizers that result in environmental pollution and health hazards. Ducks can either be stolen away or killed in the fields by outside animals if paddy fields are not fenced. Fencing cost is high in some poor Asian countries. In ecological aspects, it is observed that ducks do not only eat harmful insects but also friendly ones, such as frogs. It is reported that ducks in paddy field are also related with some health problems for farmers, such as dermatitis and adult flukes (Cagauan and Pullin, 1994; Hu et al., 1994). Farmers should protect their feet with boots or medical cream when they get into the paddy field pastured with ducks. Although there exist some limitations to the rice-duck paddy farming, the systems show increasing potentials to benefit farmers. Rice-duck farming can also be integrated with fish and the nitrogen-fixing aquatic fern *Azolla*, resulting in higher productivity. Nutrient recycling in an integrated rice-fish-*Azolla*-duck farming system is better and more efficient compared to rice-duck or rice-fish farming systems (Cagauan et al., 1996). The duck manure serves as an organic fertilizer for plankton production while the spilled feed can be directly consumed by the fish. Nutrients from the fish pond refuge may be dispersed to the paddy fields by irrigation water or by the movement of fish and ducks. Egg yolk coloration in mallard duck eggs (Alejar and Aragones, 1989; Joome, 1996) and chicken eggs has been observed to be intensified with *Azolla* in the diet. Integrated rice-fish culture also has a long history in China and Southeast Asia. In conclusion, there is a great potential for increasing the productivity of rice-duck farming system, especially if it is integrated with fish and the nitrogen-fixing aquatic fern *Azolla*. As the organic movements receive more and more attentions and the demand for organic safe food increases, the *aigamo* rice or rice-duck rice farming systems will be promoted to another peak.

5.10 Rice-fish culture systems

5.10.1 Definition and development of rice-fish culture system

Rice-fish culture system, a unique traditional agriculture practice, has been practiced for 1700 years in China and other Asian countries. Unearthed relics and some ancient books suggest that rice-fish culture dates back to the East Han Dynasty (25-220) (Guo, 1985; Li, 1992). In 2005, the rice-fish system was listed in Globally Important Ingenious Agricultural Heritage Systems(GIAHS) by the Food and Agriculture Organization of the United Nations (FAO) for its outstanding contribution to food and livelihood security, its importance in terms of biological diversity and genetic resources, landscape diversity, aesthetic beauty and cultural values and the indigenous knowledge of land and water management developed to address harsh biophysical and socio-economical constraints. According to FAO, GIAHS are defined as remarkable land use systems and landscapes which are rich in biological diversity evolving from the ingenious and dynamic adaptation of a community/population to its environment and the needs and aspirations for sustainable development (Koohafkan, 2002). The rice-fish mutualism has been practiced for over 1,200 years since people in Qingtian, Zhejing Province, China started raising fish in rice fields. As the origin of rice-fish system, the farmers irrigated the fields by leading brook into the fields and the fish from the brook grow in the fields naturally. Therefore, the cultural system of natural rice-fish mutualism was formed after a long period of domestication and evolvement. Now, the rice-fish system is becoming one of the modern ecotypic agricultural systems, whereby fish and rice grow well together and help and depend on each other. In this system, rice provides shade and organic substances, while fish help to remove aquatic weed, provide oxygen, reduce plant disease and insect pests and bring nutrients to rice. It is proved through practice that the rice-fish system helps to make efficient use of resources such as water, biological and abiotic substances in paddy fields, leading to benefits in aspects of environment, society and economy. Rice-fish systems not only provide grain and protein but also improve biodiversity, water use and nutrient cycling and retention, flood control and adaptive management to mitigate local climate variation and climate changes. Rice-fish systems are also important in global environmental issues such as climate change by reducing emission of greenhouse gas from rice field. Rice-fish systems are globally distributed with the expansion of rice production. However, they have been developed mainly in Asia and historical data reports their existence in Southeast Asia for over 6,000 years ago (Ruddle, 1982).

5.10.2 Different methods of rice–fish farming

Many methods of rice–fish farming have been developed in China. Although they involve various production systems, these different methods are inseparable and interlinked. The common aim is to boost rice production by eliminating weeds and pests. Many different types of rotation are practiced (Ni and Wang, 1995).

Rice–fish mutualism. In the subtropical areas in Asia, paddy rice crop was cultivated three times a year in succession, early, middle, and late crops. Two kinds of fry (fingerlings and summer fry) are released directly into the flooded paddy fields. Specific practices include raising fingerlings in flooded paddy fields before transplanting, raising fish in paddy growing fields and in nearby ponds, planting rice on the ridges while raising fish in the furrows, and raising fish in the small channels prepared in the paddy fields.

Breeding fry in paddy fields. Grass carp (*Ctenopharyngodon idella*) fry are released directly into early flooded paddy fields without feed supplied. After middle rice crop is planted, 1000 fry, 3.3–5 cm in length, are harvested from the early paddy fields. Early release of the fry is suggested to take full advantage of plankton growth peak. About 45000 artificially hatched fry are needed per ha. Bank borders of the fields are raised 50–70 cm high before the fry are released into the field. Lime is applied 375–750 kg per ha to kill leeches, eels, and other natural enemies of the fish. A week later, water is introduced into the field and then the rice seedlings are transplanted. Fish ditches were 30 cm wide and 30 cm deep. Net screens, each 100 cm wide and 80–90 cm tall, are installed in the water inlet and outlet. Each screen is arch-shaped with thin bamboo strips placed 0.2 cm apart and fry may then be released through into the field. When the weeds are eaten up by the fish before rice ripening, the canals and ditches are opened, the water is drained out slowly, and the fish are forced to gather in the canals and then driven into the ditch, where they are netted out.

Rice, fish, and Azolla. *C. idella* or *C. tilapia* is organically raised with *Azolla* in the paddy fields. The fish feed on *Azolla* and rice is fertilized by fish excrement. Fish and Azolla grow in the wider spaces between every two rows of rice. Rice canopy is well ventilated and light use efficiency is maximized.

Raising fish in paddy fields with wide ditches. This method is used to raise winter fingerlings. Ditches, about 1 m wide and 1 m deep, are prepared on the water inlet side and inside the field bank borders. The area of the ditches is about 5–10% of the area of the paddy fields. The ditch ridge is raised 25 cm above field level. A 24 cm opening every 3–5 m links the ditches with the field and allows the fish to move freely from the ditches to the field. Long before the rice-transplanting season, winter fingerlings are put in the ditches so that they can enter the paddy field for food as soon as the early rice seedlings turn green. Jiangxi Province devoted 6670–9330 ha of paddy fields to this method in 1985–86 and reported a 20–50% increase in rice output.

Paddy field with fish raised in a pond. When there is a time difference of about 1 month between the early rice and the hatching of summer fingerlings, it is not good for rice and fish to be mixed together. Small ponds or ditches are prepared around the paddy field. The pond is 10–30 m^2 large and about 1.5 m deep, linked by a bank to the paddy field. The pond can also be used to hatch the fry. After the early rice is transplanted and the fish canals are prepared in the field, the pond and paddy field are linked to allow the fish in the pond swim across into the paddy field. Just before the early rice is harvested, the fish are driven back into the pond. Then the second rice crop is transplanted and the fish in the pond are allowed back into the paddy field again.

Rice-on-ridges and fish-in-furrows. Ridges with furrows are prepared in the fields. Rice seedlings are planted on the ridges and fish are raised in the furrows. This method was developed on the basis of a semidry cultivation method. Root growth and activity are enhanced, soil aeration and rice canopy conditions are improved, and fish move well in the furrows.

Rotating rice and fish. Rice and fish are alternatively raised in one paddy field. Rice crop is grown once a year, and the rest of the time is used to raise fish. When the rice and fish are harvested, the straw is left in the field. Adult fish are then released into the empty paddy field. The method can also be applied in double-cropping areas, but the fish are only raised in winter.

Rotating rice and fish in low-lying land. The paddy field is planted with late rice crop and then remained fallow for the rest of the year. Fish ditches, each 50 cm wide and 27 cm deep, are prepared and then rice seedlings are transplanted at a density of 11.5 x 17 cm. The fish are grown for about two months without feed supplied.

Raising fish in winter paddy fields. The paddy fields are efficiently used in wintertime from the harvest of late rice crop to the middle rice crop transplanting. In some areas, fingerlings are released right after late rice is transplanted, and the fish are harvested either before the spring in January or February or before the next early rice crop is transplanted. During the winter season, most paddy fields store water full of plankton and organisms. In general, rice-fish culture techniques can be divided into three categories: a) rice-fish mutualism: rice and fish together in the field during the same period, b) rotating rice and fish with fish culture in the paddy field after the rice is harvested, and c) combination of a) and b). In a rotation of rice and fish, the fallow field left after rice harvest is used to raise fish. After the rice is harvested, the straw is left in the field. When the field is irrigated, the straw decays and makes the water suitable for feeding adult fish. In this form of rice-fish culture, fish have more space to move around and feeds can be conveniently spread, although the growth period is long. Fish productivity is higher than in the normal rice-fish mutualism. Rotation of rice and fish is widely used in fallow winter fields because it provides good economic benefits.

Rice-crab culture. Rice-crab culture was introduced to crop production in 1990s. River crab or mitten-handed crab (*Eriocheir sinensis*) is well sold because of its delicious taste. River crabs adapt to various ecological environments (Zhao, 1994). Paddy fields with one crop a year near water source were selected. A surrounding trench, 3 m wide and 1 m deep is prepared in the paddy field. A nursery or harvest pond, about 40 m^2 large and 1 m deep, is prepared in touch with the paddy field. The aquaculture area accounts for 15-20% of the total under rice cultivation. Anti-escape fence walls, as plastic, glassy iron or corrugated sheet with a round corner, are set up around the paddy field. Crabs mainly feed on natural rotifers, Daphnia and water worms in rice fields in addition to artificially supplied feeds such as trash fish, snail, clam, viscera of animals, blood meal and fishmeal, vegetables, rice or wheat bran, oil mill cakes, and terrestrial grass or duckweeds.

Rice-shrimp culture. A surrounding trench, 5 m wide and 1.2 m deep, and ditches inside the fields and rear pond are prepared with mesh screen inlets and outlets. Aqua plants such as eelgrass, stone-wort and pond weed are introduced and cover 1/3-1/2 of water surface. The shrimp stocking density is 4 kg per ha, equivalent to 30 millions larva per ha. Feed such as soya milk and fish gruel is supplied to the shrimp larva 3 times a day. A week later, pellet feeds or mixed feeds of wheat or rice bran with some animal food is supplied. Shrimps with marketable sizes harvested in late November while smaller ones are left in the fields for further growth until next May or June.

5.10.3 Benefits of rice-fish systems

Rice-aquaculture system is characterized by low cost, quick effectiveness and better economic returns as an additional source of food and income to the normal crop production in rural areas. As the usual cases, a 10%-15% grain yield increase is expected in addition to about 800 kg of fish per ha of paddy fields. The rice-fish culture stimulates the ecological and organic agriculture movement by the mutualism between crop production and aquaculture, comprehensive and efficient utilization of rural resources, improvement in rural environment and maintenance of bio-diversity and balance in rice field ecosystems. Applications of agricultural chemicals are reduced or exempted. The rice-fish culture also helps eliminate mosquito larva harmful to human health, and methane emission, which contributes to global warming. Many measures such as vaccine, cultures of *Azolla* and other aquaferns, have been tried for eliminations of Japanese encephalitis and malaria, the potentially fatal diseases transmitted by mosquitoes in many Asian countries, but the best way is through developing rice-fish culture, which eliminates mosquito breeding in paddy fields (Birley, 1998). It is reported that the annual incidences of malaria decreased dramatically as the area of rice–fish culture increased (Wu et al., 1988). The biotic conditions such as autotrophs and heterotrophs and the abiotic conditions such as water, heat, light, air, nutrients and soil as well as the timing and space are efficiently used by living organisms (Chang, 1997).

The keypoint of the new concept of rice fish mutualism is the improvement in rice production through using the herbivorous fish to eliminate weeds and other pests and improve the ecological conditions in the paddy fields (Halwart, 1994). Traditionally, the idea was simply to raise fish with rice as an additional source of food or income. Rice fish farming systems appear to be globally important in terms of three global environment issues: climate change, shared waters, and biodiversity. Methane is a major greenhouse gas emitted by rice fields (Ranganathan et al., 1995). The rice-fish mutualism is also an innovative agricultural system, with a variety of local designs adapted for cultural attributes, appropriate rice and fish species for husbandry, different kinds of water resources availability, timing and drainage, natural and artificial nutrient inputs for growth, biological and chemical control of pests and diseases, and for edaphic and water conditions.

In the biological community of the paddy field ecosystems, rice is predominant, but in mutualism with weeds, plankton, and photosynthesis microbes together as the primary producers (Kurasawa, 1956). However, weeds often compete with rice and may cause rice lose its dominant position. If fish, especially herbivorous and omnivorous fish, are introduced into the paddy fields, the link or the food web is balanced. In rice-fish ecosystems, materials move in a benign cycle and the energy flows in the direction favorable to both rice and fish. The paddy fields nourish the fish, and the fish nourish the rice. Mutualism means a mutual relationship whereby two different species live together and benefit from each other. The difference of the modern rice-fish systems from those natural is that fish in the system is manly controlled and an optimum balance and the maximum productivity can be expected by expending the mutualism period and fitting the peaks of both the primary producers and the consumers.

