Lessons from Nature

A guide to Ecological Agriculture in the tropics

by
Shimpei Murakami

Lessons from Nature

A guide to
Ecological Agriculture
in the tropics

by
Shimpei Murakami
1991

ISBN : 974-87054-1-2

First edition : May, 1991

Second edition : August, 1999

Illustrations by : Mari Tomita

Photographs by : Shimpei Murakami

Editing & Design by : Wilma Van Berkel

Published by : Nongjok Natural Farming Center
44 Moo 7, Rim Khlong Jak,
Khlong 12, Nongjok,
Bangkok 10530
Thailand
Phone : +66-2-989-9909
E-mail : nongjok@loxinfo.co.th

Printed by : Papyrus Publication
Sathorn Tai Road
Bangkok, Thailand

Acknowledgements

Grateful thanks to all the people who encouraged me in writing this book and made it possible.

Qazi Faruque Ahmed, Executive Director of PROSHIKA-MUK, has given me moral support in my work and financial support for this book. Manitosh Hawlader, my counterpart, has worked, discussed and explored with me the development of ecological agriculture at Proshika farm. Julian Francis, Director of CUSO South Asia has helped me much in working in Bangladesh. Thanks to Farida Akhter, Farhad Mazhar and friends of UBINIG without whose voluntary contributions the book would not have been possible. I really thank Wilma Van Berkel who kindly did the correction, editing, layout, etc. of this book. I owe special thanks to Mari Tomita, who drew the illustrations.

Finally, I would like to express hearty thanks to all people who have sent us moral and financial support from Japan, making it possible for us to work in Bangladesh.

Table of Contents

Part 2 Practical Methods

The ultimate goal of farming
is not the growing of crops,
but the cultivation and
perfection of human beings.

Masanobu Fukuoka
(The One Straw Revolution)

Foreword

Over millions of years, nature has built up an intricate system of relationship of exchange and mutual dependence among its elements - land, water, air, forest, sunlight and living things - to create what we call the ecosystem. It is the life support system of all living things on this planet and provides not only the daily needs but also saves resources for future generations. But this very life support system is endangered by man's aggression against nature. In the last few decades, the aggression has reached unprecedented levels. Blinded by his so-called 'scientific and technological achievements' he believes in 'conquering' nature and that it can be exploited endlessly. This is nothing but arrogance and an excuse for rapacious greed. With all his bragging about science and technology he fails to understand the superior science of nature. Based on this false understanding, man's relationship with nature has turned into one of enmity. But in this war of aggression, man is certainly going to be the loser; he and other living species will face extinction. Already, the signs are foreboding - global warming, acid rain, ozone layer depletion, massive deforestation, advancing deserts, prolonged drought, marauding flood and apocalyptical cyclones are ravaging many parts of the earth.

However, the destruction of the environment is not only the result of man's arrogance of science, but also a result of the way he has organized his society - its economic, social and cultural systems. The economic system encourages monopolization of resources by a few, the social system promotes the acquisition of power by a small minority at the cost of disenfranchising many, and the cultural system advocates greed and reckless consumption in the name of individualism.

If sanity does not prevail upon man, then he will soon destroy the environment and with it himself and other living things. For survival, he has to build a society which is based on equitable and sustainable sharing of resources which decentralizes social power and promotes consumption based on need, not on the greed of a few. His technology and science should try to understand the principles and laws of nature and derive sustenance in a sustainable manner by harmoniously blending technology and science with the superior technology and science of nature.

This book, Lessons from Nature by Mr. Shimpei Murakami is a praiseworthy attempt to explore the rules and principle's of nature and how these could be better understood and applied to develop an alternative agricultural system which is not only wholesome, but also sustainable. His long working experience in Japan and 3 years experience at the Ecological Farm of Proshika has made this book very practice-oriented and at the same time, he explains meticulously, the ecological principles behind each practice. As this book is written in the context of Bangladesh, it may be the only book suitable for practitioners of ecological agriculture in Bangladesh. Apart from this, it will be an excellent resource for environmentalist who will find very good reading how agricultural resources - soil, water, biodiversity etc. - are damaged by chemical agriculture. Unlike many books on the environment, this book does not stop at describing the problems only. Mr. Murakami describes in detail the alternatives and give rational hints for practice. Above all, after reading this book, one is left with a feeling of optimism, that viable alternatives to the monumental damage to the environment exist. He proves, not theoretically but practically, that ecological agriculture is not only environmentally friendly, but also more productive and sustainable than chemical agriculture. Anyone reading this book will be convinced that ecological agriculture is based on the superior science of nature and, therefore, it is the way for the future.

Qazi Faruque Ahmed
Executive Director
PROSHIKA

Preface

When I realized that agriculture itself can be destructive to nature, the basis for all living things, my view of agriculture totally changed. It was in 1982 when I stayed in Bihar, India - my first experience with agriculture in a tropical climate. Until that time, my concern had been how to get maximum production with organic methods. I was a farmer and had worked at my father's farm where he had been practicing organic farming without using agro-chemicals for 20 years. Since then, my concern has been changed to what type of agriculture is suitable to nature and optimizes food production.

In 1985, I came to Bangladesh to work for Shapla Neer, a Japanese NGO working in rural community development. I observed the situation of farmers, including agricultural practice and village life during this time. In April 1988, I joined Proshika-Muk as an adviser in ecological agriculture. Proshika-Muk is one of the few Bangladesh NGOs which is concerned with the environmental aspects of rural development and has tried to introduce alternative agriculture in this country. Since then, I have been involved in the practice of ecological agriculture at Proshika demonstration farm and conducting training on these topics with agri-extension workers.

Through these three years of practical experience and six years observation of tropical agriculture, I have realized anew, a very interesting and important factor. That is, agricultural practices which follow the rules of nature, recover soil fertility and ecological balance quickly and result in sufficient, sustainable, productivity. But anti-natural agricultural practices (chemical agriculture) degrade the soil and the ecological balance quickly resulting in decreases in production.

Compared with temperate zones, in tropical zones, both recovery and degradation occur very quickly. Farmers started using agro-chemicals about 50 years ago in Japan and other temperate zones. After 30 years of practice, adverse reactions and serious problems related to these agro-chemicals began to emerge. In Bangladesh, which is in the tropical zone, it only took 10 - 15 years for adverse reactions and problems to appear. Some Bangladeshi farmers report that in high land where no flood waters come, these problems have appeared as quickly as 5-7 years.

For this reason, it is within tropical zones where the practice of ecological agriculture is urgently needed. Otherwise, the delicately balanced tropical ecosystem will be totally destroyed by anti-natural agricultural practices.

I had two purposes in mind in writing this book. One is to write a simple manual which explains some basic ideas about nature in order to help people see what agriculture is when examined from the view point of nature. The other is to share my experiences in practicing ecological agriculture in the tropical setting of Bangladesh. In Lessons from Nature, I try to cover both purposes while explaining things in a way readers can understand easily.

Only basic information necessary to understand agriculture properly is covered in this book. I did not go into the specific technologies very much because I believe that the most important thing is to understand the basic idea. If one can understand it, he/she can develop and apply his/her own knowledge and technologies in their specific circumstances. Agriculture cannot be reduced to using the right proportion of chemical fertilizers and the right dose of chemical pesticides. Proper practice is much more complicated and diversified. There is no ready made answer. Flexibility and imagination based on the basic ideas are indispensable for the real development of agriculture.

There are two people who inspired me to work in ecological agriculture. One of them is my father who has been practicing organic farming in Japan since 1971. I was motivated towards ecological agriculture by his simple, but strong idea, that the task of agriculture is to produce food for people's health not to produce chemically poisoned food for the farmer's economic benefit. He showed me proof by his practice that any crop can grow well without using agro-chemicals so it is not a mattering of "avoiding" them in cultivation.

Mr. Masonobu Fukuoka, author of The One Straw Revolution, a natural farmer, is my agricultural master. He says that nature is perfect. It is a man who disturbs nature's work and creates problems. Man can work as much and as hard as he wants to overcome problems and the problems become worse. Soil in the natural forest is never plowed and fertilized by farmers, but it is soft and rich in nutrients. Soil in agricultural land is plowed and fertilized by farmers for every crop, but it is hard with less nutrients. Why? It is because man does not understand nature.

"Let nature follow her own way". Based on this idea, Fukuoka developed a natural farming method which is known as "do nothing farming". No plowing, no fertilizer, no weeding and no pesticide. As a result, he has been getting higher rice production than the Japanese average. I have been impressed by his theory and practice which are based on his simple, radical and deep thought and faith in nature.

Nowadays, environmental problems (ecological degradation) are becoming very serious globally and regionally. These problems can be divided into two main types. One type is caused by industrialization and so-called modern technologies. Things like : breakdown of the ozone layer, the greenhouse effect, chemical and nuclear pollution etc. The other is caused by anti-natural agricultural practices. Deforestation, soil erosion, flood, drought, desertification etc.

The common point between these two elements is that they have not occurred naturally. Man has created them. Therefore, to change technology from anti-natural to natural is not enough at all. Changing our attitude towards nature from "nature for man" to "man for nature" is essential. In this context, ecological agriculture is one of the essential approaches in working towards permanent solution of environmental problems as well as agricultural problems, technically and conceptually.

I believe that the most important thing for us is to recover a sense of learning from nature, feeling happy being in nature, and develop the sense through the practice.

"Let us take our lessons from nature".

Shimpei Murakami
May 1991 in Bangladesh.

Part 1

Background

Chapter - 1

Nature and Agriculture

If we think seriously about agriculture - its problems and its improvement - we must learn from nature. Why ? Because nature is the ideal. In biomass production, fertility maintenance, soil protection, pest control, utilization of incoming energies - nature shows us the most effective system. Where can we find real nature? In the natural forest. The natural forest produces a huge amount of biomass each year without any artificial input and provides food for all living things within it. Agriculture, on the other hand, produces less biomass, needs artificial inputs and faces many problems.

The production mechanisms of both agriculture and the natural forest are the same. They produce carbohydrates (biomass) through photosynthesis using nutrients and water from the soil, carbon dioxide from the air and sunlight (energy)., The difference is that the forest is natural and agriculture is artificial. This artificiality creates many problems which do not occur in the natural forest - soil fertility depletion, soil erosion, pest outbreak, among others and consequently - low productivity.

Though agriculture is artificial, it is within nature and therefore under the limits of nature. It is very important for agriculture to follow these rules. Almost all problems of agriculture come from man's ignorance of these rules. We need to look agriculture from a different angle in order to solve its problems.

In this chapter we explore:

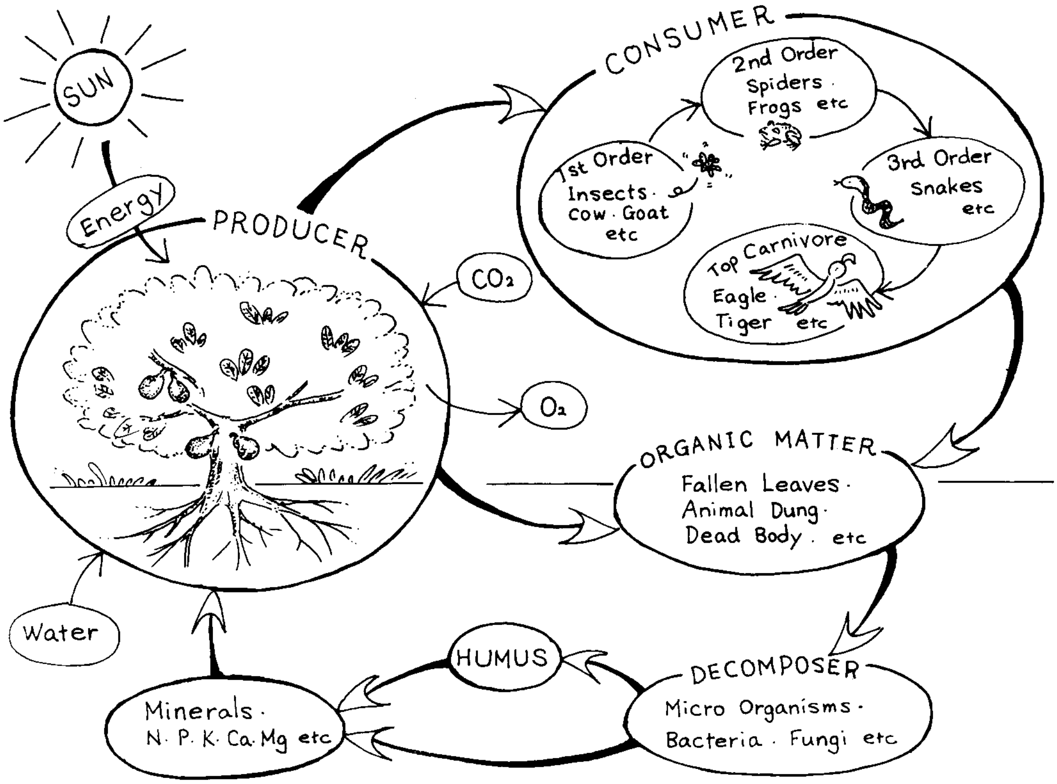
1) the rules of nature by examining the ecosystem of the natural forest
2) .the differences between nature and agriculture
3) water and its role in agriculture
4) the characteristics of the tropical ecosystem

1.1 The Ecosystem of the Natural Forest

The ecosystem of the natural forest is a perfect and complete system. In the natural forest there are a huge number of species of plants, animals and micro-organisms. Living (biotic) and non-living (abiotic) things exist within certain relationships and in a certain balance. The ecosystem describes the pattern of relationships and interactions among living and non-living things. Therefore, it is very important for us to understand this first.

1.1.1 The Nutrient Cycle (Regenerative System)

In ecology, all living things are placed in one of three categories: producers, consumers or decomposers. The main point of understanding the ecosystem is learning the interaction between producers, consumers, decomposers and other non-living things (sun, water, air, minerals, etc).



The Nutrient Cycle

Producers are plants which have green leaves containing chlorophyl. They produce food (carbohydrates) for themselves and all other living things by using sun energy (the only energy from outside) and taking nutrients (minerals, water, carbon dioxide, etc.). This production process is called photosynthesis. It is very important to note that nothing can produce food for living things except plants. That is why they are called producers.

Consumers are animals which live by eating the products (carbohydrates) of producers directly and indirectly. Consumers are divided into four groups: first order, second order, third order and top carnivores. The first order includes herbivorous animals (e.g. insects) which eat the products of the producers directly. The second order are carnivorous animals (e.g. spiders, frogs) which eat mainly animals of the first order. The third order are carnivorous animals (e.g. snake) which eat mainly animals of the second order. The top carnivores are animals (e.g. eagle, tiger.) which eat mainly animals of the third order. No animals eat top carnivores. In this way, there is a certain balanced relationship among consumers. Man is categorized as a consumer. (Note: The actual relationships among animals is more complicated. This classification shows the basic relationships only.)