5.10.4 Challenges and perspectives in rice-fish farming systems

Rainfed rice-fish farming systems are threatened by excessive application of chemicals, particularly pesticides, intensification of rice cultivation, mono-species fish culture, and modern irrigation systems. The management of rice-fish farming needs more labour and village co-operation than the mono rice production. The rice-fish system is a remarkable model of the biodiversity-enhancing agriculture system. There is a high potential to integrate the traditional rice-fish culture into those with new policy changes (Lightfoot et al., 1993). Some promotion actions are suggested as 1) documenting patterns of the traditional rice-fish system; 2) evaluating and identifying impacts of policies and technologies on practices of the rice-fish systems; 3) setting up representative demonstration sites with partnership between local communities or government and farmers; 4) identifying and demonstrating successful adaptations to social-economic changes, and exploring the multiple values of the rice-fish system in the food safety, eco-agriculture, eco-tourism and ecological conservation; 5) developing networks on conservation and sustainable management of the rice-fish system among communities, local governments, and farmer. In conclusion, rice-fish systems are important in terms of aquatic biodiversity conservation from a global environmental perspective. However, rice-fish systems function within a matrix of farming systems which, in turn, lie within catchments and river basin dynamics. The adequacy of biodiversity at the genetic and species levels, and at the farm, catchments and river basin level, needs to be assessed against design goals, adequacy measures, and potential risks. Rice-fish farming can be a low-cost, low-risk option for poor rice farmers in rice-farming countries, including

Malawi, Bangladesh, China, India, Indonesia, Korea, Laos, Madagascar, Malaysia, the Philippines, Thailand, Cambodia, and Vietnam (Dela et al., 1992; Ghosh, 1992; Hasan, 1990; Heckman, 1979; Islam, 1983; Kurihara,1989; Little et al., 1996; Vincke and Micha, 1985; Xu and Guo, 1992). Traditional rice-fish systems need to be improved. Paddy fields used to raise fish in the traditional systems do not have ditches or pits. The low volume of water in these paddy fields results in insufficient dissolved oxygen and less amount of plankton, higher water temperature in summer, and less space for the fish to hide from predators (Kurasawa, 1956). Fish species used in improved modern rice-fish systems should be those that are characterized by fast growth and low jumping habitat for prevention from escaping. As needed, artificial feed should be supplied when there is no sufficient natural feed in paddy fields, especially when plankton and weeds decrease as the fish grow during the middle and late growing stages. Late releasing and early harvest as well as short growing period of the fish are the main factors limiting the fish yield. It is better to arrange a longer period for rice and fish to grow together. It is easier for large-scaled farmer to manage rice-fish systems with improved technology than the small-scaled ones. In the present situation, all of the paddy farmers in China and Japan are almost in small-scale. Rice-fish farmers should extend their farm scales by co-operations with the neighbor farmers.

5.11 Integrated pest control

In conventional or chemical agriculture, pesticides are used effectively to control pest organisms. However, excessive uses of pesticides have caused many problems such as food and environmental pollution and risks to animals, human and other organisms in the environment. The so-called pesticide is a chemical used to control, to repel, to attract or to kill pest, such as insects, weeds, birds, mammals, or microbes that are considered a nuisance. Pesticides are usually of high poison, which causes injury or illness or death of a living organism. Chemical engineers continually develop new pesticides to produce enhancements over previous generations of products. DDT, a typical insecticide that is also toxic to animals and humans, has been banned in Japan and other countries since 1970s. DDT is one of the once heavily used pesticides and the adverse effects exist till now, for example, affecting baby by the milk containing DDT that was deposited in the mother's body several decades ago. Most of new generations of pesticides present dangers to humans when used to control weeds or insects on food crops. Food crops, such as many fruits and vegetables, contain residual pesticides even after being washed or peeled. However, they may still meet government limits. Besides human health risks, pesticides also pose dangers to the environment. Non-target organisms can be severely impacted. Therefore, alternative integrated pest management should be developed for nature farming or organic crop production. IPM was introduced as a concept in the United States in the late 1950s and developed to harmonize chemical control and biological control (Bartlett, 1956; Smith and Allen, 1954; Stern et al., 1959). Smith and Allen (1954) first established IPM as a new trend in economic entomology. The early concept was based on the premise that pesticides could have a minimum impact on the natural enemies. "Economic threshold" was introduced at the same time, based on the knowledge that pest populations fluctuate naturally. Control measures should only be used to prevent an increasing pest population from reaching the economic injury level. The "economic injury level" was defined as the lowest density that will cause economic damage. These concepts remained the major theme of IPM throughout the 1970s. There are 64 definitions of integrated pest control or integrated pest management (IPM) that have been made since the early 1930s (Bajwa and Kogan, 1996). In simple terms, IPM can be a procedure to manage pest populations by harmonizing control methods such as natural enemies, pesticides and cultural practices, in purpose of minimizing economic damage and harmful environmental side-effects by managing pest populations instead of eradicating or removing the pest. The theory and principles of IPM have been developed over the last 40 years. Prior to World War II, pest control was accomplished primarily through cultivation practices such as tillage and rotation as well as mechanical removal of pests. After World War II, DDT and other organic insecticides came into use worldwide to control insect pests. The regular use of pesticides was started in industrialized countries in the early 1950s. By the 1970s, farmers in industrialized countries had relied on pesticides without other methods considered. Pest adapted to the chemicals and no pesticide could control the pests on some farms. Some farmers increased the application of highly toxic pesticides to 60 applications during the growing season. Under these conditions, the cost of pest control made the production of cotton profitless. IPM began to shift to non-pesticidal tactics in the 1980s with expanded use of cultural and biological controls and introduction of resistant crop cultivars. In the 1990s, extension techniques and policy have been emphasized strongly in the development of IPM (Kogan, 1998). Many practices of the alternative integrated pest management have been tried at International Nature Farming Research Center and the related farms. The practical examples are introduced as in next paragraphs.

5.11.1 Biodiversity enrichment for pests control

Biodiversity enrichment is one system of practices in integrated pest management (IPM). IPM is an approach to pest control that utilizes regular monitoring to determine if and when treatments are needed and employs physical, mechanical, cultural, biological, and educational tactics to keep pest numbers low enough to prevent unacceptable damage or annoyance (Luck, 1990; Nelson, 1989; Pimentel, 1991; Pimm, 1991; Thies and Tscharntke, 1999). In IPM programs in conventional agriculture, pesticide treatments are made only when and where monitoring has indicated that the pest will cause unacceptable economic, medical, or aesthetic damage. Treatments are chosen and timed to be most effective and least-hazardous to non-target organisms and the general environment. However, no chemical pesticide is allowed in organic agriculture. One of pest control measures in organic agriculture is to enrich populations of natural enemies to pest insects. The process of finding and introducing natural enemies from their original places is a challenge (Barbosa, 1998; Beddington et al., 1978; Blossey, 1995). The introduced pest predator or parasite must undergo exhaustive testing before being released to be sure it will not harm non-target organisms. Failure can also be related to problems such as climate differences, prior or current pesticide use, disturbances of the habitat by other agricultural operations, and/or the removal of weeds that might otherwise offer food and shelter to the natural enemies. Intercropping with attractive plants, nectar-producing plants and alternate host plants in and around fields, and intercropping different crops to provide habitat diversity are all management techniques that lead to the build-up of natural enemy populations and result in enhanced biological control of pests in organic crop production (Nentwig, 1988; Nentwig et al., 1998). The author and his colleague have tried enrichments of biodiversity and populations of natural enemies, such as spiders, by placing organic materials along the walls of a soil-based greenhouse (Xu et al., 2004). The spiders predate the insects in the decomposed organic materials such as crop residuals before the insects reach the dense populations (Fig. 6). This practice effectively controlled insects of brassica leafy vegetables in greenhouse. Many practices similar to the present one have been attempted using land margin spaces to enrich biodiversity and rear natural enemies (Baines et al., 1998; Sotherton, 1984).

Figure 5. Organic materials placed along the walls of greenhouse (Left) where growing is a brassica leafy vegetable.

Figure 6. Nature enemies thriving in brassica plots (Left: a spider (*Lycosa pseudoannulata*) is fighting a green worm (*Autographa nigrisigna* Walker); Right: two frogs are patrolling on a brassica plant).

5.11.2 Pest control with plant materials or botanical pesticides

The indiscriminate and excessive use of chemical pesticides has given rise to many well-known and serious problems, including genetic resistance of pest species, toxic residues in stored products, increasing costs of input, and hazards from handling and operation. Therefore, both in organic and conventional agriculture, there are increasing demand for alternative, biodegradable botanical pesticides. Botanical pesticides are safe for both environment and high animals, and relatively specific in their mode of action and easy to process and use (Hofstetter, 1991). Botanical pesticides can be easily produced on farm by farmers or small-scale industries. Here, the so called botanical pesticides do not include those insect and disease killers that are even derived from plant materials or other natural sources but toxic to non-pest insects, humans, and animals the same as synthesized chemical pesticides. Some botanical materials kill both beneficial and pest insects indiscriminately, cause allergic reactions in people, or highly toxic to fish and animals. These are not allowed in nature farming crop production, even neither in conventional agriculture. Some plant materials, such as some spices used in daily kitchen, are not doubted untoxic because they do not harm human. These plant materials include garlic, hot pepper, Sichuan peppers, and Ginkgo leaves.

Hot pepper powder. Hot pepper (*Capsicum frutescens* L.) is a perennial plant with small, tapering fruits, often 2-3 mm at a node. The fruit of most varieties are red and some are yellow or purple. The fruit are very pungent or hot. Hot pepper is used generally as a condiment, spice and in some areas as daily vegetable. Therefore, it is not toxic and environment sound when its extracts are used to control pest insects. Hot pepper contains the active ingredient, capsaicin, which is effective to repel most common pest insects from crops. The commercial formulation, hot pepper wax, is widely used. The liquid concentrate contains chlorinated refined wax (FDA approved for edibles), hot pepper extract, kelp, eucalyptus extract, scent made from extracts of garlic, onion, parsley, basil, thyme, coriander, cumin, mustard, orange, and lemon. The main ingredient is capsaicin, an extract from cayenne pepper. Hot pepper wax is absorbed into the nervous systems of soft-bodied insects such as aphids, thrips, mites, and white flies. Initially this is apparent as an increase in nervous system activity; insects begin to move more rapidly. This action will kill some bugs on contact. Generally, it takes 24-48 hrs to be effective. It is often used on roses, orchids, cut flowers, house plants, orchards, and field crops.

Neem. Commercially used for pesticide are azadirachtin solution and neem oil made from the seeds of neem tree (*Azadirachta indica*). Neem does not poison insects outright and is effective against aphids, thrips, fungus gnats, caterpillars, beetles, leafminers, and others. The author has once tried neem for control of aphids, whiteflies and other pest insect but it does not really poison the natural enemies of these pest insects, such as spider (*Lycosa pseudoannulata* [BOESENBERG et STRAND]), frog (*Hyla arborea japonica* Gunther), little bee (*Eretmocerus nr. Californicus*) and ladybird (*Hippodamia convergens*). Amazingly, plants can absorb neem so that any insects that feed on them may be killed or deterred from feeding. It breaks down in the presence of sun and soil within about a week. Neem oil also works against some plant leaf diseases, such as black spot on roses, powdery mildew, and rust diseases.

The author has once used the whole neem fruit powder as botanical pesticide to treat whiteflies (Xu et al., 2004). The neem powder was added into the microbial fermentation to extract the active substances and then the liquid was diluted and sprayed onto the tomato leaves. It reduced pest insects but did not poison natural enemies of pests.

Pest control using neem extracts currently occurs in more than 55 countries throughout the world. Actually, neem products have been in use in Asia for over 2,500 years. The potential for use of neem in organic crop production particularly warrants further investigation. The active ingredients of neem extract include a group of seven constituents, azadirachtin and its derivatives, which have been shown to be a systemic feeding deterrent for insects (Gill and Lewis, 1971). Neem extracts work against chewing and sucking insects, mainly lepidopterous caterpillars and beetle larvae. The active ingredient accumulates in the growing tips of the treated plants, usually reaching functional levels within 24 hours after the leaves being sprayed. The toxicity of neem extracts to non-target organisms is low. Many pest species have been tested using neem extract (Friend, 1996). It has been confirmed that neem extracts have a high efficacy against pathogenic crop nematodes, especially *Meloidogyne javancia*, other *Meloidogyne spp* and *Pratylenchus spp*.

Neem oil is a natural control for many insects, mites, and fungi. It functions well as an "antifeedant", discouraging insects from feeding but not directly killing them. Neem oil is pressed from neem seeds. Naturally occurring compounds in neem oil discourage feeding on treated plants. When ingested, neem disrupts the molting and reproductive cycles of many insects. For example, desert locusts, which are voracious herbivores, will sooner starve to death when they eat plants treated with neem. Neem has proven non-toxic to birds, mammals, and beneficial predators like ladybugs, spiders, bees, and wasps. It is often used on vegetable and flower gardens, ornamentals, greenhouses, orchards and field crops to aphids, armyworms, cabbage loopers, caterpillars, cockroaches, Colorado potato beetles, cutworms, diamond back moth, flies, fungus gnats, and gypsy moth caterpillars. In early morning or later afternoon, this neem oil is diluted and then sprayed on all leaf surfaces, including the undersides of leaves once every 2-4 weeks.

***Zanthoxylum* (Sichuan peppers).** Sichuan pepper refers to a spice from a group of closely related plants of genus *Zanthoxylum*. It is used as condiment in Chinese food cooking in Sichuan Province of China. Most species are found in Asia. Common used is *Z. piperitum*. The dried fruits of sichuan pepper have an aromatic odour with more or less pronounced warm and woodsy overtones. Some of the species have deviating flavour, spicy or anise aromatic. The taste of most species is pungent and biting with a strange, almost anesthetic feeling on the tongue. Most *Zanthoxylum* species produce pungent alkamides derived from polyunsaturated carboxylic acids, which are stored in the pericarp (fruit wall, "shell") but not in the seeds. The exact nature of these alkamides varies from species to species, but the common found substances are amides of *2E,6Z,8E,10E* dodecatetraenoic acid, *2E,6E,8E,10E* dodecatetraenoic acid, and *2E,4E,8Z,10E,12Z* tetradecapentaenoic acid with isobutyl amin (known as α, β and γ sanshool, respectively) and 2-hydroxy isobutyl amin (hydroxy sanshools). Total amide content can be as high as 3% (reported in *Z. piperitum*).

The author and his colleague have once treated aphids with *Zanthoxylum* as botanical pesticide (Xu et al., 2003). The powder of *Z. piperitum* fruit was added into a microbial fermentation to extract the active substances and then the liquid was diluted and sprayed onto the Chinese radish and spinach. The aphids were anesthetized and fell down to the soil surface instead killed (Tables 27 and 28). It did not poison natural enemies of pests. Because *Zanthoxylum* is usually eaten, it is expected environment sound when used to plants.

Table 27. Aphid infection intensity and infection rate in spinach.

Treatment	Aphid infection intensity (individual m^{-2})	Aphid infection rate (%)
Organic + *Zanthoxylum*	874 ±200	79.4 ±2.4
Organic CK	2300 ±900	97.7 ±2.3
Chemical + *Zanthoxylum*	1770 ±700	80.8 ±3.9
Chemical CK	2810 ±800	100.0 ±0.0

Table 28. Aphid infection intensity and infection rate in Chinese radish.

Treatment	Aphid infection rate with different intensity (%)			Infection rate (%)
	36200-48200 cm^{-2}	15800-27100 m^{-2}	0-5700 m^{-2}	
Organic + *Zanthoxylum*	17.4±2.6	44.5±5.6	21.8±7.8	83.7±0.4
Organic CK	37.6±6.8	45.1±10.5	10.6±10.6	93.3±6.7
Chemical + *Zanthoxylum*	21.5±5.5	26.2±4.2	47.3±4.7	95.0±5.0
Chemical CK	63.6±7.0	24.1±1.5	10.5±6.5	98.1±1.9

Pyrethrins. Pyrethrum is a botanical insecticide produced from *Chrysanthemum cinerariaefolium*. It is commercially cultivated mostly in the mountainous regions of Kenya, Tanzania, and Ecuador. The term "pyrethrum" refer to the powder made with the dried flowers of the chrysanthemum, whereas the term "pyrethrins" refers to the six insecticide components occurring naturally in the powder. Pyrethrins constitute up to 1.3% of the dried flowers. These insecticidal compounds occur naturally in the flowers of some species of chrysanthemum plants. The synthetic compounds are called pyrethroids. The toxins penetrate the insects' nervous system, quickly causing paralysis. Synthesized pyrethroids are not approved for use in organic farms and gardens even though the plant material preparations at on-farm level are allowed. Pyrethrins are toxic to fish, bees and birds although no much harm to human. It kills both beneficial and pest insects. The compound may breakdown rapidly when exposed to sun and air and becomes less effective if stored for longer than one year.

The author has tested extract by adding the powder into a microbial fermentation and fermented for one week. Then the extract was sprayed onto tomato leaves for control of whiteflies. The spray reduced whiteflies but did not much poison the natural enemies such as frogs, bees and spiders since enemies do not eat the sprayed leaves.

A botanical pesticide product, Rotenone-Pyrethrins Liquid Spray, is also often used to control many insects on fruit, vegetables, ornamental flowers and trees such as apples, plums, peas, squash, cabbage, oak, elm, cedar, petunia, aster, geraniums, and marigolds. Repelled insects include Japanese beetles, stink bugs, aphids, leaf hoppers, flea beetles, ants, aphids, asparagus beetle, and boxelder bugs

Ginkgo leaves. *Ginkgo biloba* is dioecious tree as the male and female flowers grow on different trees. This name, Ginkgo, is derived from the Chinese YIN, silver, pronounced as GIN in the south dialect, and XING, apricot, pronounced close to KGO in the south dialect, as in reference to appearance of the fruit. Ginkgo leaf is first mentioned in Lan Mao's Dian Nan Ben Cao, published in 1436 during the Ming dynasty. Lan Mao notes external use to treat skin and head sores as well as freckles. Internal use of the leaves is first noted in Liu Wen-Tai's Ben Cao Pin Hui Jing Yao, an imperial commissioned work recorded in 1505. Liu Wen Tai notes use of the leaves in the treatment of diarrhea. Recent clinical reports in modern China suggest that the leaves lower serum cholesterol levels and have some clinical value in angina pectoris. In traditional Chinese pharmacopeia the seeds (with fleshy rind removed) are considered more important than the leaves. The nut, called Pak Ko in Cantonese dialect and Bai Guo in Mandarin Chinese, is recommended to expel phlegm, stop wheezing and coughing, urinary incontinence and spermatorrhea. Ginkgo leaf is a Chinese herb that has been used much more in the West than in its homeland. However, there has been no case reported for use as pesticide with the exception that the author has once tried as botanical pesticide for control of greenhouse tomato whiteflies (Table 29). The extract was made by fermentation with a microbial inoculant called EM or effective microorganisms (Higa, 1994). The spray reduced whiteflies but did not much poison the natural enemies such as frogs, bees and spiders.

Table 29. Effectiveness of the botanical pesticide materials in control of greenhouse tomato whiteflies

Material	Nymph dead (%)	Adult repelled (%)
Imidacloprid	81.7 Aa	88.1 a
Ginkgo leaf	58.3 Bb	87.8 a
Pyrethrum	35.1 Bb	67.1 b
Neem fruit	8.7 Cc	52.8 b

Values followed by different letters are significantly different at $P \leq 0.01$ (Capital) and $P \leq 0.05$ (lower case). Imidacloprid is a chemical pesticide.

Garlic extract. Garlic (*Allium sativum*) is a bulbous perennial food plant of the family *Alliaceae* (Kamenetsky et al., 2004). It is botanically related to onions and lilies. The domesticated garlic plant does not produce seeds but is grown from bulbs. The bulb is the part of the plant most commonly eaten, though some cooks also use the early spring shoots and floriferous shoot. Garlic is most often used as a condiment with superior medicinal value. It contains allicin, a powerful antibiotic and anti-fungal compound. It also contains alliin, ajoene, enzymes, vitamin B, minerals, and flavonoids. A strong liquid garlic concentrate is used as a botanical pesticide, diluted in water and sprayed on farm and garden plants to keep repel insects. Garlic extract is absorbed through pores (stomata) on plant foliage and travels systemically throughout the entire plant. It protects roots, stems, leaves, flowers, and fruit. It does not alter the taste or smell of any part of the plant. It repels aphids, apple maggots, armyworms, asparagus beetle, cane borers, caterpillars, codling moths, cutworms, earwigs, fall webworms, grasshoppers, and gypsy moth caterpillars. It also repels mosquitoes, gnats, deer flies and other pests to humans, pets, and livestock. The key to using garlic effectively as a repellent is to apply it to plants before there is a pest problem.

5.12. Evaluation of organic agricultural produces

The quality of food raised by organic farming in comparison to conventional farming is a current topic that continues to attract interest and generate discussion (Ausebel, 1994; Hornick, 1992; Knorr, 1982; Feenstra, 1992; Kenton, 1988). It has been proved that crop quality, especially the vegetables and fruits, is improved by organic fertilization (Larson et al., 2000; Pfiffner et al., 1993; Xu et al., 2003). However, an organic food label, itself, does not insure superior nutritional quality because farm-to-farm and soil to soil geographical variability is a certainty. There are many factors affecting the nutrition of food, including soil type, variety, and post-harvest handling. In addition, soil testing, mineral supplementation, and biological soil management are practices that vary from farm to farm. Nevertheless, the quality of organic food with regards to safety is superior over the conventional produces grown with pesticides and, in some cases, excessive chemical fertilizers. It is of no doubt the nutritional quality of agricultural product is high if the soil contains more organic matter and balanced macro and micro nutrients. There are pairs of data of mineral contents showing vegetables grown in organic matter abundant soil versus organic matter deficient soil as follows: P 10.45-4.04, Ca 0.36-0.22, Mg 40.5-15.5, K 60.0-14.8, Na 99.7-29.1, B 8.6-0.0, Mn 73-10, Fe 60-2, Cu 227-10, Co 69.26-3.00. The datum pairs show clearly that the vegetable grown in organic soil is superior over that grown in non-organic in aspects of mineral content (Bear, 1948). Food quality is not only in relation with the nutritional components and safety, but also associated with how people "feel" after eating food (Clancy, 1986; Hornick, 1992; Peavey and Peavy, 1993). Health conscious yoga practitioners in the United States and *Johrei* practitioners in Japan who are in tune with their bodies self-select natural and organic foods and this fact has merit comparable to a dozen scientific studies. Food quality is defined more broadly instead only on nutritional basis by the Soil Association in England with six criteria--sensual, authenticity, functional, nutritional, biological, and ethical.

Many tests and analyses have been conducted at International Nature Farming Research with some equipment of high quality and precise such as HPLC, Gas-Mass Chromatography, and Infrared Analyzer. Most of the results show that organic produces are superior over those grown with chemical fertilizers. Some simple instruments are also used by the extension technical advisors and farmers in field conditions. The refractometer with RQflex brand is commonly used in field conditions. It measures vitamin C, nitrate, soluble solids and sugars of sap squeezed from fruits or vegetables.

At International Nature Farming Research Center, several experiments were conducted to confirm quality indications, such as the leaf concentrations of sugars, vitamin C and the nitrate ion in leafy Brassica vegetable, tomato and lettuce grown with organic and chemical fertilizers. The quality was indicated positively by the concentration of soluble sugars (including sucrose, glucose and fructose), vitamin C (ascorbic acid) and minerals such as calcium, and negatively by the concentration of nitrate (Tables 30, 31 and 32). Concentrations of sugars and vitamin C were significantly higher but nitrate was lower in organic-fertilized vegetables. If the concentration of vitamin C, Sugars and Calcium, which is wanted to be abundant in vegetables, is taken as the numerator factors, and the concentration of nitrate, which is not wanted to be contained in vegetables, is taken as the denominator factors, an indicator of the quality can be obtained by the following equation:

$$Q=(K_1 B_1+ K_2 B_2 + K_i B_i+\ldots+ K_n B_n)/(k_1 H_1+ k_2 H_2 + k_i H_i+\ldots+ k_n H_n),$$

where, Q is quality indication; K_i is the constant showing the importance of the beneficial substance; B_i is the beneficial substance concentration relative to a reference value; k_i is the constant showing the importance of the unwanted harmful substance; H_i is the concentration of the unwanted harmful substance relative to a reference; and $K_1+K_2 +K_i +\ldots+K_n = 1$ and $k_1+ k_2 + k_i +\ldots+ k_n = 1$.

As shown in Tables 30, 31 and 32, significant difference was shown in this quality indication of vitamin-nitrate ratio between organic and chemical fertilization. This kind of indication is more reasonable because the consumers consider not only the nutritious substances but also the harmful compounds. For example, nitrate is known as harmful when it changes to nitrite status (Maynard and Barker, 1979). As found by Comis (1989), nitrogen overload shrivels vitamin content. The data obtained in the present study showed clearly the quality advantages for organic produced vegetables over the chemical fertilized vegetables. Similar results and discussions have been reported in other documents (Larson et al., 2000; Dloughy, 1977; Fischer and Richter, 1986; Granstedt and Kjellenberg, 1997; Gussow, 1996; Hanson, 1981; Knorr and Vogtmann, 1983; Lairon, et al., 1984; Linder, 1973; Mayer, 1997; McSheelhy, 1977; Mozafar, 1994; Newesome, 1990; Pimpini et al., 1992; Samuel and East, 1990; Schultz and Kopke, 1997; Schuphan, 1974; Schuphan, 1972; Smith, 1993; Srikumar and Ockerman, 1991; Starling and Richards, 1990; Svec et al., 1976; Warman and Havard, 1996; Woodward, 1993).

Table 30. Concentrations of vitamin C (V_C, mg kg^{-1}DM), sugars (g kg^{-1}DM), calcium (Ca, g kg^{-1}DM), the nitrate ion (g kg^{-1}DM) and oxalic acid (g kg^{-1}DM) in leafy Brassica vegetable grown with organic and chemical fertilizers.

Fert	V_C	B_1	K_1	Sugar	B_2	K_2	Ca	B_3	K_3	NO_3	H_1	k_1	OA	H_2	k_2	Q
Org	189	1.09	0.5	8.1	1.15	0.3	11.6	1.14	0.2	4.9	0.84	0.8	3.2	0.85	0.2	1.32
Che	158	0.91	0.5	6.0	0.85	0.3	8.7	0.86	0.2	6.7	1.16	0.8	4.3	1.15	0.2	0.76

Table 31. Concentrations of vitamin C (g kg^{-1}FM), sugars (g kg^{-1}FM) and the nitrate ion (g kg^{-1}FM) in tomato fruit grown with organic and chemical fertilizers.

Fert	V_C	B_1	K_1	Sugar	B_2	K_2	Acid	B_3	K_3	NO_3	H_1	k_1	Q
Org	0.14	1.40	0.5	60.3	1.51	0.3	8.65	1.11	0.2	0.25	0.71	1	1.92
Che	0.11	1.10	0.5	50.5	1.12	0.3	8.05	1.03	0.2	0.31	0.89	1	1.23

Table 32. Concentrations of vitamin C (mg kg^{-1}FM), sugars (g kg^{-1}FM), the nitrate ion (mg kg^{-1}FM) and oxalic acid (g kg^{-1}DM) in leafy lettuce grown with organic and chemical fertilizers.

Fert	Sugar	B_1	K_1	V_C	B_2	K_2	NO_3	H_1	k_1	OA	H_2	k_2	Q
No F	422	1.40	0.7	27.0	1.02	0.3	580	0.51	0.8	573	0.83	0.2	2.25
Org	249	0.82	0.7	31.5	1.19	0.3	1120	0.98	0.8	694	1.00	0.2	0.95
Che	235	0.78	0.7	20.8	0.79	0.3	1730	1.51	0.8	812	1.17	0.2	0.54

5.13 $\delta^{15}N$ used in evaluation of the biodiversity

The biodiversity is very important in the agricultural systems, especially in the organic crop production systems. A good biodiversity is shown by healthy and well organized food webs. Food webs in the agricultural systems are complex and the traditional ecological methods such as direct observation, gut content analysis and food preference tests have provided limited information on the feeding habits and assimilated dietary components of soil invertebrates. The trophic status of many soil invertebrate groups and their functional roles in soil food webs are needed to be monitored in ecological research related with organic agriculture. A novel technique used to elucidate trophic relations of animals exploits natural variations in the heavy stable isotope ratio to the light elements (Gannes et al., 1998). This approach is based on the analysis of the ratio of naturally occurring stable isotope pairs such as $^{15}N/^{14}N$ (expressed as $\delta^{15}N$), and known regularities in the change of this ratio are transferred from food sources to animals along food chains (Eggers and Jones, 2000). The stable isotopes of nitrogen (^{15}N and ^{14}N) are expressed in per mil (‰) as δ values: $\delta = [(R\ sample/R\ standard) - 1] \times 1000$, where $R = {}^{15}N/^{14}N$ for the measurement of nitrogen. According to observations in the nature farming fields at the International Farming Research Center (Fujita and Fujiyama, 2002), the $\delta^{15}N$ value for plants and animals was higher in the organic fertilized fields than conventional farming fields, suggesting that organic fields function as a better ecosystem involving comparatively diverse animals enriched with ^{15}N in the ecosystem. By analyzing $\delta^{15}N$ of an organism, one can know the source of assimilated nitrogen based on the fact that the $\delta^{15}N$ value of animals is directly influenced by the $\delta^{15}N$ of their diet (DeNiro and Epstein, 1981). By looking at $\delta^{15}N$ of potential food sources, one can know the origins of nitrogen. By looking at $\delta^{15}N$ of the soil or agricultural produces, one can know whether nitrogen from chemical fertilizers remains as residue or is applied intently in converting organic field.