Decomposers are micro-organisms (fungi, bacteria, virus. etc.) which live by eating organic matter such as the waste of producers and consumers (e.g. fallen leaves, dead body and dung of animals, etc.). There are huge numbers of micro-organisms living in the soil (more than 100,000,000 in 1 gram of fertile soil). The most important function of decomposers is to change organic matter into humus through decomposition and minerals through mineralization. Humus is indispensable for making and improving the soil. Minerals are absorbed again by producers as nutrients. (From another angle, the decomposer is the cleaner of the planet. Because micro-organisms work in the soil, the soil is kept clean and healthy, otherwise, the surface of the planet would be full of the waste matter of producers and consumers.)

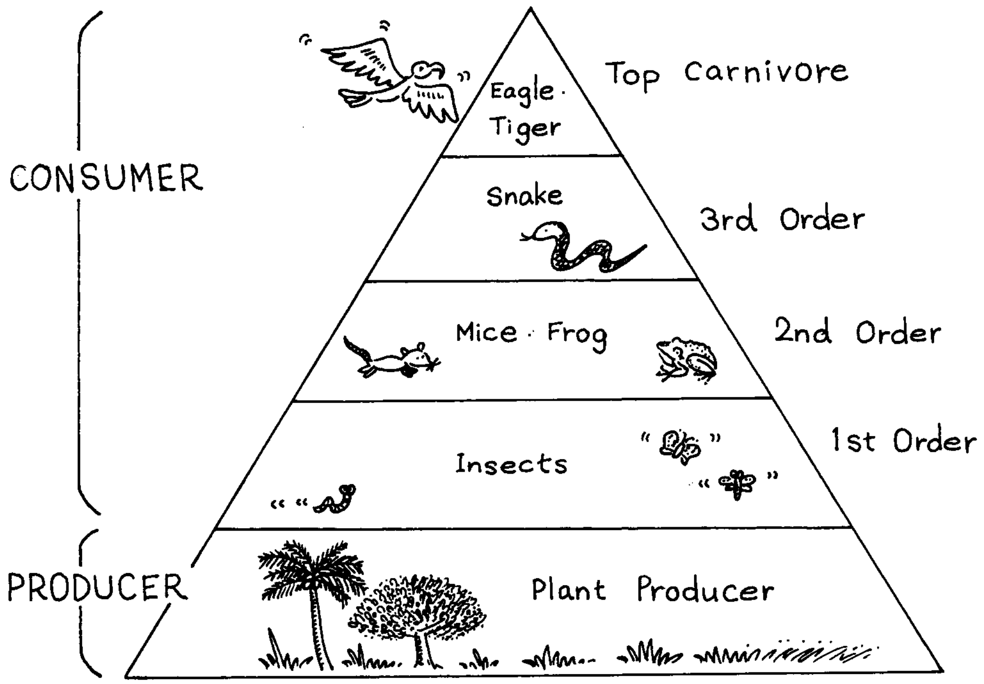
As the diagram shows, the more producers (plants) produce carbohydrates, the more consumers (animals) can live. The more organic matter is supplied to the soil from producers and consumers, the more decomposers (micro-organisms) become active and the more nutrients are supplied to the producers. The producers increase and more sunlight is used for carbohydrate production. This system is called the nutrient cycle.

It may also be called the carbon cycle, nitrogen cycle, mineral cycle, etc. The difference is in the focus. When the focus is on carbon, then it is called the carbon cycle.

Through the nutrient cycle, all living things increase and the soil becomes fertile. Every living and non-living things interacts in nature- there is nothing useless or unnecessary. They are all tied together in relationships of needing and supporting one another. If one piece is disturbed, the whole system reacts. For instance, if organic matter is not supplied to the soil, micro-organisms (decomposers) become inactive and the soil becomes infertile and the plants (producers) cannot produce well in the infertile soil. The low production of producers consequently reduces the numbers of animals (consumers).

1.1.2 The Ecological Pyramid

The ecological pyramid is another perspective on the relationships and balance between living things - especially consumers - and how nature controls and balances the numbers in each group. The shape of the pyramid shows the allocation of numbers (bottom to top large to small).



For instance, so-called harmful insects are consumers of the first order (herbivores) that eat producers (green plants) directly. However the number of insects is controlled by consumers of the second order (bird, frog, spider, etc.) and kept within certain limits. Therefore, the insects never eat up all the green plants in the natural forest. The second are eaten by consumers of the third order (snake, etc.) and the third are eaten by top carnivores (eagle, tiger etc.). In this way, each order of consumer is naturally held to certain limited numbers by the control of upper orders and the quantity of food supply from lower orders. Consequently, the shape of the ecological pyramid is formed by the numbers of each order and the producer and shows very clearly that the basic foundation are the producers. If the producers increase in number, the consumers can also increase in numbers. But a decrease in producers results in a decrease in consumers.

This relationship (eating and being eaten) between producers and consumers is called the food chain. The food chain is an ecosystem which is very delicately balanced and disturbances at any one stage upsets this. For example, if snakes are destroyed in large number for their skin, then mice and rats would proliferate. If frogs decrease greatly in number for export of frog legs, an increase in the population of insects and a reduction in crop yield would result.

1.1.3 The Important Rules for Agriculture

1) The main source of energy for the production of carbohydrates is the sun. Maximum utilization of sun energy is most important for agricultural production.
2) It is only green plants which can use sun energy to produce carbohydrates. The degree of utilization of sun energy is dependent on the quantity of green plants.
3) The source of fertility (minerals, humus etc.) is organic matter which contains micro-organisms. A supply of organic matter is indispensable for soil improvement through fertilization.
4) Every living thing interacts and there is nothing which is unnecessary and harmful in nature.

1.2 Differences between Agriculture and the Natural Forest

1.2.1 Diversity

The biggest difference between the natural forest and agriculture is the number of species. There is a large diversity of plant species in the natural forest - more than 100 species are found in one acre of land. In agricultural land, there are a few species or sometimes only one species (mono-culture) per acre. Mono-culture in agricultural land is the main cause of the unbalanced agro-ecosystem.

1.2.2 Pest Problems

There is almost no pest problem in the natural forest and it never occurs that one insect or one disease destroys the whole natural forest. Pest problems are very serious in agricultural land. One insect or one disease often destroys the entire crop. The main reason is mono-culture or lack of diversity. In the natural forest, so-called harmful insects and diseases cannot break out in isolation because there is a diversity of plant species and a balanced food chain (ecological pyramid), which puts the insects under certain conditions (numbers are limited). Even if an outbreak happens, the pest would never destroy the whole forest because it only attacks certain kinds of plants (diet habit).

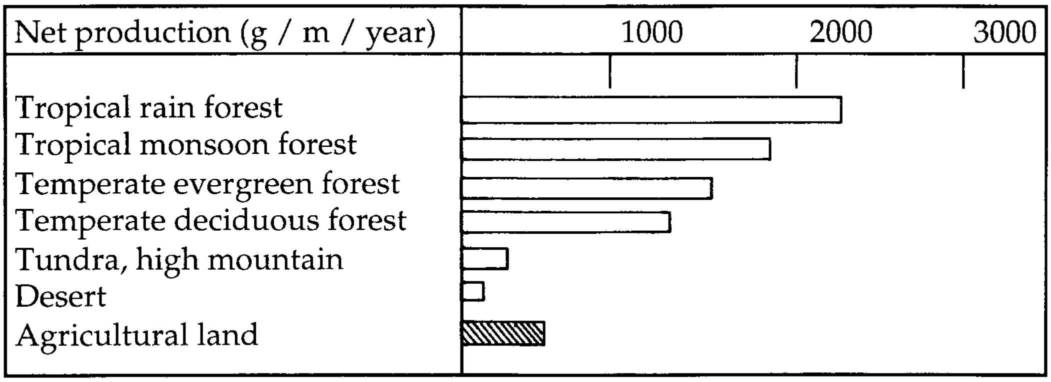
1.2.3 Soil Fertility

The soil fertility maintenance system in the forest is ideal - gradually increasing and sustainable. There is no fertility depletion in the forest. The main reasons for this are the undisturbed nutrient cycle and vegetative cover on the soil. The nutrient cycle increases fertility in the soil and the vegetative cover protects and conserves it. On the other hand, fertility depletion is one of the main problems of agriculture. The nutrient cycle is always disturbed in agricultural land because most biomass production is taken out from the agricultural land through harvesting. Very little or almost no biomass is returned to the soil so the soil fertility in agricultural land is decreasing day by day. Furthermore, the bare soil causes soil erosion which makes soil fertility depletion worse.

1.2.4 Biomass Production

As the diagram shows, the forest can produce huge amounts of biomass. The amount is more than two times that of agricultural land. The reason is the multi-story structure of the vegetation in the forest and again, the undisturbed nutrient cycle. Multiple stories ensure maximum utilization of natural energies (sun, rain, wind, etc.) and the nutrient cycle supplies enough fertility to the soil. In agricultural land, the structure of vegetation is horizontal which cannot utilize the natural energies properly. The nutrient cycle is disturbed by taking products away from the land causing fertility depletion. Therefore, production of agricultural land is less than that of the natural forest, despite many artificial (external) inputs. There are no artificial inputs needed in the natural forest.

Biomass Production in Different Ecosystems



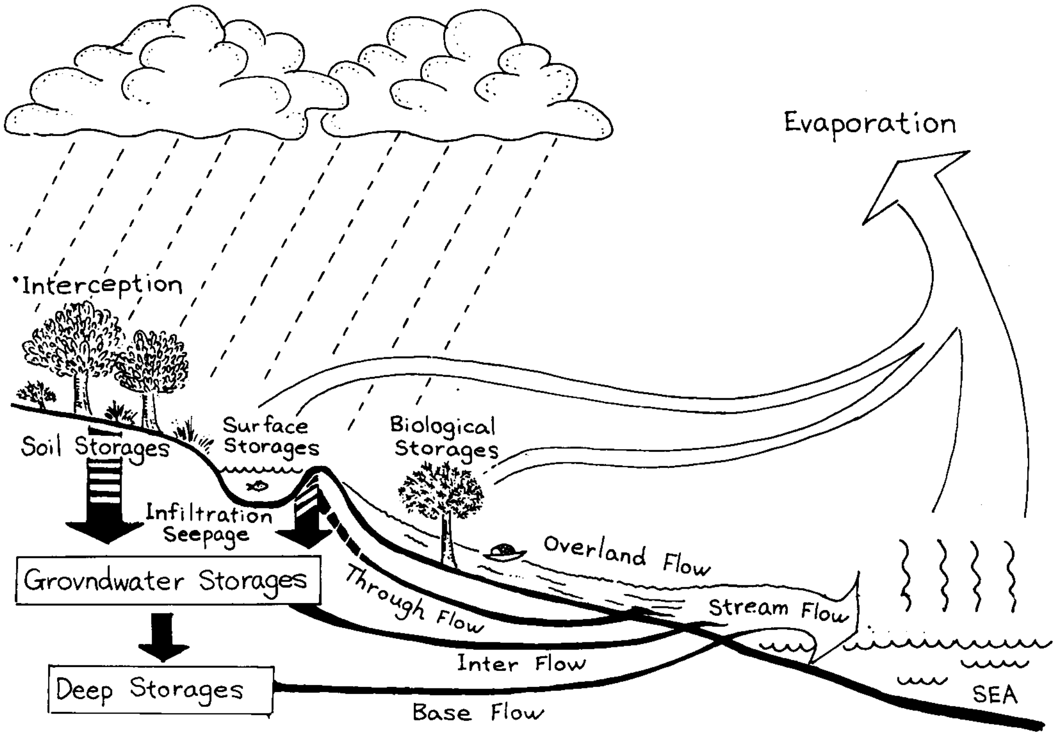
(Soil Regeneration by S. Mori)

1.3 Water

Water is the most essential substance for life and it is also indispensable for agriculture. Effective use of water is very important in agricultural practice, so it is necessary for us to understand the water cycle and the factors which aid effective use.

1.3.1 The Water Cycle

Water cycles on the planet through the force of sun energy as the diagram shows. First, clouds are formed by evaporation from the sea and forest. The cloud moves and falls on the land in the form of rain. The rainfall stays on the land temporarily in the vegetation and the soil, and goes in many ways like evaporation and run-off (the source of rivers). Finally the rain water goes back to the sea and into the clouds.



The Water Cycle

1.3.2 Actual and Effective Rainfall

The source of water for the land is rainfall. However, only part of rainwater is used by the plants while the rest is lost in many ways. Actual rainfall is the total quantity of all rainwater on the land. Effective rainfall is the total quantity of rainwater which is reserved in soil, used by plants and others and excluding that lost in run off and evaporation. The effective rainfall is the resource for plants, animals and agriculture.

1.3.3 Factors which Increase Effective Rainfall

Whether or not effective rainfall increases depends on the allocation of rainfall, the type of soil, density of vegetative cover, land shape, etc. Soil with a high organic matter content can absorb more water. The vegetation diminishes the beating effect of rainfall on the soil surface by intercepting it and water is gradually soaked into the soil from where plants use it for a long period. In flat terrain, rainwater stays longer than in sloping terrain.

Ways to increase effective rainfall for agriculture:

1) Supply organic matter to the soil which increases water-holding capacity
2) Plant permanent trees and grasses which hold much water
3) Cover the soil with vegetation and organic matter to decrease the beating effects of rainfall
4) Make water catchments such as ponds which are very useful for preserving water for the dry season
5) In sloping land, terrace cropping or contour cropping reduces water loss

Though it is indirect in effect, preserving the forest and afforestation is actually the most effective way to increase the effective rainfall in an area. The forest preserves huge quantities of rain water and releases it gradually which is the source of rivers. Furthermore, the forest increases and sustains the actual rainfall through formation of clouds as a result of evaporation, especially inland, far from the sea.

1.4 Characteristics of the Tropical Ecosystem

Each climate zone on the planet has ecological characteristics. Bangladesh is located in the tropical (sub-tropical) humid climate zone. Japan, USA, and European countries are in the temperate climate zone. There are significant differences in temperature, rainfall (allocation, quantity), quantity of biomass production, type of vegetation, soil and other aspects between temperate and tropical ecosystems. The agricultural system is very much influenced by ecological factors. If an agricultural system is not suitable to an ecosystem it will not sustain its productivity and very often disturbs the whole ecological balance of the area. A suitable agricultural system is therefore essential.

However, this rule is apparently ignored in current agricultural development efforts being carried out in many developing countries within the tropical zone. It was believed that agricultural development would be achieved by introducing technological innovations from industrialized countries. Based on this idea, the 'Green Revolution' was started and has been implemented for three decades. Through the Green Revolution, traditional agricultural systems in tropical countries, which are very unique and have sustained for many generations, have eroded rapidly. Instead, so-called modern agriculture, which is just copy of the agricultural system in industrialized countries, has been extended intensively in developing countries.

A question in my mind since I first came to tropical countries (India, Bangladesh, etc.) in 1982, has been why is agricultural production per unit of land in tropical countries so much lower than that of temperate countries? For instance, the rice production in Japan is about 7,000 kg/ha on a average while it is about 2,000 kg/ha in Bangladesh. The situation of other crops is more or less the same. This has been a very big question because, as we have seen, in terms of biomass production, the most productive place in nature is the tropical rain forest. The potential of the tropical forest for biomass production is about two times that of the temperate forest.

Then why such contradictory results? Let's examine in more detail, the characteristics of the tropical humid climate.

1.4.1 Tropical climate

High temperature and strong sunlight

Tropical zones have very hot climates. High temperatures are created by strong sunlight and a relatively longer lighting period compared with the temperate zone.

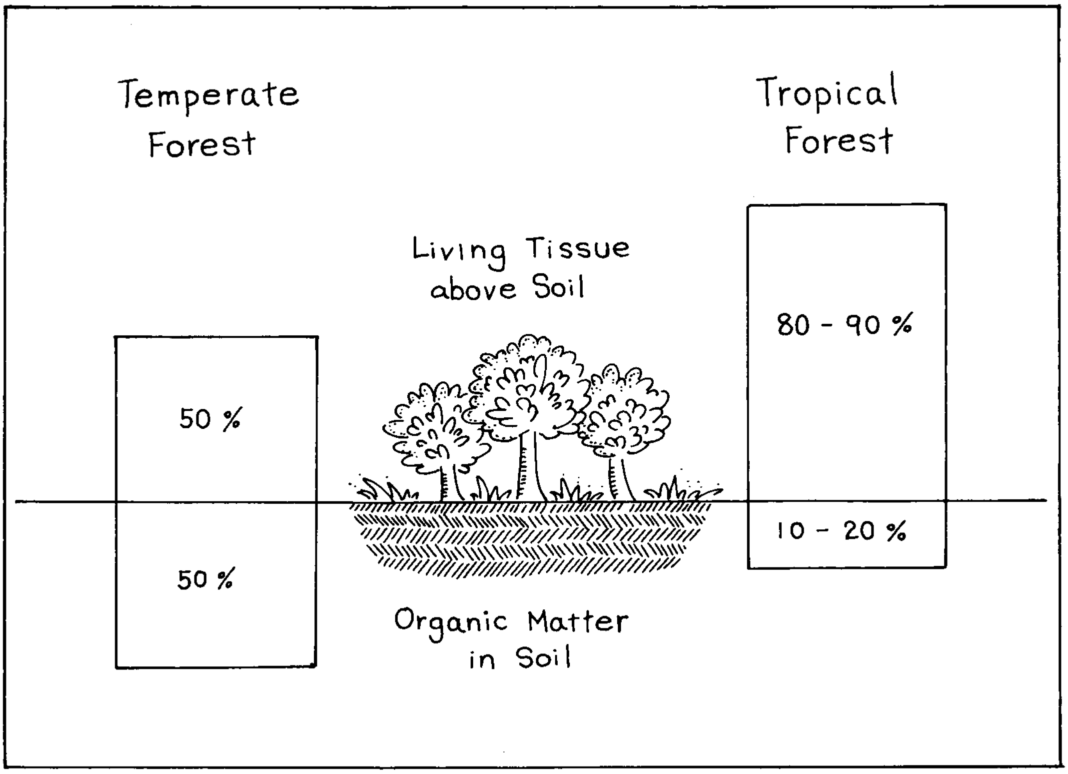
Extreme Rainfall

Rainfall shows typical tropical characteristics - strong, intensive, large in quantity and seasonal (rainy and dry season). These characteristics are extreme. In Japan, the actual annual rainfall is about 1,500 mm. on average and the allocation is throughout the year. Rainfall occurs once or twice every week and it is a gentle rain. Thus the loss through run off is relatively little. In Bangladesh, actual annual rainfall is about 2,000 mm. on average, but the allocation is only during the rainy season (June - October). There is almost no rainfall during the dry season (December-March). Rain is very strong and intensive. Thus the quantity of loss through run off is relatively high in the rainy season. Because of this extreme pattern of rainfall, the quantity of effective rainfall in Japan is much higher than that of Bangladesh.

1.4.2 Allocation of Nutrients in the Tropical Forest

Nutrients in the forest are primarily reserved in two places. One is in living tissue (leaves, branches, stems, etc.) which, except for roots, is located mostly above the soil. The other is in organic matter (fallen leaves, humus, etc.) in the soil. The allocation of nutrients is quite different between the tropical and temperate forests.

As the diagram on the next page shows, the ratio is 50:50 in the temperate forest. 50% of total nutrients are stored in living tissue (above soil) and the other half is stored in the soil as organic matter. In the tropical forest, it is 20:80 to 10:90. That is, 80-90% of the total nutrients are stored in living tissue and only 10-20% is stored in the soil as reserve. The difference occurs because of different speed of decomposition (including mineralization) between the temperate and tropical zones as outlined in the chart.



Allocation of Nutrients

High temperature and humidity in the tropical zone provide optimum conditions for decomposition, which consequently occurs very quickly. This results in two things. Minerals are available for plants sooner. On the other hand, organic matter cannot stay in the soil for long so that the organic matter content in soil is less than that in the temperate forest.

Speed of Decomposition in Different Climate Zones

Place	Average Temp (C)	Decomposition (years)	
		Half	Complete
Tropical Rain Forest	27.2	2.8	11.9
Temperate Evergreen Forest	13.7	13.9	60.3
Sub-frigid Forest	5.6	35.9	155.3

by T. KIRA (Ecology and Nature) 1971

1.4.3 The Multi-Story Structure of the Natural Forest

As we have seen, the tropical climate is extreme and the organic content of soil is relatively little. What kind of system is suitable for dealing with such conditions? Nature shows us an ideal mechanism in the natural forest - the multi-story vegetative cover. The multi-story structure can regulate the extreme conditions and utilize natural energies and resources properly.

As the diagram shows, the structure of the forest consists of:

1) big trees with large canopies which cover the whole forest
2) moderate trees under the canopies of the larger trees
3) small trees and shade living plants under these
4) the soil is covered by grass and litter

The strong sunlight is mostly used by the leaves of trees and never strikes the soil surface directly. The beating effect of the strong rain is absorbed by the top canopy, moderate and small trees, and never hits the soil surface directly. Thus rainfall slowly soaks into the litter, soil and roots of plants of the forest to maximum effect. In these ways, the natural forest uses strong sun energy and heavy rainfall properly.

High biomass production of tropical forest results from the maximum utilization of sun energy and water, and quick decomposition which release minerals for plants quickly.

1.4.4 Problems of Agriculture in the Tropical Ecosystem

The extreme climate and the quick decomposition which works positively in the forest does not work the same way in agriculture. Rather, it sometimes works negatively. Conventional agricultural practice starts by cutting and clearing the forest. In this way, 80-90% of the total nutrients are taken away from the land and the soil that is left lacks organic matter, fertility, water holding capacity and other beneficial qualities of soil. Furthermore, strong sunlight can then hit the soil surface directly which degrades the soil structure causing it to become hard. Strong rainfall beats the soil surface and as the thin top soil has little capacity to hold rain water, soil erosion occurs. When the strong sunlight and rainfall are not used properly, they become causes of soil erosion, flood, drought and other natural disasters.

Erosion

75000 million tons *of top soil is eroded every year in the world. This is equivalent to 15 tons per person.*

27 million acres *of agricultural land is lost through this erosion every year. This is more than the total agricultural land (20 million acres) in Bangladesh.*

Erosion Rate : *Agricultural land - 20 ton/acre/year*
Natural forest - 0.04 ton/acre/year

Data from "Far from Paradise" by John Seymour and Hervert Girardet

1.4.5 Conclusion

As we seen, the characteristics of the tropical ecosystem are extreme, but very delicately balanced. It is very urgent to build up a suitable agricultural system which can utilize natural energies and resources properly, is strong against natural disasters, and not destructive to the ecological balance in the area. Of course, this should not be a copy of a so-called modern system. If we succeed at building up a suitable agricultural system in the tropical zone, the productivity of this agriculture would be more than that of temperate modern agriculture. Nature shows us that the tropical zone has more potential than the temperate.

Agriculture is artificial but within nature. Agriculture does not exist beyond the rule of nature. Human history tells us that so many civilizations raised and disappeared because they failed in dealing with nature. "Civilization crosses the plant, leaving desert behind." Things happened in this way in the past and present. Deforestation and desertification are now very serious environmental problems in tropical countries. The main cause is agriculture practices which are not suitable and destructive to the ecosystem. We should understand that incorrect agricultural practice destroys the ecological basis which is the human basis. This easily happens in the tropical ecosystem.

"Nothing happens in living nature that is not in relation to the whole."

Chapter - 2

Soil

Soil is the most important factor in agriculture. Farmers who practice chemical agriculture often consider soil to be just a material which supports the plants and helps to provide the water and chemical fertilizer, but it is not such a simple matter. Because of this poor understanding of the soil, the power of the soil (not only fertility) is degraded year by year.

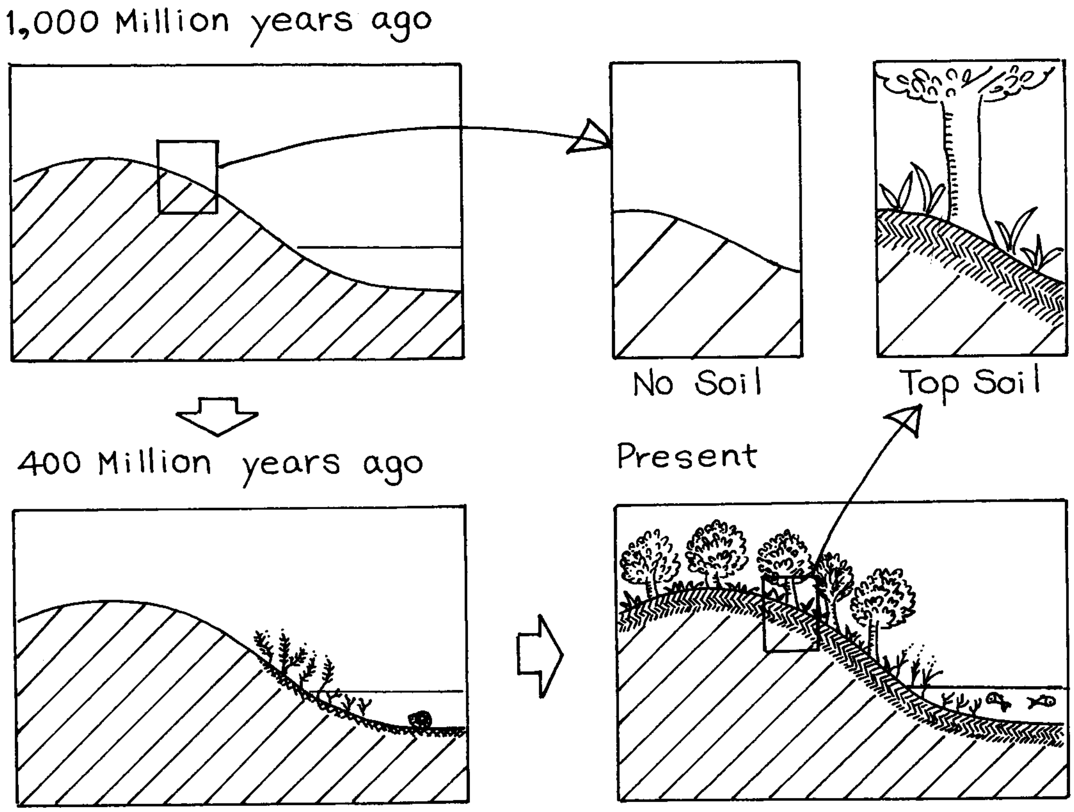
In this chapter we explore:

1) what is meant by the term "soil"

2) the functions and characteristics of the soil

2.1 What is Soil?

Although almost all land is covered by soil and we can see soil everywhere on the planet, there was no soil on the planet before living things appeared. There were only rocks (minerals) and water. After living things (plants) appeared, soil started to be made.



How was soil made? When the organic matter from plants and animals is mixed with the powder of rocks (minerals), biological (micro-organisms) activities and chemical action are started in the mixed matter (minerals, organic matter, water, air, etc.,) and humus is formed through the activity of micro-organisms. This is called soil. The simple definition of the soil is the mixed matter of minerals, humus, water, and air.

Soil has formed through the nutrient cycle and accumulated on the surface of the planet for hundreds of millions of years. This surface soil is called top soil. Top soil is rich in organic matter (humus) and is the most productive layer of the soil. Agriculture is totally dependent on top soil. Where there is no top soil, there is no agricultural practice.

2.2 The Functions and Qualities of the Soil

The functions of the soil in agriculture are: supporting plants; holding and supplying nutrients, water, and air to plants; and, providing a healthy condition for plants to grow. Good soil fulfills all three of these functions very well. Then what kind of soil is good? The farmer's perception of good soil is usually that it is rather black in color, soft, and rich in micro-organisms and earthworms, etc. In technical terms this translates into: well structured; optimal moisture; rich in nutrients; and, high in biological activity.

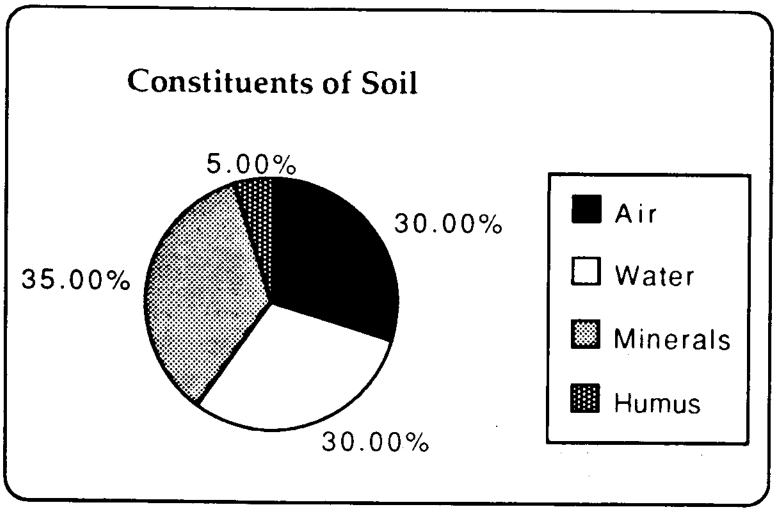
The qualities of good soil can be divided into physical, chemical and biological. Really good soil is well balanced and of high quality in these three areas.

2.2.1 Optimal Physical Qualities

Soil should have high water-holding capacity but also have good drainage. Soil which is considered to be of good physical quality or be well structured carries out both functions well.

Soil is mainly made up of three types of matter: solid (minerals and humus), water and air. Whether or not soil is well structured depends on the allocation of each of these components. If there is too much solid, the soil becomes hard. The soil should be soft enough for plant roots to be able to penetrate. Too much water in soil reduces the percentage of air and results in oxygen deficiency for plants roots. Too much air in soil causes drought. Thus an optimum allocation of water, air and solid is very important in determining a good soil.