5.14 $\delta^{15}N$ used in evaluation of the organic agricultural produces

As mentioned in the above paragraph, heavy nitrogen isotope ^{15}N usually concentrates and remains in the organic materials such as the composts where light nitrogen isotope would be lost away faster than the heavy one as ammonia to the air and as nitrate to the ground. Therefore, organic agricultural produces show higher $\delta^{15}N$ than the conventional agricultural produces. Nakano et al. (2003) found significant differences in the $\delta^{15}N$ values of tomato fruits grown under different types of fertilizer applications, especially between inorganic and organic fertilizers. The $\delta^{15}N$ value of the chemical fertilizer used for basal dressing was 0.81 ± 0.45 %o, that of the chemical fertilizer for fertigation was 0.00 ± 0.04 %o, and that of corn starch liquid organic fertilizer was 8.50 ± 0.71 %o. The $\delta^{15}N$ values of the soils reflected the $\delta^{15}N$ values of the fertilizers. The $\delta^{15}N$ values of the fruits are consistent with the $\delta^{15}N$ values of the applied fertilizers. The $\delta^{15}N$ values were 3.18 ± 1.34 %o in the fruits grown with a basal dressing of chemical fertilizer, 0.30 ± 0.61 %o in those grown under inorganic fertigation, and 7.09 ± 0.68 ‰ in those grown under organic fertigation. Fujita et al. (2003) examined 75 samples of rice produced in North Japan in organic and conventional paddy fields and found that the organic rices showed higher $\delta^{15}N$ values compared with conventional rices. The rice certified by the JAS organic certifier showed an average $\delta^{15}N$ value of 5%o with the minimum as 2.9%o. It is suggested that 2.9%o can be used the border line between organic and conventional rices. Therefore, it may be possible to use $\delta^{15}N$ values as an indicator of organic products since the $\delta^{15}N$ value of a fertilizer correlated with that of the produce.

6. Perspectives of nature farming

6.1 Agriculture in Japan

6.1.1 Low importance in the whole economy

Japan has the second largest economy in the world in terms of Gross Domestic Product (GDP), next to the United States. Japan's GDP per capita in

1999 was $34,500, one of the highest in the world. This economic scale was achieved largely due to high economic growth from 1955 to the late 1960s. For example, Japan's average annual growth rate in the 1960s was 10.39%, more than twice as much as those of Western nations. Although Japan maintained a relatively high rate of growth until 3.8%, in the late 1980s, the pace of economic growth slowed in the early 1990s, when the "bubble economy" collapsed. Japan has experienced a decline in self-sufficient agriculture with an increasing dependence on food imports. Currently, Japanese agriculture primarily depends on growing rice and fruits with high input, including heavy uses of chemical fertilizers and pesticides. Agriculture has declined its relative importance in the Japanese economy with the share of net agricultural production in GNP finally reduced to 1.6% in 2003. More than 85% of Japan's farmers were engaged in occupations outside of farming. Compared with other developed countries, the most striking feature of Japanese agriculture is the shortage of farmland and the small scale of farm. The 4.9 million hectares under cultivation constituted only 12.8% of the total land area. The farmland is intensively cultivated and paddies occupy most of the countryside, whether on the alluvial plains, the terraced slopes, the swampland and coastal bays. Agriculture is maintained through the uses of chemical fertilizers and machinery and through price supports. Agricultural cooperatives are in charge of purchasing grain according to prices indexed to the average wage rates. Food production is substantially supported by the government’s subsidy. Japan's support, about $23,000 per full-time farmer and almost $10,000 per hectare of farmland, is among the highest of the world. The government argues that this support is necessary for the economic, environmental, and cultural well-being of rural areas and for the nation's food security. Critics argue that such support deters other countries from entering Japan's agricultural markets, weakening domestic and international competition and raising prices for Japanese consumers. However, the government has never specifically supported organic agriculture. In a long government report from the agriculture authority, one can hardly find a word about organic agriculture and never nature farming also. Everybody knows that organic farmers cannot expect agriculture authorities to use budgeted money to encourage organic farming. The agriculture authorities’ sympathies lie with agribusinesses and major corporations. If they're calling for more farmers to convert to organic farming, it means that they have smelled money to be made. Most of the money will be made by the corporations that control the distribution, processing, and marketing of food. The agriculture authorities are interested only in the economic aspect of organically-grown commodities and their potential for generating profits is made obvious by their choice to call organic farming 'high-value added farming'.

6.1.2 Low level of farmers' income and farm employment

The total income per farm household was 7.8 million yen in 2002. Only 1.02 million yen of the total income was from farm income and, as the else, 4.53 million yen from non-farm income and 2.29 million yen from pension benefits and other sources. On average, 87% of a farmer householder's income is from non-agricultural activities. Employment in agriculture declined from 50% prewar, through 23.5% in 1965 and 7.2% in 1988, to 5% in 2002. Since 1950, Japan's economy has boomed without any withering and left farmers far behind in income. There are three types of farm households in Japan: 1) those engaging exclusively in agriculture, 14.5% of the 4.2 million farm households in 1988; 2) those with more than half their income from the farm, 14.2%; and 3) those holding jobs other than farming, 71.3%. The farm population declined from 4.9 million in 1975 and 4.7 million in 1990 to 4.4 million in 2003. The average age of farmers rose through 51 years in 1980 to more than 60 years now.

6.1.3 Low food self-sufficiency ratio

Japan's food self-sufficiency ratio is in a long-term downward trend, declining from 88% in 1946, 73% in 1965 to 40% in 2003. Among the developed nations, Japan has the lowest level of 40%, compared with, for example, 139% for France at the top, 132% for the United States, 97% for Germany, 77% for Britain, and 59% for Switzerland. The main reasons for the decline in food self-sufficiency are changes in the diet with a reduced consumption of rice, the Japan's major self-sufficient commodity, and an increased consumption of meat, poultry and other fatty foods, which require huge amounts of feed grains or large expanses of agricultural land for their production. Other reasons list as the restaurant industry's strategy of seeking lower costs by using imported food and the westernization of the Japanese diet, which has resulted in a decline in rice consumption although rice production is sustainable in Japan. Large quantities of foods are being imported into Japan, reaching a total of 5.3 trillion yen in 2002, equivalent to 12.5% of Japan's total imports. The most commonly imported food is fishery product, with a total cost of 1.6 trillion yen in 2002, equivalent to 31% of all food imports. Next most commonly imported are meat products, with a cost of approximately 1 trillion yen, cereals and the processed products, approximately 580 billion yen, and vegetables, about 360 billion yen. The leading exporter of foods to Japan was the United States, 28.9% of the total food imports, followed by China (13.9%), Australia (6.3%), Thailand (5.4%), Canada (5.1%) and the Republic of Korea (3.2%).

6.1.4 Food quality in Japan

Japanese concept of food quality. When the first case of BSE (bovine spongiform enephalopathy) was confirmed in the USA in December 2003, Japan immediately banned imports of US beef and related products. At the same time, avian influenza ("bird flu") expanded in Asia and then bans were placed on imports of chicken meat and related products from Thailand, China and other Asian countries. Not long since then, BSE and bird flu had been found in Japan. It is also reported that some of poison pesticides, which have been prohibited for long time, are again illegally used in Japan recent years. Paddy rice and other field crops in Japan failed because of low temperatures from the middle of May 2003. However, organically cultivated paddy rice avoided much of the damage by the abnormal weather. Pollution on vegetables by *E. Coli* and milk or meat poisoning scandals also happened with great shock in the whole country. However, the greatest problem of food quality in Japan is food contamination or food pollution by chemicals and heavy metals including the pesticide residuals and the dioxins that have derived from the pesticide residuals. The food contaminations by heavy metals released from industries have received great attention because many health problems such as Kanemi disease and Minamata disease have massively happened in the country. However, the problems caused by excessive uses of chemical fertilizer and pesticides are much neglected by the authorities and policymakers. Scientists tend to declare the safety of the modern pesticides instead indicating the problems of the pesticide residuals. Many chemicals, which have already prohibited to be used for food additives or containers, are still used in Japan so that the Minamata disease, the Morinaga arsenic milk case, and the Kanemi Yusho PCB pollution occurred in outbreak. Nakagawa et al. (1995) conducted examinations and reported high Japanese daily intakes of pesticides such as organochlorine pesticides such as exachlorocyclohexanes (HCHs), 1,1,1-trichloro-2,2-bis-(4-chlorophenyl)-ethane (DDTs), dieldrin (aldrin), heptachlor-epoxide (heptachlor), and hexachlorobenzenes (HCBs) from food such as cereals, vegetables, fish, fish products, meat, eggs, milk, and milk products.

Recognition from consumers, scientists and policymakers for the quality of organic food. Consumers often ask about the nutritional quality of organic food and authorities ask for the research data on the nutritional quality of organic food in comparison to conventionally grown food. Organic advocators claim organic foods are nutritionally superior over conventional foods because such foods contain higher levels of vitamins, minerals, and amino acids. On the other hand, the mainstream scientific community disputes these claims. Some just dispute with emotional feelings instead scientific evidence. Some are arguing that nutritional differences do not exist. One of the reasons for the disputation is quoted as "plants can't tell the difference between organic and chemical fertilizers" and "nitrate from chemical fertilizers or organic compost is the same for plants in any ways". However, these disputers forget one of the very simple evidences that the common chemical fertilizer contains only nitrogen, phosphorus and potassium and, if any, some other few minerals while organic fertilizers contain much more kinds of nutrients than chemical fertilizers. In addition to the contributions of the abundant macro and micro elements to the food quality, some small molecule amino acids can also be absorbed by plants and may contribute specifically to the food quality. Some disputers just do not want to find these evidences and do not want to show these evidences even if they are available for them. Some disputers ask for the scientific research evidences supporting the superior quality of organic food when they dispute. However, the situation does not allow the organic advocators to publish their data to a journal that is controlled by the disputers. One scientific society in Japan has once organized a symposium where a surrounding attack was attempted on the technology used in nature farming systems. Every scientist should know that soils in conventional farming systems are no healthier even though high yield can be obtained with high input of fertilizers and pesticides. "Healthy soil equals healthy food equals healthy people" is a fundamental tenet of many ecological farming systems.

6.1.5 Environmentally friendly agriculture in Japan

Organic agriculture and nature farming are seldom mentioned in Japan government documents both in publications and homepages. Instead, a terminology of "Environmentally Friendly Agriculture" is recommended in many of the agriculture related documents. As written in the government documents (the Laws of Environmentally Friendly Agriculture, the homepage of the Ministry of Agriculture and related institutions- www.maff.go.jp; www.niaes.affrc.go.jp) and cited by others (www.mate.pref.mie.jp/ kankyo/toha.htm; www2t.biglobe.ne.jp/ ~bono/ study/ report/envagri.html), environmentally friendly agriculture is called "Environmental Preservation Type Agriculture" if directly translated. The meaning of the definition is as follows. Environmentally friendly agriculture is a sustainable agricultural system where activated is the function of recycling that the agricultural system possesses and considered is the reduction in environmental impact from applications of chemical fertilizers and pesticides by improving the soil and paying attentions to the harmony with productivity. Encouragement should be expected but one cannot find where there is a difference in the definition of environmentally friendly agriculture from that of conventional agriculture. The definition looks like a diplomatic rhetoric rather than an explanation of the agricultural system. The reduction of the environmental impact or environmental load imposed by applications of chemical fertilizers and pesticides is considered. It is just to consider the reduction, reduction of environmental impact instead of the chemical fertilizers and pesticides. Encouragement from government to organic agriculture is much less than in

European and other countries. Organic story should be started from the incidence of pesticide poison killings of numerous warbler birds. A pioneer of organic rice farming in Ogata, Mr. Maeda, shock by the numerous young black-browed reed dying in agony along the rice field ridges. Mr. Maeda refused the helicopter aerial cover spray of an organic phosphate pesticide to control against rice leaf beetle. He began to seek ways to reduce chemical sprays as well as chemical fertilizers. In 1982, Mr. Maeda started his real organic rice production. Another organic pioneer in this village, Mr. Yamashita, developed a no-tillage rice-planting machine. Ten farmers with a soil scientist, Dr. Tanaka, initiated a study group called, “Ogata Low Input Sustainable Agriculture”, and started to modify and make no-tillage rice farming feasible. No-tillage created higher yields, better drainage, fewer suspended solids and less methane formation, and the population of red dragonfly, a beneficial insect, is eight times more over no-till fields than in conventional fields. Another practice for environmentally-friendly agriculture was adoption of green legume manure crop, the hairy vetch (*Vicia villosa* Roth). Without subsidies from government, profit margins for organic and environmentally-friendly farming have become smaller and quality factors and environment protection factors benefited from the environmentally-friendly agricultural practices such as no or less chemical fertilization, herbicides and pesticides as well as no-tillage and no-puddling are not reflected in retail price of rice. This is still one of the largest difficulties that organic farmers in Japan are facing now.

Technologies adopted into environmentally friendly agriculture in Japan include soil improvement, well-managed fertilization, improved cropping systems and integrated pest control. Soil improvement is referred to the soil environment improvement for the crop to extend its roots well and uptake nutrient properly by improving the physical, chemical and biological properties of the soil. In Japan, the adopted technology to improve soil physical properties includes field drainage improvement projects and applications of compost and other amendments. Nutrient leaching occurs easily in Andosol soil, the most of soils in Japan. Applications of zeolite and humic acid materials are adopted to prevent soil nutrient leaching. Composts, lime and micro nutrients are also used case by case of soils. Soil fauna such as earthworms, spiders, ticks, centipedes and other living things are protected by residual mulch and organic fertilizations. Crop diversity and antagonism between crops are adopted in improvement of soil biological properties. Nutrients are supplied in balance and organic fertilizers are used in additional to chemical fertilizers. Local application instead of spread scattering of fertilizer is adopted to improve the fertilizer efficiency. Crop rotation, legume manure crops, intercropping and antagonism between crops are adopted. Breeding and cultivation of resistant varieties is economically the most efficient. However, resistant varieties soon become susceptible with the appearance of new strains and races of pathogenic microorganisms or new biotypes of insects. Thus, biological control is adopted in addition to the proper pesticide application. In Japan, more than 400 active pesticide ingredients are used, and the total number of registered formulated products is about 6,000. The amount of pesticides sold on the domestic market is around 70,000 mt on active ingredient basis every year. In response to the consumers' demand, integrated non-chemical pest and disease controls are adopted in environmentally friendly agriculture. For example, pathogen inocula are used. Plant seedlings artificially inoculated with inoculum virus strains are subsequently protected from naturally-occurring virulent viruses. In Japan, much work has been done in order to select or to produce safe and efficient virus inoculants since L11a, a TMV virus inoculum, was first developed. Another example is solar sterilization of greenhouse soil to reduce the incidence of soil-borne plant pathogens. Sterilization of soil by solar heating in a closed vinyl house is widely used during summer in the south-western part of Japan, where many vegetables are cultivated in vinyl houses from September until the following June. The soil is piled into 30 cm high ridges and mulched with transparent polyethylene film with high soil moisture maintained. The greenhouse is kept empty and closed until the end of August.

6.2 Organic movement and nature farming activities in Japan

6.2.1 History of organic farming

Organic farming concept dates back to 1900', when Sir Albert Howard, a British colonial officer in India with the title of Imperial Chemical Botanist, carried out agricultural experiments. He found that the factor most important in soil management was a regular supply of compost prepared from animal and vegetable wastes and concluded that crops have a natural power of resistance to infection. Returning to England in 1931, Albert became known as the pioneer of the organic movement. Organic farming as a definable production system dates back to the 1930s and 1940s. Prominent pioneers such as J.I. Rodale, Sir Albert Howard, Lady Eve Balfour, and Rudolf Steiner advocated organic farming methods on the basis of biodiversity and a healthy soil, just when commercial fertilizers and pesticides were first adopted by growers. Their organic philosophy suggests that natural products for food production are desirable and synthetic ones are not; and healthy soils lead to healthy plants that resist pest attack, while healthy plants lead to healthy animals, including people. Rachel Carson, a biologist and ecologist, published her Silent Spring in 1962, challenged the practices of agricultural scientists and the government, and called for a change in the way humankind viewed the natural world. Then the consumers became aware of issues regarding modern farming practices. Some consumers began searching for food products grown with the organic farming. The environmental awareness of the 1970s led to increased demand for organic foods. This also led to the development of the early organic certification systems. In 1972, the International Federation of Organic Agriculture Movements (IFOAM) was founded in Versailles, France. Roland Chevriot, the former president of Nature and Progress and other several persons led the initiative. They aimed to establish a communication network among organic agricultural communities that had appeared in several countries.

6.2.2 Demand for nature farming or organic agriculture in Japan

Agriculture in Japan is the most intensive in the world and the energy consumption per hectare is 46,400 MJ ha^{-1}, three times higher than the world average of 1,734 MJ ha^{-1}. Fertilizers are applied with nitrogen 88 kg ha^{-1}, phosphate 85 kg ha^{-1}, and potassium 100 kg ha^{-1}. Fertilizations with these high rates are leading to not only degradation of food quality, but also pollution of the environment. The unsustainable nature of conventional agriculture is manifesting itself in terms of stagnant or declining yields, increasing ecological degradation, and worsening rural socio- economic conditions (Lucas and Debuque, 1993). Social problems such as family disputes over farm resource use, migration and family breakdown, have been exacerbated by conventional agriculture. Self-reliant local agricultural economies have been broken up as farmers were encouraged to produce crops for external markets.

The demand for alternative agricultural systems has grown in response to the failures of conventional agriculture. An increasing number of Japanese growers are trying organic methods and have succeeded in production of rice and some other vegetable crops with a close productivity to those of their chemical-using neighbours. In many cases, organic farmers follow “a natural crop calendar” in harmony with the seasons and produce tastes much better than that grown with chemical inputs, although the yields are usually 15% to 20% lower and the products often have insect holes, which are instead preferred by the consumers with higher prices. About 150,000 to 200,000 households in metropolitan Tokyo regularly eat food produced without or with reduced uses of chemical fertilizers and pesticides. Some schools and restaurants also have switched to organic food, and at least one sake brewery claims to use only organically grown rice in its premium brand. The total number or organic food consumers throughout Japan may be as high as three to five million -- about 3% to 5% of the population. Under the country's "*teikei*" systems, consumers have actually entered into "co-partnership" with commitments to buy organic produce and even volunteering to help with harvest and other field work. In Japan, organic food is distributed in three primary ways: 1) "Teikei" system of farmer-consumer cooperation as described in the previous chapter, 2) Post delivery system (Some systems have evolved into multi-billion yen operations that receive produce from 3,000 or more contract farmers located throughout the country and distribute to 10,000 to 35,000 households weekly), and 3) Organic food retails (in the Tokyo megalopolis there are about 150 retail outlets selling organic foods in recent years).

Because of a large demand of organic produces from consumers in Japan and a relatively low boom of organic production, organic agricultural products are being imported in large scales from China. Nichirei, a large frozen-food importer in Japan is selling frozen organic vegetables from China in supermarkets nationwide this spring. Nichirei has reduced the prices by contracting with local Chinese vegetable farmers and processing the final product in China. Similarly, the leading supermarket retailer JUSCO has begun selling frozen spinach, green asparagus, onions, and broccoli, in addition to the chicken and meats, imported from China. Both the raw materials from the Chinese farmers and processed products are certified under Japan's new JAS organic standard. The United States has negotiated with Japan government on an interim agreement, in an effort to ensure that U.S. exports of organic products to Japan are not interrupted due to Japan's new requirements on organic products standards and third party certification by Japanese certifiers, which went into effect on April 1, 2001.

6.2.3 Governmental policies for organic agriculture

Up to now, national research institutes have paid little attention to organic farming and always considered food productivity and food self-sufficiency as top priorities and organic farming to be a passing phase, without any support in organic farming research. Only when organic farming was on the increase, did agriculture authority issue guidelines describing farming practices necessary for a grower to label produce "organic", with the aim to protect consumers from false advertising instead of supporting organic farmers. Although without willing to support organic agriculture, Japan government has tried to use organic principles and standards to cut down the import of agricultural produces from overseas. Agricultural and environmental policies, especially those responding to food safety concerns, play a large role in facilitating or hindering the adoption of organic agriculture. As in some European countries, from these policies come out the financial support to the organic conversions and regulations protecting the claim of organic producers, the public investments in research and the technical training. The main factor limiting organic agriculture development is its reliance on knowledge. In Japan, extension personnel rarely receive adequate training in organic methods and organic agricultural research is under-funded. Ultimately, the development of technical progress will determine the evolution of relative profitability of food systems. The increasing demand for certified organic foods entails a great capacity to respond to traders, retailers and consumers' needs in terms of quantity, regularity and quality of supply. Suppliers must be able to demonstrate that their products comply with organic standards. The establishment of reliable certification and accreditation systems requires advanced legal and technical knowledge and organizational skills. Active support to inspection and certification is necessary to facilitate the participation of farmers, and especially small holders, to the benefits of the organic system. Up to now, there has been no any financial support from the government for both the organic farmers and certifiers. Most of the certifiers in Japan are private corporations and some of them cannot support themselves by the profits from the certification as a business. Some certifiers have to move their business to overseas countries, help the overseas farmers to develop their organic products and in many cases help the overseas organic producers to export their products to Japan. In a sense, this increases the competition between the domestic and overseas organic producers. Japan government should support the domestic organic producers to increase their competition ability instead of trying to cut down the import, which is not feasible in today's internationalized global situation. With adequate support from the government, this global competition, which organic agriculture in Japan is facing in, will lead to increasing organic demands and high production efficiency.

6.2.4 Organic movement in Japan

As defined by IFOAM, organic agriculture is an agricultural production system that promotes environmentally, socially and economically sound production of food and fibers, and excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, livestock feed and additives and genetically modified organisms. Farmer use both traditional and scientific knowledge in organic agricultural systems and the practices should promote and enhance biodiversity, biological cycles and soil biological activity. Organic agriculture is based on minimal use of off-farm inputs and on management practices that restore, maintain or enhance ecological harmony. The purpose of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people. The definition and principles of organic agriculture are similar those of nature farming in Japan.

As a part of the global proliferation of alternative strategies for environmental, social, and personal transformation, the Japanese organic agriculture movement has its roots in the social upheavals of the 1960s against war, pollution, corporatism, and sexism. In Japan, if one talks organic agricluture, he usually includes nature farming crop and husbandry production. Organic produce is finally taking root in Japan, years behind Europe and the

United States, owing to a recent series of food safety scandals. The outbreak of mad cow disease in September 2004 had a profound impact on consumers. Japan became the first Asian country known to harbour BSE, or mad cow disease, triggering a nationwide health scare. People are looking for safe food and shops selling natural food are becoming popular. Many people get interested in organic food because they want safe food for their children. A farm ministry survey of 2,300 households published in 2005 found that food safety had overtaken price, a balanced diet and taste as the most important consideration for Japanese consumers. Organic vegetables account for only 0.1 percent of vegetable production, 0.04 percent of fruit, 0.09 percent of rice and 0.43 percent of soya production. Processed organic foods such as fruit juices and cereals, meanwhile, have to be imported from Europe, Mexico and the United States because it would be too costly to produce them domestically. Integral to the success of the Japanese organic farming movement are the networks of grassroots organic foods distributors, retailers, and new consumer food cooperatives, many of which were established in the early 1970s.

6.2.5 Movement against GMO (Genetic Modified Organisms)

Organic movement participants are not denying the fact that uses of chemical fertilizers and pesticides have increased world food production and will be continually adopted in a large scale in future. However, agricultural or biological science and industry should not go far away from the environment and biodiversity protection. For example, GMO (genetic modified organism) is one of the modern achievements of the agricultural or biological science and industry. Genes in a species are transformed from and to another species, even from animal or microorganisms to plant. Recently, the benefits and risks of GMO are actively discussed and argued worldwide; especially many real and imaginary risks of GMO are indicated. In Japan, only in this aspect as against GMO, governments and the related authorities go together with the organic movement participants. It does not mean that governments are supporting the organic movement. GMO is a green lift for Japan government and agriculture authorities to control and minimize the import of agricultural products. Moreover, only the GMO abroad has received attentions from the authorities and government agency continues to invest large quantities of money to support the research and development of GMO. Before organic movement take action against GMO, first the risks of GMO should be elucidated to those who are interested or involved in organic agriculture movement.

Definition of GMO. In a broader sense, genetic modification include the conventional genetic modification such as selective crossbreeding and hybridization, biological genetic modification such as interspecific and intergeneric protoplast fusion, in vitro gene transfers, somaclonal selection, haploid doubling, and artificial mutagenesis (McHughen, 2000). In the broader scientific sense, virtually all the agricultural crops have been genetically modified overtime. However, adopted or accepted definition of genetic modification is the process where the genetic material is altered anthropogenically by means of gene or cell technologies. These technologies refer to 1) gene transfer, including isolation, characterization, and modification of genes and introduction into living cells or viruses, and 2) production of living cells with new combination of genetic material by the fusion of two or more cells (ICES, 1995). Here, the most important is that first we should make it clear what GMO (genetic modified organism) is in a correct definition. A genetic modified organism is an organism (a plant or an animal) or microorganism in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination. The keyword here is “naturally”-natural mating or natural recombination. Naturally, the higher plant corn can not mate with a bacterium. Therefore, Bt corn is a GMO. Genes in animal mouse was transferred to potato plant and the shape of the potato looks like a mouse. No need to mention again, the mouse potato is a GMO. With a similar genetic engineering technology, a gene for powdery mildew resistance in a cucumber plant can be transferred to another cucumber plant that is susceptible to powdery mildew disease but holds other many good agronomic traits. Consequently, a good variety with high disease resistant ability can be bred by genetic engineering. Of course, this kind of variety can also be bred in a normal field breeding procedure by crossing two varieties of the same species, and it can also be selected in natural field environment because two varieties of the same species can mate naturally. The difference in breeding between genetic engineering and normal field cross or selection is in the time to get a desired variety. As mentioned at the beginning, we should know the correct definition of GMO. In the EU regulation, the concept of GMO generally refers to an organism — whether a plant, an animal or a micro-organism (bacterium, fungus, yeast, etc.) — that has been produced using modern biotechnology, including recombinant DNA technology. This is essentially the definition used by the EU in its regulations, and by the Codex Alimentarius in its "Draft Principles for the Risk Analysis of Foods Derived from Modern Biotechnology", which is submitted for adoption by the FAO/WHO Codex Alimentarius Commission at its next meeting in Rome in July 2003. If the definition above was used, the powdery mildew resistant cucumber as mentioned above would also be a GMO no matter the mating and crossing between two cucumber varieties can occur naturally. The problem of the EU’s definition is in the misunderstanding of the biotechnology or specifically the genetic engineering. It seems that the fault is in biotechnology instead in GMO. In addition, the biotechnology is too broad that it does not only include genetic engineering.

The US Department of Agriculture includes chromosome manipulation and interspecific hybridization in their definition of techniques applied to organisms that should be subject to performance standards for genetically modified fish and shellfish (ABRAC, 1995). The Fisheries Department of the Food and Agriculture Organization and the International Center for Living Aquatic Resources Management support an even broader definition of GMO that would include any genetic manipulation, including selective breeding, hybridization, sex reversal and chromosome set manipulation as well as the modern biotechnologies of gene transfer (Pullin and Bartley, 1996).

Regulations in Canada under the Food and Drug Act use a further broader definition. As the act says, a GMO includes an organism that exhibits characteristics that were not previously observed in that organism, regardless of the method used to obtain the new characteristic. It means that this definition covers more than just transgenic organisms. The Round-Up Ready® canola is a transgenic variety, while a Clearfield® herbicide-tolerant canola is a variety produced by chemical mutagenesis without transferring genes from one species to another. The problem in the definition of Canada’s act is in the keyword of “characteristics that were not previously observed”. Scientifically, mutagenesis can occur naturally. Some mutation occurs in extreme environment such as high UV irradiation, extreme temperatures, salinity, drought, etc. In aspects of mechanism, there is no distinct line between 'traditional' plant breeding techniques, through which the human being has been doing the selection for thousands of years, and the intraspecies or within-species breeding with the modern genetic engineering. However, genetic engineering to move genes across genera and families, and between animals and plants, is completely different from the traditional breeding.

GMO different from genetic engineering technologies.

The organic agriculture movement acts against GMO. However, organic agriculture should not reject a variety, such as the powdery mildew resistant cucumber as mentioned above, bred by genetic technology in a way that does occur naturally. Genetic engineering is only a technology and itself is not harmful to nature and organic agriculture. Instead, organic agriculture should use genetic engineering technology to solve problems in organic crop production. For a long time, human beings have spent a lot of time to develop modern agricultural technologies but many are done in wrong ways. If the money, the labour and the effort, which have been used to develop and make pesticides, other chemicals and related technology, were used to develop biological technologies for agriculture, many high-yielding and high-resistance varieties would already have come out of the modern scientific technologies. For example, crop plants can fix nitrogen more effective than ever from the atmosphere instead of dependence on chemical fertilization. Many effective natural enemies (predators and parasitoids) of pest insects would have been bred, selected and conserved for pest control. More effective nitrogen-fixing algae and microbes would have thrived in agricultural systems.

The real risks of GMO.

Moving genes across genera or families, and between animals and plants, may give rise to unanticipated interactions within the genome with unknown effects. The real risks of GMO can be summarized as follows.

1) The most serious environmental risk is the transgenes escaping from cultivated crops into wild relatives or contaminating organic varieties on nearby farms. Genes from existing inorganic crops can escape to wild relatives and organic crops, and vice versa. For example, implanted genes with herbicide resistance will escape from cultivated crops into wild relatives and create super weeds. Even self-pollinated crops, such as rice, wheat and beans, will cross with wild relatives. Such risks are higher in developing countries, where wild relatives are common and cultivated land is far more mixed with uncultivated land than in the developed countries.
2) If plants containing genes from viral pathogens that confer resistance to these same pathogens, expressing the viral genes in plants somehow disrupts the virus infection process. Nevertheless, exchange of these genes with other viral pathogens may be possible, creating entirely new virus strains with unknown properties.
3) There is a potential for pests to evolve resistance to the toxins produced by resistance genes, such as Bt genes. There might be even more problems with the induced resistance. Introduction of Bt into a wide range of crops implies a much higher selection pressure than from spraying the insecticide on a single crop. It is better to use *Bacillus thuringiensis* as an insecticidal spray than to introduce the Bt genes into crops.
4) Toxins produced by Bt genes also kill other insects. The research has shown that pollens from Bt corn kill caterpillars of the Monarch butterfly. Bt toxin may remain active and persistent in the soil like the pesticide residuals. Therefore, effects of Bt crops on the environment cannot be neglected. However, microbial Bt is a safe biological insecticide since it mostly kills pest caterpillars leaving beneficial insects unharmed, and consequently it is used as in integrated pest management programs.