The allocation of well structured soil is usually 40% solid (out of this, humus is 5%), 30% water, and 30% air.



The type of soil is determined by the amount of these different components. Clay soil is high in solid content and good in water holding capacity but low in air supply. Sandy soil is high in air content and supply but low in water holding capacity. The difference between clay and sand is the size of the particles and the size of the pore spaces between particles. The optimum size of pore spaces are those which can hold both water and air equally. Clay has small particles and small pore spaces so that if water comes the pore spaces are filled with water and the air is forced out. Sand has big particles and big pore spaces so that though water comes in, air infiltrates and the water is forced out. Therefore, clay and sand mixed soil is appropriate for agricultural land.

Though the type of soil may be the same, some soil is well structured and other is not. Or, in other words, the same soil can be good or bad. The reason for this is the amount of humus in soil. Because of the characteristics of humus, soil which is rich in humus (more than 5%) is very well structured. First, humus is like a paste which combines small soil particles and makes a crumble structure (optimum size of particles and pore spaces). Second, humus is very high in water holding capacity. As a result of these characteristics, if enough humus is supplied, clay soil becomes good in drainage and sandy soil becomes good in water holding capacity. It is very important to note that it is only humus which improves soil structure effectively.

We have learned from the nutrient cycle that humus is made from organic matter by micro-organisms in the decomposition process and disappears in mineralization. Humus doesn't stay forever in the soil. Thus if the supply of organic matter is stopped, the structure of the soil degrades. Chemical fertilizer never develops the structure of the soil. Rather, it destroys it by killing micro-organisms and accelerating mineralization. The main reason for soil structure degradation in Bangladesh is over dependency on chemical fertilizer and lack of organic matter (humus) supplied to the soil.

2.2.2 Optimal Chemical Qualities

The chemical qualities of the soil are the functions which are supported by chemical action. Soil which is chemical of good quality usually has a high nutrient-holding capacity and optimum soil PH.

Nutrient-holding Capacity (CEC)

When minerals dissolve into water, they are divided into cation and anion through chemical action. Most nutrients (minerals) necessary for plants are held in the soil in the form of cations with the colloids except for a few such as phosphorous. Plant roots take these minerals by exchanging cations with the colloid. Therefore, the degree of CEC (Cation Exchange Capacity) of the soil is used by soil scientists as an indicator of the nutrient-holding capacity of the soil.

Whether or not soil has high CEC, depends on the quality and quantity of colloids in the soil. Good quality colloids can keep many cations while poor quality colloids cannot. Colloids are supplied by clay and humus. Sand has no colloids. Therefore, sandy soil is very poor in nutrient-holding capacity while clay soil is much better. The best colloids come from humus. The humus colloid is the deciding factor in whether or not soil becomes good in nutrient-holding capacity. A lack of organic matter in soil causes low nutrient-holding capacity of the soil.

Nutrient Holding Capacity - CEC

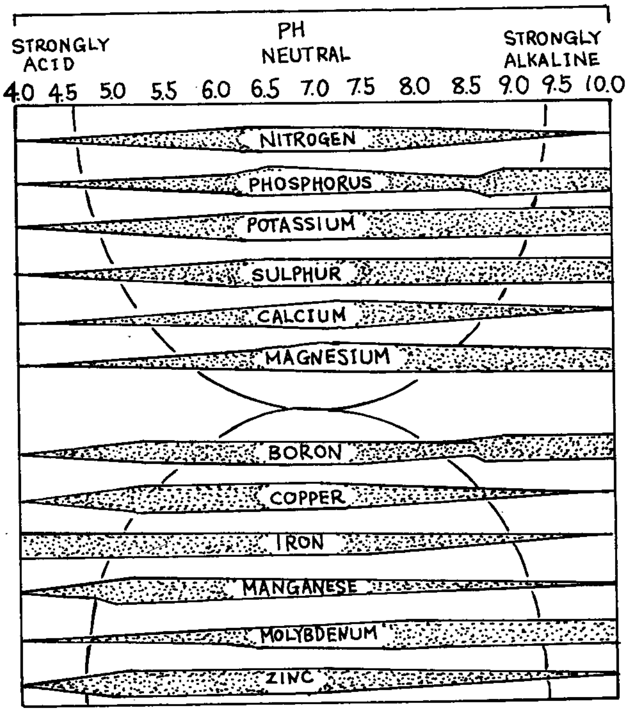
Particular	me/100g
Humus	600
Good clay (Montmorillonite)	80 to 150
Not good clay (Kaolinite)	3 to 15
Sand	0
Good Soil	20 above
Bad Soil	5 below

by M. Maeda and Y. Mastuo (Basic Knowledge of Soil)

Almost all farmers who use chemical fertilizer complain that they must increase the quantity of chemical fertilizer each year, otherwise they cannot maintain yields at the same level. The reason for this problem is the degradation of the nutrient-holding capacity. Dependency on chemical fertilizer for fertilization and lack of organic matter supply reduces the quantity of humus and humus colloids in the soil. Consequently, it becomes poor in nutrient-holding capacity and farmers need more and more chemical fertilizer to compensate. Chemical fertilizer increases the availability of the main minerals (N.P.K.) but it never develop the CEC.

Soil PH

Soil PH indicates whether soil is acidic, neutral or alkaline. Levels go from 1 - 14 with 7 neutral. A smaller number than 7 indicates acidity and a larger number indicates alkali. Plants cannot grow or absorb some minerals in soil which is too acid or too alkaline. The optimum PH level for plants is 5.5. - 7.5. Keeping and regulating soil near neutral PH 7 is a very important part of agricultural practice.



PH Effect on Mineral Availability

Humus has the important function of regulating soil PH. Humus itself is neutral and it can absorb acid and alkali shock from outside. Application of chemical fertilizer makes soil acidic as it is acidic in nature and has no function to regulate PH. Application of calcium is recommended for neutralization of the soil acidity by scientists but this is only a temporary solution and creates other problems (Section 3.1.1).

2.2.3 Optimal Biological Qualities

The biological characteristics of the soil are the functions which are supported through the activity of micro-organisms such as bacteria, fungi, earthworms etc. There are huge numbers of micro-organisms in the soil (more than 100,000,000 numbers in 1 gram of fertile soil). Their activities and balance are the deciding point of whether the soil is of good biological quality or not.

Decomposition and Mineralization

As we learned from the nutrient cycle, micro-organisms have an important role in forming soil and supplying nutrients to plants by producing humus in the decomposition process and releasing minerals in the mineralization process. Decomposition and mineralization are indispensable for soil and plants. The more active micro-organisms, the more humus and minerals are available for soil and plants. Therefore, the supply of organic matter, which is food for micro-organisms, is a must for soil improvement - physically and chemically. Unfortunately, farmers do not put emphasis on supplying organic matter to soil nowadays because of chemical fertilizers.

Soil Health

Another important role of micro-organisms is to promote soil health. There are some micro-organisms (nematodes, fungi, virus, etc.) which are the cause of plant diseases, but the numbers of these disease-causing micro-organisms are very few compared with other harmless and beneficial micro-organisms. If the balance of micro-organisms is not disturbed, the disease-causing micro-organisms are controlled at levels that do no harm to plants.

For example, there are more than 200,000 kinds of nematodes. Out of these, only 2% are known to be harmful to plants and the other 98% are harmless. As well, within the 98% are some which actually minimize the harmful nematodes. Some algae also eat harmful nematodes. The nematode problem never occurs in conditions where micro-organisms are balanced. Nearly 90% of plants diseases are caused by fungi, however some fungi produce disease curing matter (penicillin from blue fungus etc). In well balanced soils, the number of fungi are low in comparison with bacteria. This results in a high B/F (bacteria/fungi) ratio.

A situation where micro-organisms are well balanced is created by sufficient quantity and types of organic matter supply and the elimination of disturbing factors. Chemical agricultural practice disturbs through a lack of organic matter supply, addition of agricultural chemicals and an anti-natural cropping system (Chapter 6).

Chapter - 3

The Problems with Chemical Agriculture

After the Green Revolution, when technology and the notion of chemical agriculture were introduced to Bangladesh, it seems that the gross production of the main grain, rice, has increased. It has, however, created a large negative impact in the rural areas which are very serious for farmers and the natural environment.

Chemical agriculture is only oriented towards economic profit. It takes no consideration of ecological and social factors. From the ecological perspective, it is totally anti-natural and destructive. Consequently this agricultural technology creates many problems.

Soil degradation, increase in production costs, pest problems, health problems and environmental pollution by agricultural chemical poisons (pesticides, fungicides, etc.), and food degradation are some of the problems. Many farmers and other people are now beginning to realize the scale of these problems.

In this chapter we explore:

1) the problems with chemical agriculture

*ecological

*economic

*social

2) how these problems are created

3.1 Ecological Problems

When farmers start using chemical fertilizers and pesticides, they begin to experience a series of problems. We will discuss them in turn.

3.1.1 Degradation of the soil

The first problem farmers using chemical agricultural practices face is degradation of the soil. One cause is lack of organic matter supply. The diminished supply of humus which results in turn causes problems:

1) soil structure is broken down so the soil become hard
2) the water-holding capacity decreases
3) the nutrient-holding capacity also decreases
4) there is micro-nutrient deficiency
5) micro-organisms decrease in number and become inactive

Another factor is the disturbance of micro-organisms caused by the added chemicals in fertilizers and pesticides. As discussed above, very good soil is physically well structured, chemically well balanced and biologically balanced and active. Chemical agricultural practice only improves the availability of some minerals (N.P.K.- a part of chemical quality), while worsening the physical quality, other parts of chemical quality and the biological quality of the soil. Agro-chemicals result in:

1) PH imbalance wherein the soil become acidic
2) accelerated elimination of humus
3) death to some micro-organisms causing an imbalance

To solve these problems, the practice includes the application of more of the same chemicals, as well as others (calcium, zinc, sulphur, etc.) This is only a temporary fix, however, and creates other problems while accelerating the soil degradation. For example, the practice recommends the use of calcium for regulation of low PH (high acidity). Calcium can regulate the soil PH for 3 or 4 months, but after the calcium is no longer effective, the soil PH becomes lower than before. The next time, the farmers need to apply even more calcium. This much calcium in the soil obstructs magnesium and other mineral supply to the plants which is called micro-nutrient deficiency. It is only well decomposed organic matter (humus) which can regulate the soil PH permanently.

3.1.2 Increasing Pest Problems

Degraded soil is unhealthy soil. Unhealthy soil grows unhealthy plants that are easily attacked by pests (insects and diseases). Then, farmers use chemical pesticides which are poison and harmful for all living things to kill the pests. There is no consideration of the root causes of pest attack in this and consequently pest problems are not solved and become worse. The causes of the worsening pest problems are described in the Vicious Cycle of Chemical Pest Control. (Section 7.2)

3.1.3 Degradation of Food Quality

The products grown with chemical fertilizers are low in food quality. This low food quality becomes apparent in taste and preserving capacity of the products. People say that rice and vegetables grown by the chemicals are tasteless and they cannot preserve the products for a long time as they decay sooner. The promoters of chemical agriculture may complain that people have false ideas and this is not scientific. But the perception of people is correct. The low quality is not only in taste and preserving capacity but also in the nutrient content of the products.

Recently, many studies of food nutrients have been carried out on the difference between chemically and organically grown products in Japan. The results show that chemically grown products have less nutrient content (protein, vitamins, minerals) and higher water content compared with organically grown products. The high water content may be one of the main reasons for lack of taste and low preserving capacity of chemically grown products.

Difference in Quality of Products*

Quality	Organically Grown	Chemically Grown
Dry matter	5.90%	3.60%
Vitamin C	67 mg/100g	30 mg/100g
Vitamin C after cooking	24 mg/100g	10 mg/100g
Vitamin C after 10 days	38 mg/100g	2 mg/100g

** Sample is Komastuna (a kind of Chinese cabbage)*
by Study group of Sanbongi Agriculture College in JAPAN 1985

3.1.4 Pollution of the Soil, Water, Air and Products

Use of chemical pesticides results in pollution of the environment as they are chemical poisons. They are very effective in killing living things and have a long term residual effect (some poisons last more than 10 years, e.g. DDT). Actually they are very dangerous for all living things. The poison pollutes the products first, and the soil, air, and water consequently. This pollution results in poisoned products, soil degradation, and the disappearance of fish, birds and other animals in rural areas.

3.1.5 Health Hazards

People experience health hazards in two ways. One is that people eat the poisoned agricultural products and other contaminated food (meat, milk, fish, etc.) from chemical agricultural production. The poison accumulates in the living body and through the food chain, the poison is condensed and becomes a health hazard. It is misinformation that chemical pesticides are not very harmful for the human body because it is used in thinner form. If a person continuously eats the poisoned foods, that person will experience poison accumulation in his/her body.

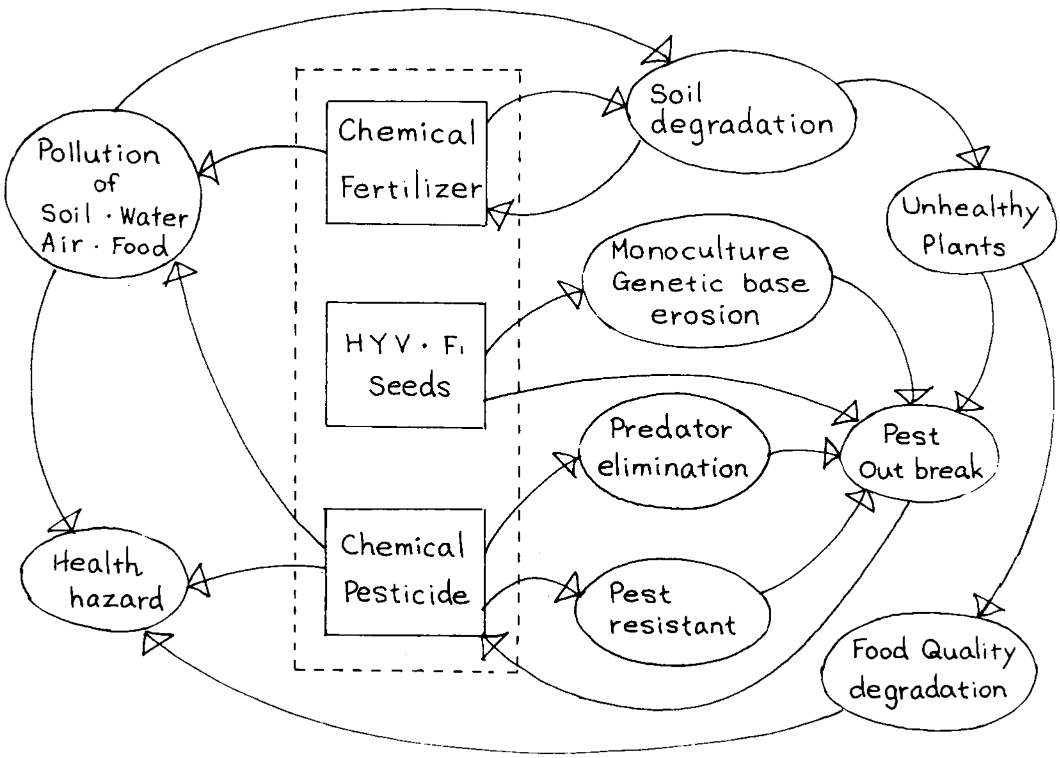
The other hazard is that the chemical pesticide directly affects the farmers who use it. In Bangladesh, most farmers handle pesticides without protection for their bodies (sometimes farmers spread it with bare hands and wearing no shirt) and they are usually the most serious victims. The chemicals also produce a health hazard to other living things, especially livestock. Nowadays, a common accident in the rural area is death of a cow or goat which has fed on crop residues sprayed with chemical pesticide.

3.1.6 Disappearance of Local Varieties

Local varieties are the genetic base for improving seeds and are a very important resource for the future. But more local varieties are disappearing each year. The main reason is the introduction of HYV seeds and hybrid (FI) seeds. Farmers are giving up the use of local varieties and growing a few kinds of HYV and hybrid seeds. That accelerates mono-cultural practice and creates an ecological imbalance in agriculture. (Section 8.1)

3.1.7 Other Problems

Aside from these, there are some other problems. One of the serious problems in Bangladesh is reduction in ground water. Deep tubewells are now commonly used for irrigation of HYV rice paddy in winter (dry) season. However, this causes a decrease in ground water level. Many hand tubewells do not work in areas where many deep tubewells are working. If the intensive use of ground water is continued for a long time it will use up all the ground water which will not be restored for years. As there is a high iron content in ground water in Bangladesh, iron accumulation in the soil is another problem. This will create more problems (imbalanced nutrients, etc.) in the future.



The Vicious Cycle of Chemical Agriculture

3.2 Economic Problems

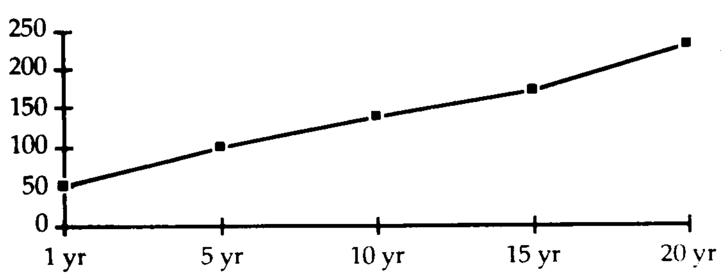
As mentioned before, chemical agriculture is profit-oriented based on the purchase of external inputs (chemical fertilizer, pesticide, HYV seeds etc.) in order to get maximum output or yield. This is supposed to give economic benefits to farmers. However, recently, it does not seem to work that easily. The economic problems they face are discussed below.

3.2.1 Increase in Production Costs

In chemical agricultural practice, annual production cost increases are unavoidable. There are mainly two reasons. One is increase in the quantity of external inputs. (chemical fertilizer, pesticide, etc.) Most farmers started HYV rice cultivation in Bangladesh about 15 - 20 years ago. When they started using chemical fertilizer for rice cultivation, they used about 50 kg of chemical fertilizer (usually only urea [N]) per acre. Today, they have to use 200 to more than 300 kg of chemical fertilizer (not only urea, but also, TSP [P], MP [K], etc.) per acre and they still cannot get the same yields as before. The reason for this is soil degradation.

The other factor in increasing costs is the increase in the price of external inputs. The price of chemical fertilizer was only 0.5 taka/per kg in 1972 but today it is 5.0 - 6.0 taka/per kg. This is a more than tenfold increase in 20 years. The cost of irrigation has also increased nearly 6 times. Meanwhile the price of rice has only doubled in 20 years.

Trend of Chemical Fertilizer Consumption (kg/acre)



*This is a common case of farmers who use chemical fertilizer for HYV rice production in Bangladesh by S. Murakami 1990

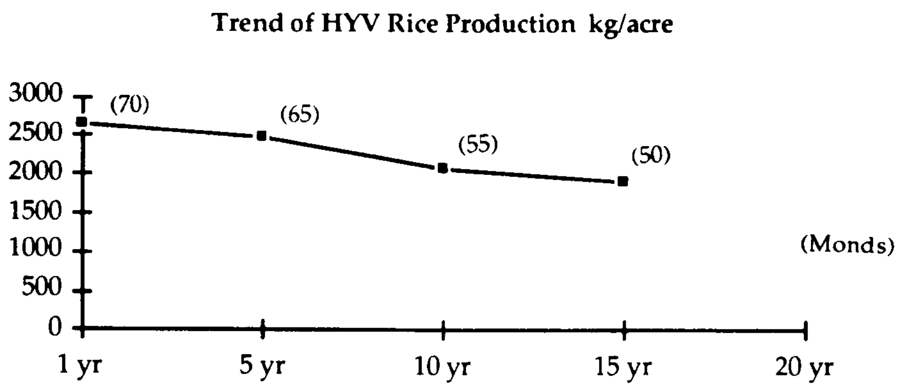
Some farmers say that HYV rice cultivation using high levels of agro-chemicals and irrigation will never give them profits.

It is a losing concern.

3.2.2 Decrease in Yield

Though farmers increase the quantity of external inputs, they cannot get as much production as before. For example, there is the case of a farmer who started HYV rice production 15 years ago. When he started using agro-chemicals for the first time, he used to get about 70 mond (2,660 kg) of rice production per acre. Nowadays, a good yield is about 50 mond (1,900 kg) per acre. This is not a unique case but common and almost all farmers who cultivate HYV rice using agro-chemicals have this kind of experiences.

The reason for the decrease in yield is again, soil degradation. It is obvious that degraded soil never produces good yields.



*This is the common case of farmers who adapted HYV rice cultivation using agro-chemicals in Bangladesh. by S. Murakami

3.3 Social Problems

Many people believe that technology is neutral, and that good or bad results depending on the people who use it. A knife, for example, is very useful and indispensable for cooking, but deadly as a weapon. However, this general idea is not always true. Technology has a character which is based on the background and notions of those who innovated and developed it. Some technologies require less energy, only locally available resources and are environmentally sound (e.g. appropriate technologies). Others require much energy, external inputs and are destructive to the environment (e.g. nuclear plant). Every technology influences its environment somewhat when it is introduced. A technology which depends on external resources and has a major monetary requirement creates a large impact on society (community) and this impact is usually negative for poor people. The Green Revolution (chemical agriculture) is an example of the latter. The social problems created are discussed below.

3.3.1 Creating a Gap between Rich and Poor

This is the major problem which is criticized in many developing countries. The causes are mainly two. One is that it was only rich people who could use the Green Revolution technology in the initial stages when resources and facilities were limited. They had enough money to purchase external inputs (agricultural chemicals) and social power to access facilities (e.g. government subsidies for irrigation). There was little scope for small farmers to use the technology. The other relates to the characteristics of chemical agriculture. It can sustain increased yield (2-5 times of local variety yield) and give profits for about 10 years. Sustaining about 10 years is too short for the adapted farmers, but long enough to create the gap between the adapted (rich) and the non-adapted (poor).

3.3.2 Creating Dependency

When farmers start chemical-agriculture, they need materials and know how. But both the necessary materials and the know how are from the outside. The materials (fertilizer, pesticide, etc.) are factory products. The know how has been introduced by agricultural scientists and has no relation to local knowledge or traditional farming systems, and rather, denies that local knowledge. In these ways, chemical agriculture is making farmers dependent on others (outside) materially and mentally.

Consequently, farmers are losing their independence and confidence which are most important for them to solve their problems.

Further, internationally, developing countries are becoming more dependent on foreign aid countries (industrialized countries) which give aid in the name of assistance for developing chemical agriculture and selling agricultural inputs. Another aspect of foreign aid for promoting chemical agriculture is to create markets for agricultural inputs such as chemical fertilizer, pesticide, irrigation facilities and machines.

3.3.3 Losing the Traditional Farming System and Knowledge

Traditional farming systems, regarded as out of date and unscientific by agricultural scientists, are disappearing year by year. Farmers are becoming convinced that there is chemical fertilizer for soil fertilization and chemical pesticide for pest control. If there are other problems, then they go to their agricultural extension worker for help. Traditional farming knowledge is being lost.

Evaluating the traditional farming system, we find that it is based on ecologically sound agricultural methods. For example, farmers used to grow Dhaincha (Sesbania aculata) for 1 - 2 months and mix it with the soil for soil fertilization. The Dhaincha is a fast growing leguminous crop which supplies nitrogen to the soil. Farmers did not know that Dhaincha fixes nitrogen but they understood its effectiveness. There were many traditional methods in soil fertilization, pest management, cropping pattern, etc. All these methods are environmentally sound with low external inputs, stable and sustainable.

If agricultural scientists could realize the importance of the traditional farming system and try to improve agricultural methods based on it, it would be a really helpful contribution for farmers and for the country. Unfortunately, they regard traditional farming methods as out of date and unscientific. Consequently local knowledge is being lost.

Since then, Western patriarchy's highly energy-intensive, chemical-intensive, water-intensive and capital-intensive agricultural techniques for creating deserts out of fertile soils in less than one or two decades has spread rapidly across the third world as agricultural development, accelerated by the Green Revolution and financed by international development and aid agencies.

Vandana Shiva
(Staying Alive)

Chapter - 4

The Principles of Ecological Agriculture

If we understand the problems with chemical agriculture, we soon realize that there is no option but to find an alternative method of agriculture. This method should have the following criteria:

1) not disturb the natural environment
2) ensure as much or more productivity as chemical agriculture
3) ensure sustainability
4) less dependent on external inputs

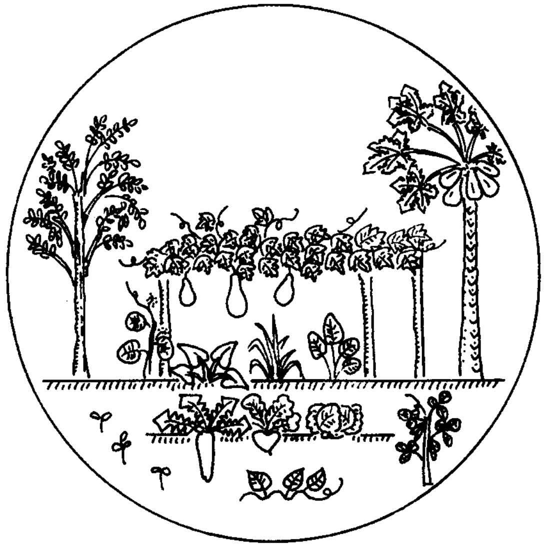
As the alternative, we introduce ecological agriculture which is based on the ecological system of the natural forest. As we have seen, the natural forest shows us the ideal system for bio-mass production, stability, soil conservation, etc. and we can identify the principles of ecological agriculture from it.

In this chapter we explore:

The principles of ecological agriculture –

1) Diversity
2) Living soil
3) Recycling
4) Multi-story structure

4.1 Diversity



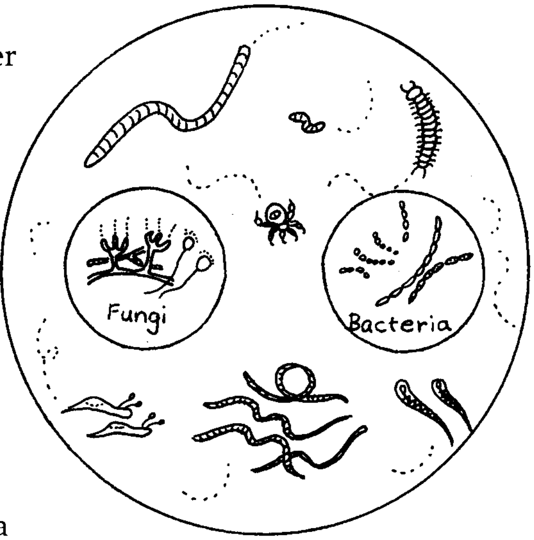
In the natural forest, there is almost no serious pest problem. The reason is the diversity in plant species and varieties and in animals and micro-organisms. For example, there are approximately 100 plant species grown per acre of natural forest but in one acre of agricultural land, there are very few species, and in mono-culture, only one.

It is diversity which ensures ecological balance (stability) while mono-culture is the most unstable ecosystem and susceptible to things like pest outbreak. Therefore, increasing diversity is one of the most important points in ecological agriculture for ensuring stability of farming.

In addition, diversity varies income sources in a farm, which reduces the risk of total failure of crops. Farming methods which ensure diversity include the following:

1) Diverse cropping (Section 6.3)
2) Mixed cropping (section 6.5)
3) Crop rotation (Section 6.4)
4) Planting permanent trees and grasses in the boundary area (Section 5.5)
5) Keeping various animals (livestock, fish, bees, etc.)

4.2 Living Soil



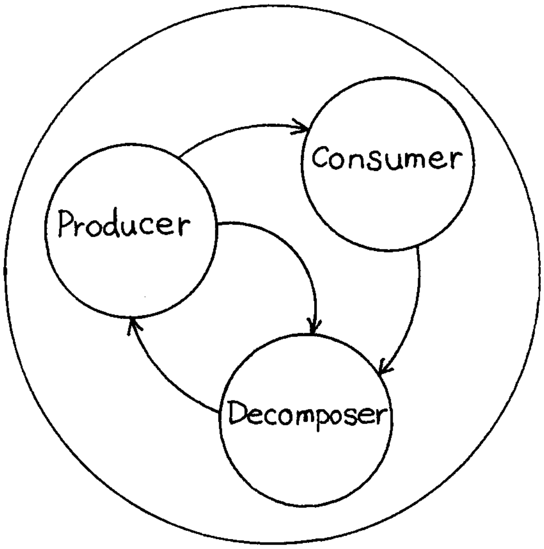
Soil is not only physical matter which supports plants and keeps water and nutrients. It is living.

Chemical agriculture has lost this important understanding, consequently, soil degradation becomes very serious in this practice. This problem has not occurred naturally, but is created artificially through lack of knowledge of and emphasis on the soil among farmers and agriculturalists. To restore the soil, it is necessary to change our idea of the soil from non-living matter to a living thing.

Living soil means that there are huge numbers of micro-organisms in the soil. The activity of micro-organisms is the deciding factor in the health and fertility of the soil. As living things need to be fed and cared for, so the soil should be fed and cared for. The points which ensure the living soil are as follows:

1) Feed the soil through the regular supply of organic matter (Section 5.1)
2) Cover the soil in order to check erosion (Section 5.1)
3) Remove disturbing factors such as agricultural chemicals (Section 5.1)

4.3 Recycling



In the natural forest, there is a nutrient cycle based on the soil. Everything comes from the soil and is returned to the soil. Because of this cycle, there is nothing unnecessary in nature. Everything needs and everything supports in turn. This cycle is a key point for proper use of resources but in agricultural practice, the cycle is always disturbed and problems are created.