5) The most possible health risk is that GM crops carrying antibiotic genes used as markers may generate antibiotic resistance in livestock or humans.
6) Transgenes may increase allergies, through the inadvertent transfer of allergenic proteins, as occurred in the transfer of a gene from Brazil nut to soybean.

The imaginary risks of GMO

Other many risks might exist even though they have less scientific basis. It is called imaginary risks here.

Damages to physical health. Since the toxins produced by Bt genes kill a live insect, a lower animal, it might be harmful to human, a higher animal. Scientists have shown more than a thousand scientific studies to assess the effects of GMO foods on physical health and repeatedly that GMO foods do not harm human health. However, all the health-related studies on GMO food have been conducted on animals, and almost all by the biotech companies themselves. Actually, there is no one of evidence that GMO food harms human health because no studies have been done on human body. A dog or a mouse cannot be sick or die after it drinks dirty water on the roadside but human would be sick even dies without medical treatment, if he drank the dirty water on the roadside. No harm to a dog does not mean no harm to human. It might also kill other insects and animal and it might harm to human in some unknown ways. In other words, it might hold unknown and potentially dangerous characteristics that could potentially destroy biodiversity and lead to widespread damage to the environment and human beings.

Escape and drift of genes. Some studies have shown that genes implanted to another species may drift and escape out to other species and create one more species characterized by the escaped genes. For example, the genes of herbicide resistance can escape out and drift into a wild plant and create a super weed. Genes of mouse have been implanted into potato and a mouse-shaped potato has been bred. Is there a significant meaning to breed a mouse-shaped potato? Is it worth for a scientist to spend a lot of money to do this kind of things? Genes from a mouse can be implanted into a potato and it also can be implanted into human being. Implanted genes can escape and drift into other species and so the genes may drift into human being. It is no doubt that no one likes a mouse-shaped baby.

Effects on environment. Corn that has been genetically modified as Bt corn to act as an insecticide, poisoning the insects that eat it, is not equivalent to a conventional corn. Bt corn may kill other insects and animals and consequently destroys the biodiversity and the balance of the food web in nature.

The balance of benefits and risks

Consumers gain no benefit from the GM food currently available, neither for European consumers nor for American consumers. The benefits all go to the American farmer and to the biotechnology companies. Although there are environmental benefits as caused by decreases in pesticides application, consumers concern more about other risks, among some are real and some are imaginary. In spite of worrying about the GMO, more biotechnology products or new transgenic plants are already created by biotech companies and university laboratories. These crops are characterized by better flavor and appearance, greater shelf life, improved nutritive value, and stronger pest resistance. The questions whether or not the implanted genes are stable and from where the genes are introduced. It should be discussed and scientifically tested whether the consumers should or should not accept the new products.

Need for tests and evaluation

In order to gain a better assessment of benefits and risks, appropriate scientific tests must be conducted independently. For example, in the case of the vitamin A rice we need to ask a series of critical questions. What levels of intake are needed for children to obtain sufficient vitamin A from a diet based on rice? Is there a danger of excessive intake? Is there a risk associated with excess intakes of beta-carotene or vitamin A? Are there any other potential health hazards? Could an allergy have been transferred. It is also needed to know what effects the beta-carotene might have on the environment, for example, will it affect the insects that suck the grain? If beta-carotene gets into the grain of wild rice, will it persist and will it have any significant effect? Another example is the mouse-shaped potato. Do the genes drift or escape from a species to another species and affect human being ultimately? The developed countries are clearly better equipped to assess such hazards, if any. A crucial need is to provide the necessary training in bio-safety for the developing countries.

6.3 Nature farming activities in Japan

There are many research organizations, farmers, food processors and dealers working specifically following nature farming principles. The activities include fundamental research, plant breeding, education and training, international cooperation, organic production, food processing, and organic food certification.

6.3.1 Fundamental research

Fundamental research has been conducted at the Agricultural Experiment Station of International Nature Farming Research Center (INFRC). The projects involve pest and disease control (Xu, 2004), soil and plant nutrition

(Xu et al., 2003), soil fauna (Fujita and Fujiyama, 2000; Aryal et al., 2003), paddy management and weed control (Iwaishi and Umemura, 1999) and plant breeding (Nakagawara, 2000; Xu et al., 2000). Every year, several visiting scientists from China and other countries come to work at this station. As supervised by Dr. Hui-lian Xu and other senior researchers, the visiting scientists have done a lot of good research every year in various areas of nature farming system and sustainable crop production. Some achievements are summarized in the book entitled Nature Farming and Microbial Application (Xu et al., 2000), published in scientific journals (Aryal et al., 1999; Fujita and Fujiyama, 2001ab; Wang et al., 2000; Xu et al., 1998; Xu et al., 2004) and presented at several conferences. At other three experimental farms located in Nagano City, Chiba Prefecture and Kyoto Metropolitan that run by INFRC, some applied research has been conducted and every year a workshop to discuss the research is held in the Agricultural Experiment Station or in the head office of INFRC. Applied research is also conducted on Ohito Experimental Farm and other two experimental farms run by MOA Nature Farming Institute (MOA). Research about nature farming practices adapted to cold weather is conducted at Experimental Farm in Hokkaido Prefecture.

6.3.2 Plant breeding

Activities of plant breeding include collections of local seed resources. The crops are grown in nature farming field with little fertilization to select the varieties that can grow better in organic conditions without much fertilization and pesticides. Plant breeding is conducted at both INFRC Agricultural Experiment Station and MOA Ohito Experimental Farm. Especially, about 100 good varieties of various vegetables, upland cereals and paddy rice are released from INFRC Agricultural Experiment Station. These varieties are adapted to nature farming conditions and show high quality with reasonable yield. For Example, a cucumber variety ‘Kamikochi’ bred by INFRC is highly resistant to powdery mildew. Its fruit yield is similar to the conventional popular variety ‘Nankyoku 1’ under organic fertilization although lower in chemical fertilization. Even at the same fertilization, ‘Kamikochi’ shows lower accumulations of nitrate and amino acids but higher nitrate reductase activity in the leaf compared to the conventional ‘Nankyoku 1’. Low nitrate accumulation is not only positive with the fruit quality but also positive to the disease resistance. Many delicious pumpkins, tomatoes, lettuces, cabbages, radishes, green peppers, and carrots are released in this research station and are being distributed to the farmers.

6.3.3 Soil analysis and evaluation for farmers

Excellent equipment, such as gas-mass chromatography, high performance liquid chromatography, for soil analysis and for food quality evaluation were introduced to INFRC Agricultural Experiment Station and the MOA Applied Microorganism Institute. The technicians working on extension and education for farmers collect soils from the organic farmers over the country and send the soils to the laboratory for analysis. The nutrient conditions and the pesticide residues are analyzed in laboratory and the data are reported to the farmers. Qualities of vegetables and rice are also evaluated in the laboratories.

6.3.4 Education and training

Agricultural Experiment Station was established in Matsumoto-City Suburb in Nagano Prefecture by International nature farming Research Center (INFRC). An experiment farm for nature faming was established in Ohito Town in Shizuoka Prefecture by the original un-separated INFRC and now run by the MOA Nature Farming Research Institute with the MOA Nature Farming School on this farm together. Not only fundamental and applied research is conducted but also education and technical training are programmed at these research stations and experimental farms, At the Agricultural Experiment Station and on Ohito Farm, education courses of nature farming are conducted at different levels and scales for youngsters and farmers. The courses include lectures on general agriculture and on nature farming, laboratory experimentation in biology and soil analysis, and off-site training. Lectures are given by active and retired university professors and research staff from testing laboratories, as well as by researchers and technicians at the station or on the farm. Field studies include the production and use of compost and training in the use of agricultural machinery. These are in addition to practical training in nature farming cultivation, principally of vegetables and paddy rice. Training graduates are now active as producers, researchers and businesspersons both locally and abroad.

6.3.5 Production, processing and marketing of nature farming products

About 0.1% of the Japan total farmers are producing crops strictly following nature farming's principles. They get technical advices from the workers of INFRC and MOA organizations. Organic marketing has not developed to an enough high level for organic farmers to sell their products. Organic farmers sell their products through home-delivery and some small stores specific for nature farming products. Under the supervision and financial support of SKK, several companies, such as Zuiun Co. Ltd. do business of organic food processing and marketing. Production and marketing of nature farming or organic products are managed in different ways from the conventional agriculture. Because there is no one marketing system for organic products, the farmers of nature farming or organic farming and their policy promoters and food processors create a special system that is called "Teikei" in Japanese means "co-operation". The *Teikei* movement suggests local self-sufficient, a local unit where the food consumed is produced and processed within the area, independent from the national and world marketing chains. There are about 1,000 consumer groups that are directly connected with producers of nature farming or organic farming in the *Teikei* relationship across the country. The groups vary from less than 10 to more than 5,000 households. However, the *Teikei* movement faces several problems. On the consumer's side, some consumers do not like the complicated delivery system and prefer to buy in the easier market. On the producer's side, the leading growers are aging and the young generation does not like to work in agriculture. Nevertheless, *Teikei* system is helping promote nature farming and organic agriculture in Japan. As more and more agricultural produce is imported, some of agriculture policymakers try to stop the green invasion and protect Japan’s food production capacity. The local *Teikei* system helps waken people’s concerns over the environmental and food pollution problems. *Teikei* is about the process of creating a new culture, a culture not restricted to the profit motive. Starting with food and a critique of the present food system, a system is leading to the realization of the need to build a society based on emerging values. In co-partnership arrangements, the consumers tell the farmers that they can set their own prices and they will accept the delivery of all the produce grown. Respecting the consumers, the farmers set a fair price and try to grow only the amount of produce they feel appropriate for the number of consumer members in the co-partnership. This proves that humans are not inherently profit-oriented and proves that new human relations based on mutual trust, respect, and understanding can be realized.

6.3.6 Organic certification

The seal for organic agricultural products is called JAS Organic Label and organic certification program was introduced to JAS law in 2000. JAS means Japanese Agriculture Standards. Some private organizations have once been involved in the labeling business before the new JAS organic law comes out but they work for their oriented producers and processors. The revised new JAS law changes the practices of JAS labeling and allows the appointed organizations, the accredited certifiers, to do labeling. In this system, full responsibility for use of JAS seal belongs to the growers or manufacturers who are certified by accredited certifier. Certifier's responsibility is to monitor the quality management system of the growers, manufacturers, repacking operators or importer in accordance with JAS requirement.

International Nature Farming Research Center and MOA Nature Farming Institute are both the accredited certifiers (Fig. 7). There established a department specific for organic certification in INFRC and hundred of farmers have been certified as legal organic producers with their products labeled a JAS mark. The JAS mark certified by INFRC is as follows. The upper part is the same for all certifiers but the lower part is the shortened name for the certifier organization. Here the lower part in Japanese means International Nature Farming Research Center.

Figure 7. A JAS Mark- Seal for certified organic products.

6.3.7 International communications

International Conference for Nature Farming and Microbial Technology has been held once two years from 1989 in Thailand, Brazil, USA, France, South Africa and New Zealand. Research papers presented were formally published as proceedings (Parr et al., 1991, 1994, 1996, 1998; Senanayake and Sangakkara, 1997). There are about 200 scientists and related persons from more than 50 countries who have attended the conferences. Most of the attendants are in collaboration with INFRC. An organization for regional collaboration is established as Asia-Pacific Nature Agriculture Network (APNAN) with its head office in Bangkok, Thailand. As written in its homepage (www.apnan.org), APNAN is a small organization or network in relation with nature farming and Higa's EM technology. After the First International Conference on Kyusei Nature Farming, held in Thailand, the 13 countries in the Asia-Pacific region, ranging from Pakistan across Asia to the East Coast of the USA formed the network APNAN, with the objective of testing the scientific validity of the technologies offered at the conference in their respective ecosystems. Now, the activities of APNAN have spread across Asia, organized the International Conferences on Nature Farming in France, Thailand, South Africa and New Zealand, and hosted smaller meetings in Thailand and neighboring countries. Today APNAN has contacts in all continents and conducts training programs to the international community in activities related with nature farming and EM Technology. The spread speed of EM around the world is amazing as it grows exponentially. Now in about 160 countries, EM is being used in agriculture and environment management. One can surfer lots of information off the net. The quality of the research happening in Germany and Holland is high top scientists from universities and government research organizations have worked on EM and showed both positive and neutral results. There are also many branches of SKK in other countries than Japan, Thailand, USA and Brazil. SKK branches there establish public foundation for nature farming promotion, for example, the Mokichi Okada Foundation in Brazil and Nature Farming Training Center in Thailand. Recently, INFRC collaborated with universities, research institutes and local governments in China for nature farming promotion. INFRC also invites scientists from China, Bangladesh, Nepal and India to do visiting research in the Agricultural Experiment Station. There are also some technicians from abroad to take part in short period visiting training in this station.

6.4 History and versions of nature farming

6.4.1 Chronological history of nature farming and Okada's philosophy

1882 Mokichi Okada was born in Tokyo on December 23.

1897 Mokichi Okada was admitted to Tokyo School of Fine Arts, left the school six months later due to his eye problem, and began studying gold-inlay lacquer techniques on his own.

1905 *Korindo*, a notion store was opened by Okada in Tokyo.

1907 Okada started his business of accessories wholesale in Tokyo.

1919 Okada's wife died of an immature birth of the baby who died too and Okada began experiencing a great financial difficulties after his remarries.

1920 Okada became aware of the existence of the spiritual world.

1926 Okada received revelation from God regarding his predestined task of creating a true civilization

1934 Okada developed *Johrei* medical art and began the practice and promotion activities

1935 Okada established Japan *Kannon* Society (*Dai Nihon Kannon Kai*) to advance the work of creating a true civilization and at this time he advocated his philosophy of nature farming. Okada first spoke of his ideas concerning agriculture.

1936 Okada started growing vegetables and raising chickens at his Tokyo residence.

1939 Fertilizer-free cultivation of vegetables was first practiced by Mokichi Okada.

1942 Okada cultivated rice without fertilizer uses and he elucidated the principles of nature farming in his publication entitled "Tubercular problem and the solution".