In agricultural land, almost all biomass production is taken away from the land by harvesting. Almost nothing is left or returned, and only some minerals are added through chemical fertilizers which cause soil fertility depletion. In the case of commercial livestock, a farmer trys to keep as many cows or chickens as possible in a limited place, and all livestock and feed are purchased and fed from outside. The farmer may get good income by selling products. However at the same time, the farmer will face the problem of dealing with a huge amount of cow or chicken dung, because there is not enough land to return it. This causes a sanitary problem in the area called livestock pollution. (This problem is very common in Japan.) In this way, breaking the cycle creates extreme problems. One is the fertility depletion due to the lack of organic matter and the other is the pollution due to too much organic matter.

The problems are created by a lack of knowledge of the nutrient cycle among farmers and agriculturists, and their tendency to specialization (thinking about one unit without considering its relation with others). Therefore, to solve the problem, it is very important to understand cycling and think how to recycle in agricultural practice. Recycling makes the proper relationship between farm elements (crop plants, animals, fish, trees, etc.) in order to have benefits for every element. Recycling is the key point in using available resources on the farm properly and reducing external inputs to farm production.

A Fishery Case Study

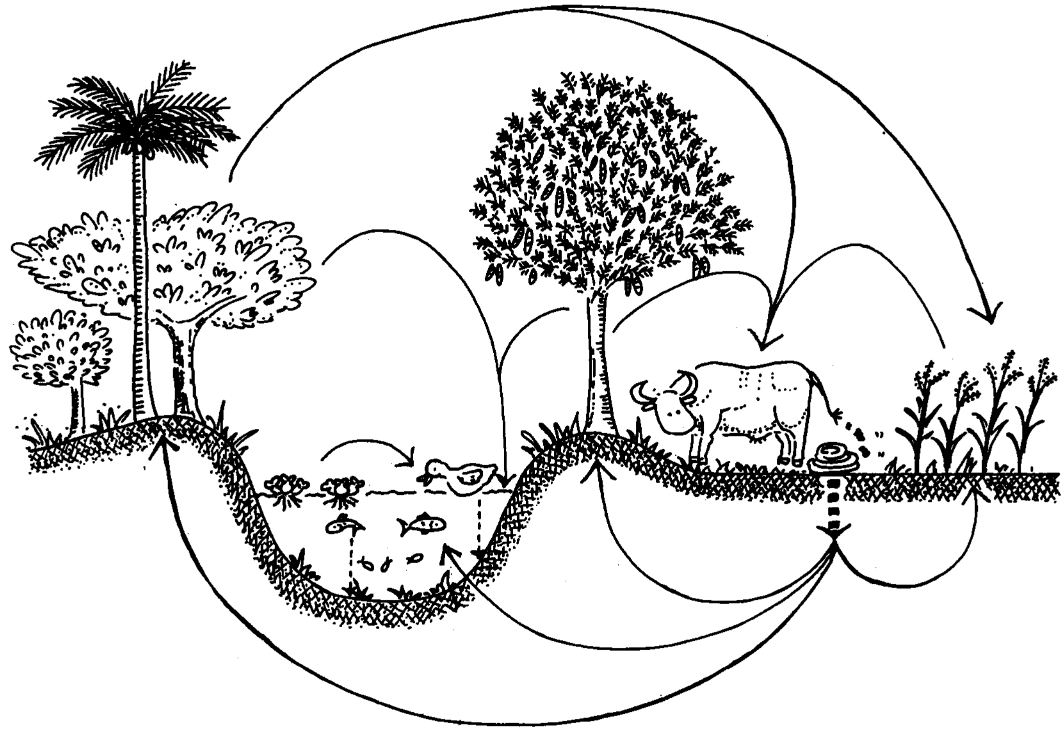
In the case of fisheries, specialists do not want to plant trees and grasses on the bank of the pond and have water plants in the pond because they think that tree shade and water plants reduce the plankton production of the pond and therefore fish production. They clean the pond and purchase the feed (input) from outside and sell the fish (production) to the outside. There is no recycling in this conventional practice and this creates some problems. The bank of the pond is broken by the rainfall so that re-excavation is needed, and oxygen deficiency due to lack of water plants causes fish diseases so that the use of medicine (chemicals) and the purchase of an oxygen supply machine are needed. They may get maximum production of fish but they will face many problems which sometimes cause the total failure of fishery or increases the cost of production for temporary solutions.

However, if trees and grasses are planted on the bank of the pond and the idea of recycling is introduced, much benefit will be gained.

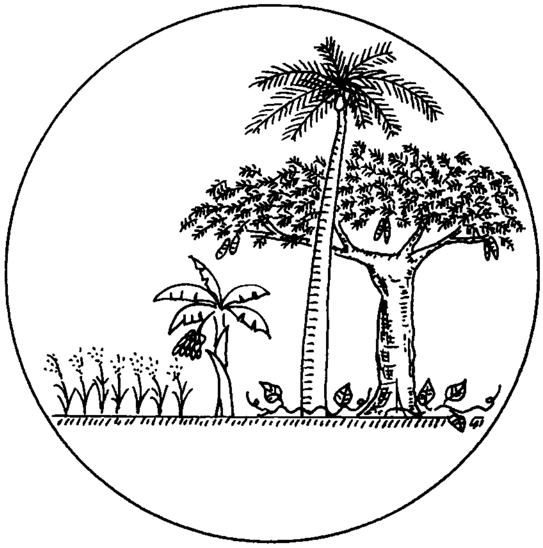
1) the bank of the pond is protected by the trees and grasses so that no re-excavation is needed
2) grasses (para, etc.) and leaves of trees (legume trees, etc.) can feed some cows
3) some ducks can be kept in the pond by feeding on water plants and others
4) cow and duck and organic matter from trees and grasses can be used as feed for fish, so that purchase of feed is not necessary
5) the water of the pond is kept clean by water plants (no oxygen deficiency) so that fish can live healthily
6) fruit production (papaya, banana, coconuts, limes, etc.) will be another source of income in a few years
7) other benefits such as the production of fuel and organic matter for soil fertilization as well as an ecological balance in the farm

This practice may reduce fish production somewhat but the increase in other sources of income (fish, cow, duck, fruits), reduced costs (almost no expenses) on external inputs (feed, etc.), and decrease in fish disease will result in more net income than that of the conventional fishery.

In this way, the problems will be solved by applying the idea of recycling and much benefit will be gained from it. It is only necessary for the fishery specialists to be released from their specialization trap.



4.4 Multi-Story Structure



The real source for agricultural production (biomass) are sunlight and rainwater. In the natural forest, the biomass production is always higher than that of agricultural land. The reason is the multi-storied vegetative cover of the forest that enables maximum use of sunlight and rainwater. The structure of agricultural land is usually horizontal, which cannot utilize these resources properly.

If the sunlight and the rainwater are utilized properly in agricultural land, they can provide great benefits to the land. If not, they become the main causes of drought and soil erosion. Strong sunlight and rainfall are characteristic of a tropical climate such as that in Bangladesh, so it is very important for tropical agriculture to build up the multi-story structure of agricultural land.

The points which ensure the multi-story structure in a farm are as follows:

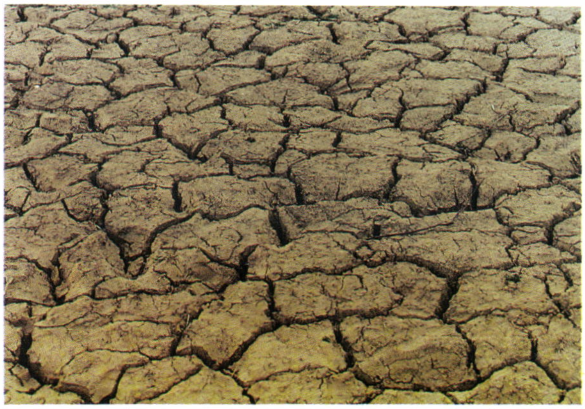
1) Planting various kinds of permanent trees in the boundary area and planting shade tolerant crops. (Section 5.5)
2) Mix tree crops and annual crops in good combination. (Section 6.5)

The energies coming into our system are such natural forces as sun, wind and rain. Living components and some technological or non-living units built into the system translate the incoming energies into useful reserves, which we can call resources.

Bill Mollison
(Permaculture - A designer's manual)

A. AGRICULTURAL PROBLEMS CAUSED BY EXTREME CLIMATE

1. SOIL EROSION
Heavy rain is the main cause of erosion of agricultural land. Farmers suffer from too much water in the rainy season (June-September).
June 1988, Proshika farm)



2. DROUGHT
There is almost no rain from November - February. Farmers suffer from lack of water in the dry season.
(February 1990, Kaliakul, Bangladesh)

B. ECOLOGICAL AGRICULTURAL APPROACH TOWARDS A SOLUTION

3. TREES AND GRASSES IN THE BOUNDARY AREA
Lemon grass and leucaena (Ipil ipil) at the boundary of a farm. Planting trees and grasses is one of the solutions to check erosion. It also creates a "multi-story structure" and enriches "diversity" in a farm.
(November 1989, Proshika farm)

4. MULCH
Egg plant field is mulched with Lemon grass. Mulch protects soil from heavy rain and prevents evaporation by strong sunlight. It supports the "living soil".
(February 1991, Proshika farm)

5. COMPOST
Leaves of Sesbania (Dhaincha) are piled in a compost pit. Compost is good fertilizer for the "living soil" and also supports "recycling".
(July 1988, Proshika farm)

6. GREEN MANURE
Grass pea (Khesari) is a very good green manure and cover crop for the winter dry season.
(February 1991, Proshika farm)

C. THE BOUNDARY AS PRODUCTIVE SITE

7. WINDBREAKER
Leucaena and other timber trees are planted as a wind break. Timber and fuel are also provided by the trees.
(November 1988, Chitwan, Nepal)

8. ORGANIC MATTER PRODUCTION
Flamengia trees are planted on the border of an egg plant field. The leaves are a very good mulch and compost material.
(February 1991, Proshika farm)

9. FUEL
Branches of leucaena are good fuel for cooking
(January 1990, Proshika farm)

10. FERTILIZER
Leaves of leucaena are put on a field as mulch.
(January 1990, Proshika farm)

11. FRUITS
Papaya trees are planted on the border of a field.
(November 1989, Proshika farm)

12. PAPAYA
This high yielding papaya is a local variety. More than 50 kg of papaya was harvested.
(March 1990, Proshika farm)

D. SOME RESULTS OF ECOLOGICAL AGRICULTURE AT PROSHIKA FARM

13. CABBAGE WITH GREEN MANURE MULCH
Black gram (Mashikalai) was grown for 1.5 months, cut and not plowed and put on the bed. Then cabbage seedlings were transplanted in.
(October 1989)

14. CABBAGE
Cabbages after 3 months. The average cabbage is nearly 2 kg in weight. There was almost no pest attack. No additional fertilization after the green manure mulch and no plowing.
(January 1990)

15. MIXED CROPPING
Planting pumpkin with chili is one traditional mixed crop in Bangladesh.
(October 1989)

16. PUMPKIN
A pumpkin from the mixed crop is about 15 kg. No pest attack.
(December 1989)

17. CAULIFLOWER
The process of growing was the same as cabbage, green manure mulch and no plowing. There was no pest attack.
(November 1989)

18. MASTER PIECE
This cauliflower is 2.2 kg in weight. Nature shows that without agro-chemicals, crops grow excellently and healthily if man does not disturb.
(December 1989)

E. OTHERS

19. LEUCAENA (Ipil ipil)
One of the fastest growing multi-purpose trees in Bangladesh. It can be cut 3 times a year. Leaves are used for fodder and fertilization and branches as fuel.
(October 1989, Proshika farm)E. Others

20. LABLAB BEAN
Dolichos lablab (Seem) is a common bean in Bangladesh. It produces a large amount of biomass and is a good cover crop in the hot, dry season.
(February 1991, Proshika farm)

21. MIXED CROPPING
Radish (Mula), Mustard (Shorisha) and Potato (Alu) planted in the same field. This is also a traditional practice. It enriches "diversity" and minimizes pest attack.
(November 1988, Chitwan, Nepal)

22. SESBANIA SESBAN (Joyanti)
Sesbania sesban is also one on the fastest growing multi-purpose trees in Bangladesh. It grows to 14 foot height and a 4 inch diameter in about 8 months.
(February 1991, Proshika farm)

23. SHADE TOLERANT CROP
Turmeric (holud) and Giner (Ada) are planted under the shade of mango trees. They are a good shade tolerant crop.
(October 1990, Northeast Thailand)

24. WATER LILY
Water plants have the function of purifying and supplying oxygen to the water.
(January 1991, Proshika farm)

Part 2

Practical Methods

Chapter - 5

Soil Fertilization and Conservation

Soil fertilization is one of the most important tasks in agriculture. Every good farmer is concerned about how to keep or restore soil fertility in order to maintain good yields.

As we saw in Chapter 2, a good soil is not only rich in the basic nutrients including nitrogen, potassium and phosphorous, it is also physically well structured and biologically very active. When the chemical, physical and biological qualities of the soil are well-balanced, we consider it to be optimal soil.

Many farmers are concerned about adding fertility or nutrients, but there are very few who are concerned about, and put emphasis on, protecting soil through soil conservation. Nutrients involve the chemical quality of the soil, the latter its physical and biological quality. This is the main reason why erosion is a problem in agricultural land. If we think about it, we will realize that fertilization and conservation are equally important.

In this chapter we explore:

1) the principles of the soil fertilization and conservation

2) methods of soil fertilization and conservation

   * mulch with less tillage
   * green manure
   * compost
   * planting permanent trees and grasses along the boundary

5.1 The Principles of Soil Fertilization and Conservation

The ideal model of soil fertilization and conservation can be found in the natural forest.

A regular supply of organic matter.

Adding and returning organic matter to the soil is essential. It is only organic matter which can provide the necessary elements (nutrients) for growing plants, and improving the chemical, physical and biological qualities of the soil. The amount of humus in the soil decreases through mineralization, thus resupplying lost humus every year is a must for maintaining soil fertility and quality. Approximately 8 ton/acre of organic matter a year is necessary for this purpose. To improve soil quickly or to treat chemically spoiled soil, an initial addition of double this amount (16 ton/acre) is recommended. Organic matter can be added using various methods (mulch, green manure, compost, etc.). If enough organic matter is supplied to soil, no crop would face nutrient deficiency. It is ideal if sufficient organic matter for a farm is produced within it.

Cover the soil.

The surface of the soil should always be covered by vegetation or organic matter. When the soil is left bare, it is easily attacked by rain, wind and sun heat - the main causes of degradation of the soil structure and soil erosion.

Raw organic matter should not be mixed with the soil

Mixing raw (not well decomposed) organic matter with the soil should be avoided as the early stages of the decomposition process will create many problems. These include:

1) consumption of air in the soil causing oxygen deficiency - very important for plant roots
2) production of methane, a gas harmful to plant roots
3) increased (organic) acidity in the soil
4) disturbing the balance in micro-organisms by increasing harmful fungi and creating a low B/F ratio

All of these are harmful for plants and cause pest problems. Raw organic matter should only be put on the surface of the soil as mulch. Incases where raw organic matter needs to be mixed with soil (e.g. green manure), sufficient time should be given for complete decomposition before planting.

Plant trees and grasses in boundary areas

The boundary area of the farm should be covered by vegetation through the planting of perennial trees and grasses. The main purpose is to protect it from being easily broken by rain and to check top soil run off. In addition, this area then becomes a source of organic fertilizer, fodder, fuel, food (fruits), timber, etc. and it also acts as a wind breaker.

No use of agricultural chemicals

Agricultural chemicals may demonstrate quick action in supplying nutrients (N.P.K.) and killing insects but they should be avoided as they create an imbalance in the soil ecosystem. The acid of chemical fertilizer disturbs the activity of micro-organisms and the poison of chemical pesticide kills them. They both create an imbalance in micro-organisms and cause pest problems. In addition, the nutrient balance in plants will be disturbed through the supply of only a few nutrients causing disease and the insect attack. Farmers think that the use of both chemical and organic fertilizer is better for growing plants. This practice will never solve pest problems which result from an imbalance of micro-organisms in the soil and nutrients in the plants.

5.2 Mulch with Less Tillage

Mulching involves covering the soil surface with various kinds of organic matter such as weeds, grasses, fallen leaves, straws, etc. The function of mulch is both conservation and fertilization. Less tillage is possible where enough mulch covers the soil.

5.2.1 Advantages

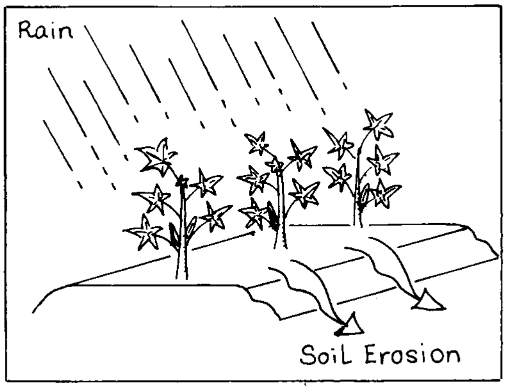
Soil Protection

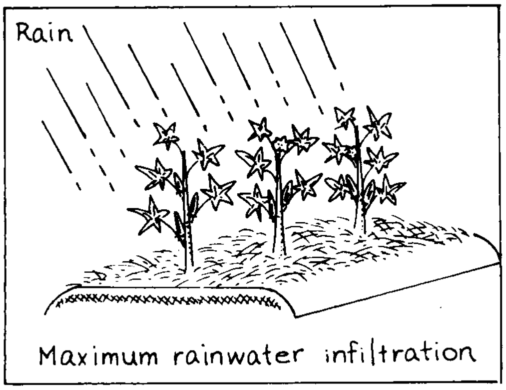
The sun heat and rainfall cannot attack the soil directly because of the mulch material on the soil surface. The main cause of erosion in Bangladesh is bare soil in agricultural land and strong rain fall in the rainy season. Plowing is also sometimes the cause of the soil erosion. Therefore, mulch with less tillage is a very appropriate and effective soil protection method for this country.

Effect of Mulch Rate on Run-off and Soil Loss

Mulch rate (t/ha)	Run-off (%)	Soil Loss (T/ha)
0	50	4.83
2	19.7	2.48
4	8	0.52
6	1.2	0.05

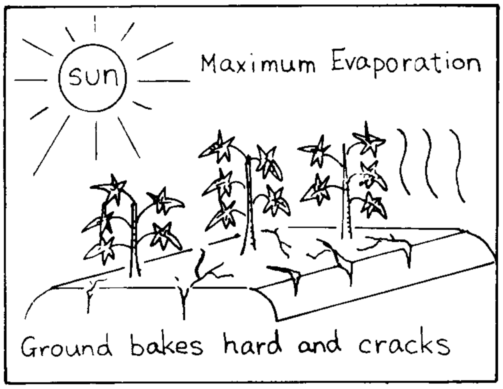
** Rainfall 61 mm. on uncropped land*
by Vandana Shiva (Staying Alive)

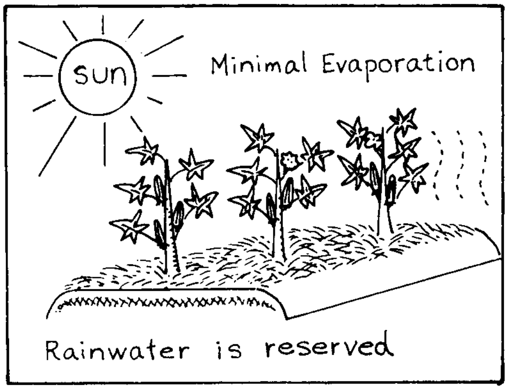




Improvement of Physical Soil Structure

Because the soil surface is covered by mulch, the soil is not compacted by rainfall and not dried up by direct sun light. Mulch develops the crumble structure on the soil surface which increases water holding capacity and keeps optimum moisture in the soil. In the dry season, mulch prevents evaporation and retains moisture. If soil is always covered by thick mulch (above 2 inch or 5 cm), plowing is not necessary.





Gradual Fertilization

Mulch eventually decomposes and disappears. As it decomposes it adds nutrients to the soil. Mulch fertilization is:

1) balanced and rich in micro-nutrients
2) slow and steady in decomposition
3) less wasteful as the decomposition process takes place on the land where the nutrients are needed

Weed Control

Weeding is a major task in agriculture. As mulch reduces the weeds on the land, continuous mulching is an excellent weed control method. At the Proshika farm, more than 2 inch (5 cm) thick mulch controlled nearly 90% of the weeds.

Simple and Less Labour

Mulching is a very easy method as it simply involves putting mulch material (e.g. grasses) on the soil surface. Furthermore, as mulch reduces the need for tillage, plowing labour is reduced.

5.2.2 Disadvantages

Fungi

In the rainy season, mulching sometimes introduces fungi harmful to plants. This can be minimized however by selecting material such as high C/N ratio grasses and by drying the mulch material before using it. Continuous mulching can also minimize fungi problems by creating a balance of micro-organisms on the soil surface which control the outbreak of harmful fungi. It is recommended that mulching begin in the dry season and continue in the rainy season. At the Proshika model farm, mulching has been practicing for almost 3 years and there are no disease problems caused to date.

Obstruction to Seed Broadcasting

Mulch sometimes becomes obstructive for broadcasting seeds. Thin mulch after sowing is not a problem but thick mulch before sowing is sometimes a problem for seed germination. The problem can be minimized by controlling the thickness of mulch and timing broadcasting of seeds. There is no problem caused to the planting of seedlings.

5.2.3 Mulch material

Any kind of organic matter can be used as mulch material including tree leaves, grasses, crop residue, saw dust, etc. Weeds, lemon grass, coconuts leaves, straw, water hyacynths, leaves of multi-purpose trees (Ipil Ipil, Grilicidia, Flamengia, etc.) and compost have been used as mulch material at the Proshika farm.

In selection of mulch material, it is important to consider your particular requirements and the characteristics of the material. If you require soil protection and want to avoid fungi problems in the rainy season, the use of high C/N ratio (high carbon content) material (more than 60 e.g. straw, lemon grasses, coconuts leaves, etc.) are recommended. These last for a long time and fungi do not break out as easily in such material. For soil fertilization purposes, low C/N ratio (high nitrogen content) material (e.g. leguminous grasses, residue of leguminous crop, leaves of leguminous trees, compost, etc.) are recommended.

5.2.4 Living Mulch

Living mulch involves growing a leguminous grass, short in height and with spreading ability as opposed to putting mulch material on the soil. The advantages are:

1) there is no need to collect mulch material
2) very effective and long lasting soil protection
3) leguminous grasses can provide nitrogen to the main crop

In temperate zones, clover is commonly used as living mulch (Fukuoka uses clover for his rice field and orchard for mulching purpose). In Bangladesh, Khesari (grass pea) can be used as living mulch with a somewhat taller crop (e.g. egg plant) in winter season.

5.2.5 Cover crop

A cover crop is a sort of living mulch. It covers the land with vegetation in the hot dry summer season when land is fallow. Advantages are:

1) prevention of evaporation lowering moisture loss
2) uses sun energy to produce biomass (a source of fertility)
3) weed control

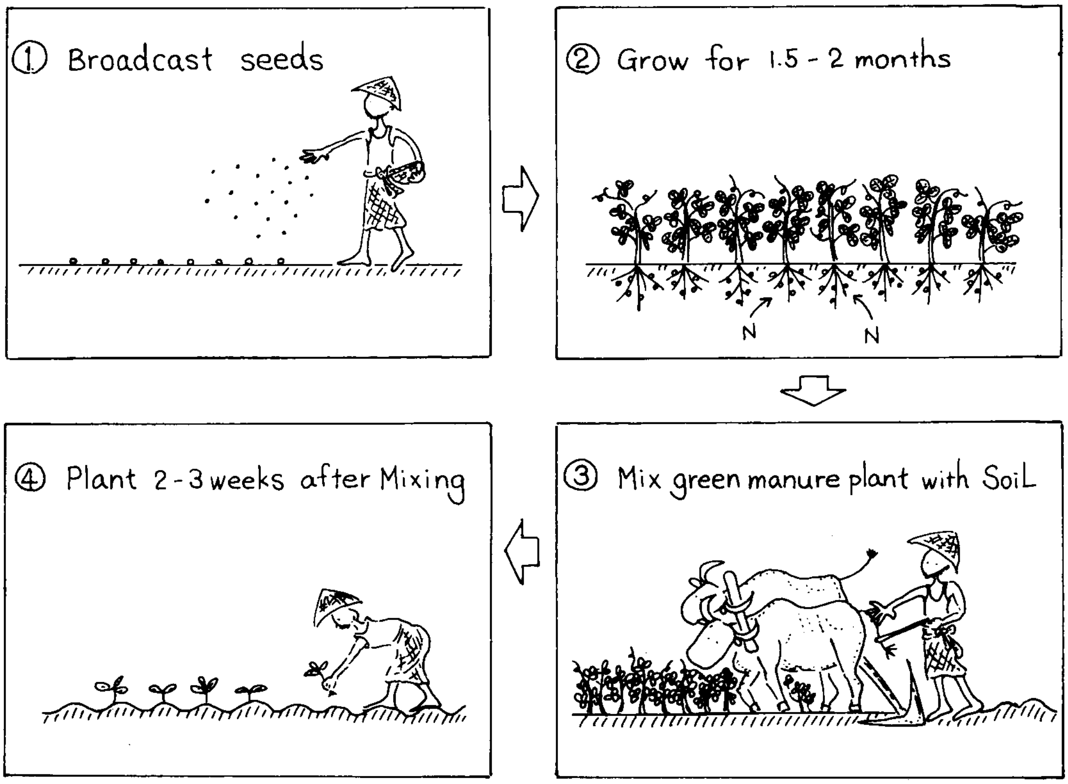
Favourable characteristics of a cover crop are:

1) leguminous crop
2) wide spreading (cover big area)
3) strong against heat

Seem (Dolichos lablab) is a very effective cover crop in summer time (March - May) in Bangladesh. Velvet bean has excellent potential as a cover crop, though it is not common in Bangladesh. (The seeds of velvet bean are available at Proshika farm).

5.3 Green Manure

The process of green manure is to grow green manure plants (legume grasses and others) for one or two months and return all the biomass to the soil as organic fertilizer.



5.3.1 Advantages

Organic Matter Supply

Why can farmers not supply enough organic matter to the land? The main reason is the shortage of organic matter. The necessary amount of organic matter per acre is usually about 8 - 10 tons per year. That amount of organic matter is not easily available from outside and collecting it is quite tedious work. Green manure is a very effective method which can easily supply the necessary amount of organic matter to the land and bypasses the need for outside collection.

Improve Soil Quality

Green manure provides a large amount of organic matter to soil at once which other methods cannot do easily. Therefore, this improves soil quality dramatically. First, soil structure is improved so that soil becomes soft and water holding capacity and drainage ability increase. Second, availability of nitrogen in soil increases with leguminous green manure crops and other chemical qualities (CEC, Ph, etc.) are improved. Third, numbers and activity of micro-organisms increase. This minimizes the numbers of nematodes (increase of algae decreases nematodes).

Less Labour and Cost

Green manure practice only requires labour in broadcasting seeds and plowing or cutting afterwards. For one acre only 20 - 30 kg of seed (e.g. Dhaincha) is required which costs only Tk 200 - 300.

5.3.2 Disadvantages

Time Required

Though there are many advantages, farmers are not very interested in practicing green manure. The main reason is the time required to produce it. (1.5 - 2 months for growing and 2 weeks for decomposition.) The land cannot be used for growing other crops during this time and therefore, this necessitates a cropping pattern to leave time for green manure. A shorter term practice is green manure mulch. As the crop is not mixed in but just cut and left on the soil surface, 2 - 3 weeks of decomposition time can be eliminated.

Risk

If insufficient time is given for decomposition after mixing the green manure crop with soil, it creates harmful gas (Section 5.1) and crop plants cannot grow well. Leaf and fruit crops are particularly susceptible to this gas while cereal crops experience less difficulty with it. It is a bit difficult to judge whether decomposition is complete as the appropriate time is dependent on temperature, soil moisture, kinds of planting crop, etc. High temperatures and optimal moisture reduces the time. A farmer should decide the time from his/her experience, but 2 - 3 weeks should be sufficient.

5.3.3 Green Manure Crops

Favourable characteristics of a green manure crop include:

1) fast growing so that a large amount of biomass is gained in a short time
2) leguminous crop which can fix nitrogen (N) from air into soil by N-fixing bacteria at its roots

Proshika farm has mainly used leguminous crops including Mashikalai (back gram), Mung bean, Dhaincha (Sesbania aculata) and Khesari (grass pea). Cereal crops such as maize and sorghum supply large amounts of organic matter and heal the land when used as green manure.

Amount of Nitrogen Fixed by Different Leguminous Plants

Plant Name	N-Fix Bacteria	Amount Kg/ha
Sesbania	Rhizobium	524
Ground nut	"	172 to 240
Bengal gram	"	100 to 140
Soya bean	"	50 to 150
Indian bean	"	50 to 125
Sweet pea	"	30 to 100

by Buckman and Brady 1984 (Natural Property of Soil)

5.3.4 Green Manure Mulch

This is a variation of green manure. The difference is you cut the manure plants and put them on the soil as mulch. Advantages are :

1) reduces time of decomposition
2) soil protection
3) reduces the labour for plowing

Cauliflower and cabbage were supplied with Mashikalai (black gram) green mulch material at the Proshika farm in '89 - '90. The results were remarkable.