1944 Okada moved the head office of *Kannon* Society from Tokyo to Hakone and purchased properties of land and others in Atami. He commenced full-scale activities trying to create a new civilization after World War II. Okada expended his trial of no-fertilizer crop cultivation.

1948 Okada's first thesis on "Fertilizer-free Agriculture" was released and published in "Terrestrial Paradise".
1949 Okada published his thesis entitled "No-fertilizer cultivation in home garden" in the journal of "*Hikari*", and another thesis "No-fertilizer cultivation methods" in the special issue, Agriculture Thematic Issue, of *Hikari*. In these thesis, elucidated his nature farming philosophy as 1) use only compost for fertilization, 2) no fertilizer, no pests, 3) chemical fertilizers make the soil lose its original activities and become dead.
1950 The name "Fertilizer-free Agriculture" was changed to "nature farming". Okada published many articles about nature farming, such as "great revolution of agriculture" and "the victory of nature farming cultivation-the principles of nature farming", in the thematic issues of some newspapers and journals related with SKK.
1951 Mokichi Okada began a correspondence with the famous American naturalist J. I. Rodale. The pocket version booklet "Introduction to Nature Farming" was published. Nature Farming Department was established in SKK.
1952 Okada published his article "the surprise of nature farming" in a nature farming thematic issue. Hakone Museum of Art was opened. A ground project for *Shinsenkyo* was completed in Hakone and Society for Nature Farming Extension was founded.
1953 The Association for Nature Farming Promotion was established.
1954 Construction of *Kyusei Kaikan* (Salvation Hall) (the head office of SKK up to now). The first issue of the journal "Nature Farming Research" was published.
1955 Okada passed away in Atami at his age of 72. The booklet "Twelve Months for Nature Farming Practices" was published.
1956 In the whole Japan, 53 farms for nature framing crop production were established and managed by the nature farming extension stations.
1957 A 650-m^2 nature farming experiment field was established in the back yard of the SKK Hall.
1959 A workshop of nature farming was held with 64 attendants from the whole country.
1962 The *Shumei* Group began growing vegetables with nature farming method on Kishima Island as its youth activities.
1964 The first meeting of Nature Farming Extension Society was held.
1969 The Nature Farming Extension Society was dismissed.
1970 Nature farming farm was established in Thailand. *Shumei* Group and its Branches became an organization independent from SKK and "*Shumeikai*" was renamed as "*Shinji Shumeikai*". Then, Research Committee of Nature Faming was established

1971 The Integrated Institute for Environmental Science was founded with support by SKK.
1972 The First Nature Farming Exhibition was held. A nature farming farm was established in Nanakuli, Hawaii, USA.
1975 A nature farming farm was establish in Camarillo, CA, USA
1976 The first workshop for nature farming technicians was held.
1979 A nature farming farm was established in Atibaia, Brazil.
1980 Mokichi Okada Association (MOA) was founded. The fist summer nature agricultural products exhibition was held.
1982 International Nature Farming Development Center and Ohito Experimental Farm were founded and established. MOA Museum of Art opened and construction of *Zuiunkyo* grounds in Atami was completed. *Tomei* Society for the Preservation of Art Objects was reorganized by government as MOA Art and Culture Foundation.
1983 EM (the effective microorganisms) technology proposed by Dr. Higa was adopted to nature farming systems and the related research and experiments were started.
1985 International Nature Farming Development Center was recognized by government as a public-service foundation and it was formally named as International Nature Farming Research Center (INFRC). A nature farming training station was established in Nagano city.
1986 Dissemination of EM technology was commenced and an experimental farm was established in Okinawa.
1987 The first meeting of Symposium for Food, Agriculture and Soils in Consideration, a successive conference, was held in Tokyo. Nature Farming Producers' Cooperatives was established by MOA group who were separated from INFRC and Standards for Nature Farming Systems and Practices was published.
1988 A nature farming farm was established in Saraburi, Thailand and the first issue of Nature Farming Newsletter was published.
1989 The first International Conference of Kyusei Nature Farming and EM Technology was held on October 17-21 in Khon Kaen, Thailand and 201 individuals as delegates for 13 countries attended the conference. Brazil Nature Farming Extension Center with a 170 ha farm was established in Rio Claro. California Nature Farming Research and Development Center with an 80 ha farm was established, USA. Kyoto Experimental Farm of International Nature Farming Research Center was established.
1990 Agricultural Experiment Station of INFRC was established with Dr. Hiroshi Umemura, a soil scientist, as the director. The Asia-Pacific Nature Agriculture Network was open with the head office in Thailand and the first meeting was held in Atami city.

1991 The Second International Kyusei Nature Farming Conference was held on October 7-11 in Brazil with 83 attendants from 17 countries over the world. The EM Institute of INFRC was opened. The completion symposium for the buildings of Agricultural Experiment Station of INFRC was held with the headline of “Another Choice for Future Agriculture”. MOA Federation of Diet Members for Contemplating Food and Agriculture and Protecting the Global Environment was established. World Sustainable Agricultural Association (WSAA) and MOA Kyushu Life Science Institute were founded.

1992 Nature Farming Committee of *Shinji Shumeikai* was established and a nature farming conference was held in Shiga, Japan. The first issue of "Natural Agriculture News" was published.

1993 The Third International Kyusei Nature Farming Conference was held on October 5-7 in the United States with 225 attendants from 16 countries.

1995 The Fourth International Kyusei Nature Farming Conference was held on June 19-21 in France with 169 attendants from 24 countries.

1996 Dr. Hui-lian Xu was involved to International Nature Farming Research Center, then signed as the deputy director of the Agricultural Experiment Station, and started a series of fundamental research on nature farming crop production and EM technology. A delegate from *Shinji Shumeikai* visited the Rodale Institute in Pennsylvania and set up a collaboration relationship.

1997 The Fifth International Kyusei Nature Farming Conference was held on October 23-26 in Thailand with 86 attendants from 29 countries.

1998 *Shinji Shumeikai* and The Rodale Institute signed formal documents to establish a partnership. Then a workshop for program directors was held at The Rodale Institute in Pennsylvania. Dr. Linda Sanders, Dean of the College of Environmental Studies at the California State Polytechnic University in Pomona visited Misono and Kishima Island. A nature farming research project was begun at the College of Agriculture, California State Polytechnic University in Pomona. The workshop involving *Shinji Shumeikai* was held at Rodale Institute, Pennsylvania.

1999 The Sixth International Kyusei Nature Farming Conference was held on October 28-31 in South Africa with 156 attendants from 36 countries over the world.

2000 International Nature Farming Research Center was recognized by Japan government as an organic food certification body.

2002 The Seventh International Kyusei Nature Farming Conference was held on January 15-18 in New Zealand with 231 attendants from 30 countries.

6.4.2 Different versions of nature farming in Japan

It is not very clear when the terminology came into Japanese language. The term 'nature farming' is much better than 'organic farming' in fitting the meaning of a sustainable agriculture system. However, one can find several versions of nature farming in Japan in the documents and on the internet. There are many organizations in Japan to follow Mokichi Okada's philosophy as one of their religious activities and promote nature farming as one of their religious activities. In addition to Mokichi Okada's nature farming, Fukuoka's nature farming is also popular in Japan and over the world. There are also many people are doing the same thing to promote organic crop production but they call themselves not organic promoters but nature farming followers. There are also some organizations such as Japan Organic Agriculture Association and IFOAM-Japan (International Federation of Organic Agriculture Movement-Japan). They also do co-operate with nature farming followers.

Kyusei nature farming and MOA nature farming

There are many of Mokichi Okada's followers in Japan and over the world. Some of them are practicing nature farming successfully on a farm scale, while some just worship his philosophy in connection with the religion of *Sekai Kyusei Kyo* (SKK), which was founded by Mokichi Okada. Okada's followers have also founded several organizations relevant to nature farming according to Mokichi Okada's philosophy. The International Nature Farming Research Center and Applied Microorganisms Institute are also financially supported in part by Mokichi Okada's followers. Most of these organizations are supported one way or another by SKK. In early 1990's, some organizations including SKK itself were separated into several groups, which advocated slightly different in ideological and organizational aspects. Consequently, prior to early 1990's, Okada's followers were not able to focus adequately on nature farming research and development needs. Now that the followers have taken steps to re-unite, many expectations should be realized in the future on much-needed research and development for nature farming practices. Nevertheless, one can still find some different version of nature farming on the internet and by other information accesses. For example, Kyusei Nature Farming and MOA Nature Farming are often met in the documents. Actually both are in accordance with Okada's nature farming philosophy. As mentioned above, Okada's followers separated into several groups. One of the groups uses the terminology of MOA Nature Farming and another uses Kyusei Nature Farming for their discrimination. "MOA" here means Mokichi Okada Association and "Kyusei" means world-saving. Organizations such as International Nature Farming Research Center are foundations of public-service although they are related to SKK in one or another way. MOA Nature Farming is associated with the Mokichi Okada Association (MOA) in Japan. In the early 1990's, MOA and the World Sustainable Agriculture Association (WSAA) combined efforts to promote MOA Nature Farming and sustainable agriculture in general around the world. Kyusei Nature Farming is associated with the International Nature Farming Research Center, promoting the use of Effective Microorganisms, or EM.

Religion groups in relation with nature farming

Sekai Kyusei Kyo, shortened as SKK, is one of more than 700 new religions founded in Japan in the last two centuries. SKK is originated in Omoto religion group, a family of religions from the early 1900s. All are syncretic, incorporating elements of *Shinto*, Buddhism, and Christianity. *Mahikari*, an off-shoot of SKK, is probably the best known to the English-speaking public. Besides being prominent in Japan, SKK has missionized Brazil and Thailand, where there are large Japanese immigrant populations. SKK has established branches in the United States, where it appeals to a mixed Japanese-American and Anglo-American population. There are several region groups, related with SKK, that promote nature farming according to Mokichi Okada's philosophy. The present SKK in Japan is a legally registered inclusive religious corporation body with the head office in Atami city. The religion worships God of *Mikuro-Omikami* with followers of more than one million in Japan and over the world. The present Lord is Yoichi Okada, the fourth generation, and corporation representative is Rev. Tetsuo Watanabe. There are mainly three groups included in this corporation, which are again registered as included corporation body. The three groups are SKK *Izunome*, SKK *Tohono-Hikari*, and SKK *Shunohikari*. There are also many other groups in relation with SKK or Mokichi Okada's philosophy. Some have once been originally branches of SSK. They are *Jieido*, *Mikuro Shinkyo*, *Tensei-Shinbikai*, *Gorona Daieikai* (J-Healing), *Tsukuino-Hikari Kyodan*, *Kyusei Shinkyo*, *Koumyo-Miroku-kai*, *Shinji-Shumei-kai*, *Kyusei Shinkyo* (Kyusei True religion), *Johrei Gijutsu Fukyu-kai*, *Kyusei Shinkyo*, *Omoto-hikarino Do, Seimei Kyo*, *Reimei*, Society of *Johrei*, and others.

SKK was founded by Mokichi Okada, aiming at building a paradise on earth, an ideal world free of diseases, poverty and conflict. Jesus prophesied the advent of heaven on earth and Buddha foretold the coming of a perfect world. Many other saints of the past ages made similar predictions. The SKK promotes civilizations through three channels, *Johrei*, nature farming and art beauty appreciation. *Johrei*, the term, is from Japanese, meaning the purification of the spirit and used to heal and improve health in a non-touching way. Nature farming, the term, is also translated from Japanese, meaning food production in a way respecting the nature. Art beauty appreciation is a part of the religion's activities and the religion itself owns several large art museums in Atami and Hakone. Japanese common cultural activities, such as *kado*, the flower arrangement, and *sado*, the tea ceremony, are also promoted by the followers.

SKK insists that their goal is to spread happiness throughout the world, provide practical ideas and steps to increase quality of life through good health, prosperity and peace. It acts as a multi-cultural, multi-faith, service-oriented organization with a common vision. The fellowship embraces the spiritual philosophies of both the eastern and western world, with the practice of truth, goodness and beauty in the daily lives. The followers believe that the universe extends far beyond the comprehension, knowledge, senses, and scientific exploration by human beings. They agree with scientists' discoveries that matter which seems to be standing still, contains small particles which are moving at tremendous speed – that matter is in itself energy. Although all things may seem separate, all that exists is a part of a great network of energy, an inter-woven web which is ever growing and evolving harmoniously. The harmony is one of the insistences of the SSK to reach their goal. As to the importance of art beauty appreciation, Okada writes, "If you were taking a walk down the street, what if there were no trees, green gardens and shrubbery, no houses, stores and buildings? What if instead the streets were lined with straight gray walls like those of a prison? Most of us would not be able to bear walking more than a block". The same is true of the countryside with its varying terrain of mountains, rivers, streams and endless variations of colors and textures which stimulate us and enrich our feelings. As believed by Okada, for a peaceful world it is important to put aside our prejudices and respect the differences which exist among us, and in this way, the human life will become greatly broadened and enriched as a result of each person's contribution.

SKK Izunome. It is one of the main branches, included religion corporate body, of *Sekai Kyusei Kyo* (SKK), the inclusive corporate body with Rev. Tetsuo Watanabe as the corporate representative. Rev. Watanabe is the corporate representative for both the *Izunome* and the SKK Inclusive Corporate Body. *Izunome* is one that is supporting the International Nature Farming Research Center. Sometimes one can find in documents that *Izunome* uses the terminology, Kyusei Nature Farming. It is the same as nature farming with a specific address for distinction from the MOA nature farming promoted by *Tohonohikari*. As described in a booklet (Okada, 1993), the principles of Kyusei nature farming promotes crop production in consideration of the dynamic and balanced production systems in nature, which are a result of the interactions of sunlight, water, soil, animals, plants, and microorganisms in natural ecosystems. Also as written in the booklet (Okada, 1993), "Kyusei Nature Farming is a simple and effective method of growing food crops, without harming the environment. More importantly, this technology, although advocated long before the green revolution, addresses a key issue in agriculture today. This is sustainability and the use of available resources to produce sufficient quantities of healthy food for humankind. It is also an integrated approach to chemical free sustainable agriculture”.

SKK Tohonohikari. The so-called MOA nature farming is promoted by *Tohonohikari*. As described in the homepage of MOA international, MOA is dedicated to creating a better world by helping people around the globe overcome the obstacles to solving environmental problems. The organization bases its efforts on the philosophy and initiatives of Mokichi Okada. The immediate task confronting MOA is the prevention of further destruction to the world's natural environment.

SKK Shunohikari. *Shunohikari* is another branch of SSK and a registered religious corporation body included in the inclusive corporation of SKK. The same as *Izunome* and *Tohonohikari*, *Shunohikari* promotes *Johrei*, nature farming and art beauty appreciation.

Shinji-Shumei-kai. *Shinji Shumeikai* is a spiritual or religious organization dedicated to elevating the quality of life. *Shumei* is committed to the creation of an ideal state of health, happiness, and harmony by applying Mokichi Okada’s philosophy. As taught by Mokichi Okada a world free of sickness, poverty, and discord is possible through the spiritual exercise of *Johrei*, the appreciation of art and beauty, and the practice of Natural Agriculture. *Shinji* means divine love, *shumei* means supremely bright, and *kai* means organization. There is no conflict between *Shumei*'s approach to any religion that seeks human wellbeing. *Shumei*’s members come from diverse backgrounds, and many maintain and deepen their various religious beliefs and practices. *Shumei* expresses deep concerns for the health of the Earth and promotes the practice of the nature farming, a method that emphasizes the integrity of nature and the purity of soil, water, and air.

Kyusei Shinkyo. The so-called *Kyusei Shinkyo* is also a branch separated from SKK. It promotes *Johrei*, nature farming and craft-art activities. With EM technology proposed by Higa, *Kyusei Shinkyo* recommends the followers to promote nature farming and environment purification activities. Every year, *Kyusei Shinkyo* sponsors and organizes a conference on nature farming and EM technology.

Reimei. *Reimei* is a religion corporate body of believers following Mokichi Okada's philosophy and is dedicated to spreading his philosophy to people around. The name of *Reimei* stands for "dawn." The word is used in a passage at the beginning of a seminal work by Mokichi Okada: "Civilization as we know it transitory; it will pass away with the dawn of the New Age as the true civilization is born". *Reimei* is still a small group, trying to disseminate the knowledge of *Johrei* and philosophy of nature farming to people not only in Japan but also in other countries.

Gorona Daieikai (J-Healing). *Gorona Daieikai* is a branch separated from SKK in 1970. Recently, *Gorona Daieikai* has organized a MD Nature Farming Extension Club and promotes sustainable crop production and environmental protection using the EM technology proposed by Higa (1980).

World Divine Light Organization. World Divine Light Organization is the English name of *Sekai Mahikari Bunmei Kyodan*-USA, which is legally registered as a Californian non-profit religious corporation. The World Divine Light Organization offers Spiritual Training and a Spiritual Purification Art, which purifies the spiritual aspects of everything, and the Teaching of God's Righteous Law the guiding principle of life. They offer these spiritual contributions to a number of people all around the world.

Other Related with Mokichi Okada's Philosophy. There are many other groups originally related with SKK or **M**okichi Okada's Philosophy. They also promote nature farming and *Johrei*. They are *Jieido*, *Mikuro Shinkyo*, *Tensei-Shinbikai*, *Tsukuino-Hikari Kyodan*, *Kyusei Shinkyo*, *Koumyo-Miroku-kai*, Study of Mokichi Okada, *Kyusei Shinkyo* (Kyusei True Religion), *Johrei-Gijutsu Fukyu-kai*, *Omoto-Hikarino D*o, *Seimei Kyo*, Society of *Johrei*, and others.

6.4.3 Fukuoka's nature farming

Masanobu Fukuoka was born in 1913, later than Mokichi Okada. It is clear that Mokichi Okada proposed nature farming earlier than did Masanobu Fukuoka. However, one cannot find the name of Mokichi Okada in Fukuoka's book and even nobody argues or tries to know about the copyright. The author here does not know the reason either. This might be of the specific culture of Japan. Educated as a microbiologist and soil scientist, Fukuoka is now a Mahayana Buddhist. Today situations are exactly as he said: "On this planet we do not have something we can call Nature any more. We have lost it. We do not have Nature we can go back to. What we must do is search for Nature. But human knowledge cannot do it. We can only ask Nature. Therefore, we, and especially seed companies in the world, should collect all kinds of seeds on the planet, and offer them to God, Nature and pray. This kind of attitude toward Nature is necessary. Of course, even if we pray, God will not say anything. We may not be inspired either. Nevertheless, the plants which start growing are God's answer. Nature will teach you."

Fukuoka is author of *The One-straw Revolution*, an extraordinary document that distills the deepest of philosophical and spiritual truths into a practical approach to agriculture that he calls natural or do-nothing farming. This philosophy clearly root in the philosophy by Laozi, Zhuangzi and Mozi in ancient China (Csikszentmihalyi and Ivanhoe, 1999). Fukuoka is especially famous and popular in India, where he received the Deshikottam Award in 1988 from Vishwa Bharati University. Some of his books (Fukuoka, 1978, 1985, 1987ab) have been translated into Indian languages and published by Madhya Pradesh's Friends Rural Society. One can read the following paragraphs to understand Fukuoka's Nature Farming Philosophy.

Natural farming with orchards and vegetables

The power of Nature is great, because the natural structure is solid, three dimensional, not horizontal or two dimensional. Some of my mountain peach trees have kiwis climbing on them, and above the kiwi vines, there is a kind of melon. So three kinds of fruit exist together at different heights. I get one or two kilograms of fruit from one square meter of ground. This is a good sustainable yield. Natural production is greater than man-made production, because the structure is solid. Humans are destroying the power of Nature. We have only one fourth of the growing power of Nature left. We are not increasing fertility or production, but rather trying to prevent production from failing by using fertilizers. The world is digging itself into a bottomless pit with modern agriculture. The simple hearth of the small farm is the true center of our universe. Scientific thought is leading you away from a healthy life. Even the practice of conventional organic agriculture is a dangerous digression. It cannot be sustained if you have to rob part of the earth to feed another.

Most farmers begin by asking, what if I do this or what if I do that, but only dissipate themselves that way. My approach just the opposite, seek the pleasant, natural way of farming. In order to make the work easier, not harder, I ask, how about not doing this or how about not doing that? By actual practice I finally reached conclusion there is no need to plow, no need to apply artificial fertilizer, no need to use pesticides at all. Most of the work of farming is created by tampering with nature, which causes negative side effects. Very few agricultural practices are even necessary, just scattering seed, spreading straw on the soil and harvesting.

Natural farming with grains and legumes

The secret of growing grain is as simple as the symbiosis of rice, barley or wheat, and clover. In October I broadcast clover and barley over the ripening heads of rice. A few weeks later harvesters actually trample the seedlings, but they recover quickly. The gathered rice is dried for three days, thrashed, and the uncut straw scattered randomly back on the field. If ducks or chickens are not free to roam then occasionally I add a little manure as well. Before the New Year arrives I coat rice seeds with clay and broadcast them over green barley, then I wait for spring to come. By harvest in May the winter *crop is ripe, white clover covers the field, and rice shoots are sprouting from clay pellets. Barley is harvested, dried and thrashed, and the uncut straw mulch is again returned to the field. I then flood for five or six days, just to weaken the clover while the young rice shoots break through. In June and July my field goes dry though my neighbors keep theirs under water. In August I irrigate every week or ten days. That's about all there is until harvest, and the cycles begin again.*

Natural farming with seed balls

You know that daikon radish seeds are in hard shells, well, I noticed that when they drop on the ground, they decay as they start to sprout. So I realized if they need a shell like that, then clay can be the shell for a ball with many seeds inside. Seed balls need at least one hundred kinds of seeds. One seed eventually makes ten thousand seeds. If you sow seed balls, and wait three years, you will understand what Nature is. It works much better than reading books about Natural Farming. Seed balls are a small universe in themselves. I have written six books, but I was unable to express what Nature is in words. So I decided to manifest Nature in form. A seed ball is a one centimeter model of a Natural Farm, with trees, fruits, vegetables and grains. I do not say my one hundred kinds of seeds are the best. It is just an entrance to Natural Farming.

I love best to give children boxes of seeds as gifts because they scatter them so innocently. Sow seed balls with a child-like mind whenever, wherever, without judging the first year. During the second year birds or bugs will carry the seeds from the plants and sow them naturally for you. So in the third year you will get a natural design. Children sometimes sow seeds in unexpected places, and that brings us to a big discovery that we never even considered. Even if ninety-nine percent fail, and only one percent succeed, that will take us to new possibilities. If you use human wisdom, you will only achieve the result you expect. Give yourself to whatever you do one hundred percent or not at all, and do not doubt. Everything will be all right. Just spread seed balls and Nature will do the rest.

6.4.4 Organic Agriculture

"Organic Agriculture" is a new terminology in comparison with "Nature Farming" in Japan. In the government and legal documents, people usually use "Organic Agriculture" instead "Nature Farming" because the former is considered more authorized and internationally accepted. There are several organizations, such as Japan Organic Agriculture Association and IFOAM Japan, promote organic agriculture and use the term of organic agriculture. People do not make difference between nature farming and organic agriculture in aspects of practice and food quality.

Japan Organic Agriculture Association

Japan Organic Agriculture Association (JOAA) was founded in 1971 as a non-profit voluntary organization. The members include organic producers and consumers. The activities financially depend on membership without any subsidy from governments and organizations. There are about 3,000 members in the association at present with growers as 25% and the remaining mainly consumers and a few social workers. The association publish monthly newsletter "Soil and Health", call monthly seminars and now-and-then lectures for those who want to be involved in the organic agriculture movement, and hold general conference once a year. JOAA has developed principles of “*Teikei*”, which, in Japanese, means cooperation between producers and consumers. The "Ten Principles" in summary form are:

(1) Produce crops in accordance with pre-negotiated agreements between farmers and consumers;
(2) Build a friendly and creative relationship between farmers and consumers, not limited to the relationship as trading partners;
(3) Accept all the produce delivered by the farmers;
(4) Negotiate prices in a mutually-beneficial manner;
(5) Build the rapport necessary to gain the mutual respect and trust required for a successful continuation of the relationship;
(6) Manage the self-distribution of produce, either by the farmers or by the consumers;
(7) Allow for participatory involvement of all members, based on democratic principles;
(8) Develop an interest in studying various social and political issues related to organic agriculture;
(9) Maintain an appropriate number of both farmers and consumers in relation to the group as a whole;
(10) Persevere with the ultimate goal of attaining a balance with nature and a relationship of equality between humans based on organic agriculture and the organic link between farmers and consumers.

IFOAM-Japan

IFOAM Japan is an association based mainly on the members who are already the member of world IFOAM (International Federation of Organic agriculture Movement), who have been active for promotion of the domestic organic agriculture. IFOAM Japan calls communication activities such as meetings, lectures and visits, both domestically and internationally for organic agriculture producers, consumers, manufacturer and the distributor. As the representative of Japanese IFOAM member IFOAM Japan talks with world organization and people about the guideline and standard for organic agriculture and interpret the related world information including the standard and guideline to the members in Japan. IFOAM Japan also communicates with government for the establishment of organic law. As one can read in the IFOAM's homepage, IFOAM is an organization leading, uniting and assisting the organic movement in its full diversity. Its goal is the worldwide adoption of ecologically, socially and economically sound systems that are based on the principles of Organic Agriculture. IFOAM was founded in Versailles, France in 1972. The founding members of IFOAM aimed to establish a communication network among organic agricultural communities that had appeared in several countries. As declared in the homepage, IFOAM represents the complete spectrum of stakeholders in organic agriculture movements worldwide and the major aims and activities are described as 1) to provide authoritative information about organic agriculture, promote its worldwide application and exchange the knowledge; 2) to represent the organic movement at international policy making forums; 3) to make an agreed international guarantee of organic quality a reality; 4) to establish, maintain and regularly revise the international "IFOAM Basic Standard" as well as the "IFOAM Accreditation Criteria for Certifying Programs"; and 5) to build a common agenda for all stakeholders in the organic sector. As a member organization of world IFOAM, IFOAM Japan fulfill its activities as a whole according to world IFOAM's policies.

6.5 Future of nature farming

Mokichi Okada initiated a quiet revolution by developing nature farming philosophy. In the decades before World War II, long before the organic agriculture and environmental movements gained their present level of acceptance, he already warned against the damage to the health of people and the environment that was being incurred by the rampant use of pesticides and chemicals to produce food. Today, although not yet in very large scales, nature farming is adopted on many farms throughout Japan and extensively practiced and researched in Japan and over the world. As mentioned in previous paragraph, many organizations have begun work in collaboration with other research institutes, universities and public agencies in Japan and over the world in concerns with healthy and sustainable food production. It is believed that the promotion of nature farming is vital to the future of human being and the earth environment. Through nature farming practice, human beings will assume a more harmonious relationship with nature and help restore both the physical and spiritual health of human.

The future of nature farming or organic farming has been reviewed and discussed by many scientists (Lockeret et al., 1981; Harwood, 1984; Vogtmann, 1984; Hasumi, 1991; Nakasuji, 1991; Minamino, 1994; Kumazawa, 1996). Detailed descriptions are omitted here. Nature farming and organic farming should have a bright future because people worldwide come to realize that they must respect nature and nature's laws in our modern society. If chemical agriculture is allowed to continue, the environment in which we live will be severely threatened. Therefore, it is believed that nature farming or organic farming has a good future although there are many problems yet to be overcome by practitioners. In Japan and many countries over the world, a great number of nature farms are operated on relatively large scales by organizations associated with the International Nature Farming Research Center, MOA Institute of Applied Microbiology and other organizations in relation with SKK. On these farms, the principles of nature farming proposed by Okada are strictly followed. Cereals, vegetables and fruits are produced without the use of chemical fertilizers and pesticides, and even without fresh animal manures and urban wastes. Although nature farming has not been adopted by farmers on large commercial production scales, most farmers are practicing nature farming on a small scale for their own consumption and the urban people produce nature farming vegetables in their home gardens. Some farmers never eat cereals, vegetables and fruits that they produce with chemical fertilizers and pesticides. They know how poisonous these chemicals are to humans, animals and wildlife. These farmers are not lacking morality when they produce agricultural products with poisonous chemicals for sale to consumers. It is society and the consumers who push the farmers to do this. If the farmers do not use chemicals, they can not gain enough income to sustain themselves and their families. Society does not insure their normal life without appropriate income from the high yield of chemical agriculture. The consumers select agricultural products, especially those such as fruits and vegetables, by shape, size and color. One will be surprised to hear that the apples under 270 g are not marketable in Japan. Even a small scar caused by insects on the fruit surface renders them un-marketable. Without chemical fertilizers and pesticides, the farmers cannot produce larger attractive products that are demanded by consumers today. Thus, farmers are forced to depend on poisonous chemicals even though they are aware of their adverse effects to societies and the consumers. The policies and consumers' habits make it difficult for nature farming to be adopted on large scales.

Although nature or organic farmers and those who are devoted to organic movement are facing many problems and difficulties, the future is still bright. Because they respect the nature and believe the nature, the laws of nature will help them to solve the problems. "Nature is God". They just need to understand the laws of nature and solve the problems following the laws of nature. Scientists over the world have started research works on organic or nature farming and many successes are achieved. This is just the beginning and good beginning means half success as a whole.

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