Green Manure and Cover Crops in Bangladesh

	Name of Plant	Sowing Time	Seeds/Acre
1	Sesbania (Dhaincha) *Sesbania aculata*	Apr. - Aug.	25kg
2	Black gram (Mashkalai) *Phaseolus mungo*	Mar. - Oct.	30kg
3	Sunnhemp (Sonpat) *Crotalaria juncea*	Mar. - Jun.	30kg
4	Mung bean (Mung dal) *Phaseolus radiatus*	Mar. - Sep.	30kg
5	Cow pea (Go seem) *Vigna tunguiculara*	Mar. - Sep.	35kg
6	Jack bean *Canavalia ensiformis*	Apr. - Sep.	40kg
7	Grass pea (Khesari) *Lathyrus sativus*	Oct. - Dec.	30kg
8	Sweet pea (Motarshuti) *Pisum sativum*	Oct. - Dec.	30kg
9	Lentil (Mashuri dal) *Lens culinaris*	Nov. - Dec.	25kg
10	Faba bean (Bakla kalai) *Vicia faba*	Oct. - Nov.	40kg
11	Indigofera (nil) *Indigoferà sumatrana*	Oct. - Nov.	15kg
12	Jute (Pat) *Corchorus olitorius*	Apr. - Jun.	20kg
13	Lablab bean (Seem) *Dolichos lablab*	May - Jan.	10kg
14	Velvet bean *Mucana pruciens*	Apr. - Oct.	10kg

5.4 Compost

Composting is the most popular practice for improving soil fertility. The process involves mixing various organic material (high and low C/N, wet and dry matter, dung, grass, soil, etc.), allowing for decomposition, and after complete decomposition, using this as organic fertilizer. The main purpose of composting is to make raw organic matter into humus which is most important for the soil and not harmful to plants.

5.4.1 Advantages

Quick Action

Compared with mulch and green manure, compost starts working very quickly - in about 10 days. The organic material in compost is already decomposed during the process (2 - 3 months) and is in a form (humus and nutrients) suitable to plants.

Healthy Fertilizer

Good compost is a healthy fertilizer and creates healthy soil. One of the main benefits of this method is it avoids mixing raw organic matter with soil by decomposing the organic matter completely first. Raw material is harmful to plants and causes pest problems (Chapter 5.1).

Uses Locally Available Resources

Any organic matter can be used to make compost. Even waste matter, which cannot be used on land directly, can be used. This method also promotes use of locally available resources such as Kochuripana (water-hyacinths) which are available in huge amounts in Bangladesh. Most farmers regard Kochuripana as a problem and expend a lot of labour to remove them (sometimes by firing) from the land. If they realized that Kochuripana is rich in minerals and makes a very good material for compost, as well as realized the advantages of compost, they would compete with each other to use it.

5.4.2 Disadvantages

Amount of Organic Matter Required

The necessary organic matter for one acre per year is about 8 ton or 8,000 kg. If a farmer wants to supply that amount of organic matter through only compost, a huge amount of organic matter is needed. It is almost impossible for most farmers in Bangladesh to gather this much as organic matter (e.g. cow dung, crop residue) is also required for fuel for cooking and other purposes as well. To deal with this it is necessary to find alternative fuel sources (multi-purpose trees) and use other fertilization methods (green manure, and mulch) with compost.

Nutrient Loss

During the process, some nutrients are lost to sun heat, rainfall and wind. To check this loss, the following points should be considered :

1) site selection (under tree canopy, roofing)
2) proper processing including appropriate timing, turning and completing within 3 months

Labourious

The process of compost is quite labourious as it involves collecting material, making the compost, turning the compost pit and carrying the compost to the field. Therefore it is recommended that most organic matter be returned as mulch and unsuitable material be used for compost.

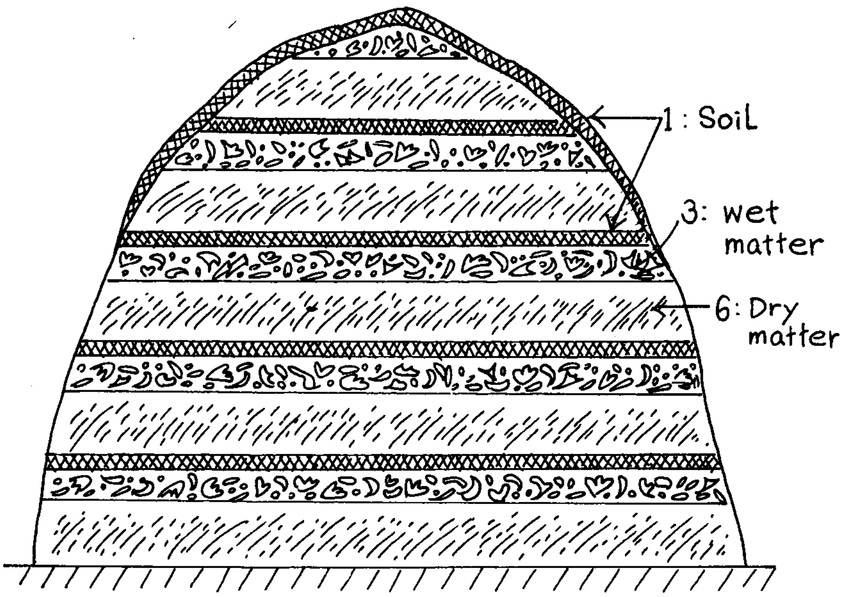
5.4.3 The Composting Process

The followings are some important points for making good compost:

Mix dry and wet matter with soil

It is important to mix dry and wet matter with soil in order to provide the micro-organisms which help good decomposition. The aerobic bacteria which mainly carry out the composting process also require sufficient water and air. The appropriate ratio of each material is 6 (dry matter): 3 (wet matter): 1 (soil). Dry material has little water content and usually high C/N ratio which decomposes slowly.

Examples are rice straw, other crop residue, dried water hyacinths, sawdust and tree leaves. Wet material has high water content and usually low C/N ratio which decomposes quickly. Examples are cow dung, other animal dung, kitchen waste, leguminous grasses and leaves of leguminous trees.



Oputimum size of compost is 5" x 5" x 5"

Balance compost material

All organic matter has a C/N ratio. For instance, rice straw is 60 and cow dung is 25. Material with a high C/N ratio decomposes more slowly than that with a low C/N ratio. Mixing the two is important. Micro-organisms work most effectively when the C/N ratio of the total organic matter is around 40 (e.g. mixing equal amounts of rice straw and cow dung).

Turn compost pit twice every 3 weeks

To make good compost it is important to turn the compost pit twice every 3 weeks in order to supply air to the micro-organisms. This also allows observation of the compost (moisture, progress of decomposition, etc.) and introduction of any control measures needed (e.g. water, drying).

Good compost smells good, is black brown in colour and has a regular consistency with no trace of the original material.

5.5 Planting Trees and Grasses along the Boundary

Utilization of the boundary of a farm is very important in ecological agriculture. Farmers tend not to think of the boundary as a resource, but it can become a very productive and useful area by planning perennial trees and grasses.

5.5.1 Advantages

Checks Soil Erosion

The main cause of soil erosion in Bangladesh is heavy rainfall in the rainy season and bare soil. Top soil is washed away because of the heavy rain if there is no protection on the boundary of the land. The heavy rain sometimes not only washes away the top soil but also breaks the boundary. Such erosion problem can be solved by planting trees and grasses on the boundary.

The roots of trees and grasses hold the soil firmly so that the boundary will never be broken and top soil run off is checked. Proshika farm faced serious erosion in 1988 when the boundary of the farm was broken several time by heavy rain and much money was spent on repairs. After planting trees and grasses, the problem was solved in a year.

Wind Breaker

Trees along the boundary are a wind breaker, protecting the crops from strong wind. In Bangladesh, the beginning of the rainy season is a season of storms (cyclone, etc) but damage to crop will be minimized in this way.

Organic Matter Production

Boundary areas are usually not used for any production. By planting trees and grasses, this area can be a source of organic matter, which can be returned to the land as organic fertilizer. Permanent trees utilize sunlight all year and nutrients deep in the subsoil which annual crops cannot use. They also produce a large amount of organic matter (biomass).

Fodder Production

Leaves of leguminous trees and grasses (para, nephia, etc.) are very good fodder for livestock. Scarcity of fodder is a very serious problem in Bangladesh which will be minimized by trees and grasses in boundary areas.

Fuel Production

The shortage of fuel wood in the rural areas of Bangladesh is very serious. Rural people use almost all available organic matter (cow dung, crop residue, etc.) as fuel which means they cannot use it for soil fertilization. Trees can provide many branches for fuel which will solve or minimize the fuel problem. If you plant 365 Ipil Ipil or Joyanti (Sesbania sesban) 2 feet apart along the boundary, in one year, sufficient fuel for a family will be available from the trees. The required boundary area for this is only 700 feet (210 m) which is the minimum boundary line of 2 bigha (2/3 acre = 0.27 ha).

Increased Diversity

Aside from these direct impacts, there is a very important indirect effect of building up the ecological balance of the farm land. Various kinds of permanent trees and grasses increase plant diversity and provide living places for animals (birds, spiders, frogs, etc.) which control insects. The diversity builds up ecological balance.

5.5.2 Disadvantages

Shade

Shade is the main reason farmers do not want to carry out this practice. This problem can be minimized, however, through the planting of shade tolerant crops under the trees and using trees that can be cut several times a year.

Long Term Process

Though farmers know the advantages of planting trees and grasses, they are not very interested in the practice because it takes at least one to two years to establish effective conditions and the benefits gained by the practice are indirect and difficult for farmers to understand. So it is very important for motivation to demonstrate the practice.

5.5.3 Multi-Purpose Trees

Usually farmers do not want to plant any trees in a farm because they believe that trees make shade in which crops may not grow well. It is important to advise farmers to plant multi-purpose trees in the boundary area. Multi-purpose trees are usually not very tall and can be cut several times a year. Most multi-purpose trees are fast growing and leguminous and provide all the advantages listed above.

Proshika has been using Ipil Ipil, Gliricidia sepum, Sesbania sesban, Sesbania glandiflola, Babula, etc. in the boundary area of the farm and along the ban of each plot. Using as many kinds of trees as possible (diversity) is always better than mono-plantation (e.g. only Ipil Ipil) in terms of ecological balance.

At the back of the book are a series of tables listing trees of various types (multi-purpose, timber, shade and fruit) for reference.

An object seen in isolation from the whole is not the real thing.

Masanobu Fukuoka
(The One Straw Revolution)

Chapter - 6

The Cropping System

Mono-culture and continuous cropping are the normal cropping system in present agricultural practice. Ecologically, these are totally anti-nature. Consequently, this cropping system causes many problems such as nutrient deficiency, disease and pest outbreak. These problems are very serious. To solve these problems, the introduction of an alternative cropping system is necessary.

In this chapter we will explore:

1) The problems with the present cropping system including -

   *Mono-culture

   *Continuous cropping

2) An alternative cropping system based on -

   *Diverse cropping

   *Crop rotation

   *Mixed cropping

6.1 The Problems with the Present Cropping System

6.1.1 Mono-Culture

Man's tendency in agricultural practices today is normally towards monoculture. That is, to grow only one or a few kinds of crop species which are profitable. Traditional farmers avoided monoculture as they realized this was a cause of pest outbreak and very risky. As the introduction of chemical pesticides and fertilizers shows quick action temporarily, farmers are motivated to practice mono-culture. In addition, introduction of HYV seed accelerates the extension of mono-cultural practice in rice growing. Major problems are:

Pest Outbreak

It is easy for an insect or disease pest to destory only one kind of crop. There was serious pest outbreak at Amra (Hog palm) tree farm in Manikganj in 1990. Almost all the Amra trees in the area were attacked by beetles and the leaves were eaten all up. After eating up the Amra trees, the insects tried to eat the leaves of other trees but they could not. Finally the insects disappeared, leaving the Amra trees damaged and the others untouched. Each insect has a diet habit. In this case, if Proshika had a mono Amra orchard, it would have faced complete damage of the orchard. Fortunately, the orchard was saved because it was a mixed fruit garden. This shows that mono-culture is susceptible to pest attack and creates favourable conditions for the pest to spread.

Erosion of Genetic Resources (local varieties)

HYV and hybrid (F1) seeds have been introduced to farmers. Because of these seeds, farmers stop using local varieties which are very important for maintaining diversity and as a genetic resource in future. (Chapter 8.1)

High Economic Risk

Planting only one crop is very risky. If the crop is damaged by insects, diseases or climate (flood, drought, storm, etc.) this will mean total failure of the farm. Even if production is good, the market price of the crop might be down due to over supply in the market. Mono-culture will never contribute to a stable economic condition for the farmer due to these factors.

6.1.2 Continuous Cropping

Continuous cropping means the same kinds of crops are planted on the same land every year or seasonal continuous cropping. For example, a farmer planted cabbage last winter and again he/she is planting cabbage this winter on the same land. The problems caused are:

Specific (Micro-) Nutrient Deficiency

Zinc and sulphur deficiency in the paddy in Bangladesh are examples of micro-nutrient deficiency. The main reason for this is continuous cropping which requires consumption of the same nutrients continously and use of chemical fertilizers which supply only a few nutrients (N.P.K.). In this situation, addition of other kinds of chemical fertilizers containing the deficient nutrients will never solve the problem. It is necessary to introduce crop rotation and a supply of organic matter to the soil.

Specific Diseases

The zone around plant roots is very special and very different from the other parts of the soil in terms of activity of micro-organisms. Usually micro-organisms are very active in the root zone because of root secretion. Each plant root zone creates its own unique conditions for specific micro-organisms. For example, the root zone of the tomato plant is favourable for the propagation of nematode, while the maize (cereal crop) is not. Therefore, if continuous cropping is practiced, favourable condition are established for certain micro-organisms and specific plant diseases may result.

Numbers of Micro-Organisms
Continuous and Non-Continuous Tomato Crop

Micro-Organisms	Continuous	Non-Continuous
Fungi (F)	2.1×10^4 (4.4×10^5)	1.3×10^3 (9.0×10^2)
Bacteria (B)	1.8×10^6 (1.8×10^7)	6.8×10^5 (1.9×10^7)
Nematode	25 (28)	0 (0)
B/F ratio	85.7 (40.9)	523 (21111)

** (   ) is one month after transplanting*
by M. Kobayashi, 1985 (Micro-organisms and Organic Matter)

6.2 An Alternative Cropping System

To solve problems like pest outbreak and micro-nutrient deficiency it is important to introduce an alternative cropping system. Avoiding mono-culture is a must. Some alternatives can be found in traditional local farming practices. The alternative cropping system includes the following:

1) Diverse cropping
2) Crop rotation
3) Mixed cropping

In order to practice an alternative cropping system, it is necessary for farmers to understand the classification of crops. All crops are classified botanically, however, it is very difficult for farmers to understand botanical family classifications. It may be appropriate for them to classify the crops by look and shape of plants.

<u>An Alternative Crop Classification</u>

<u>Cereal crop</u>
rice family crop, rice (dhan), wheat (gom), mazie (bhuta), etc.

<u>Legume crop</u>
bean family crop, Indian bean (seem), black gram (mashikalai), grass pea (khesari), long yard bean (boloboti), etc.

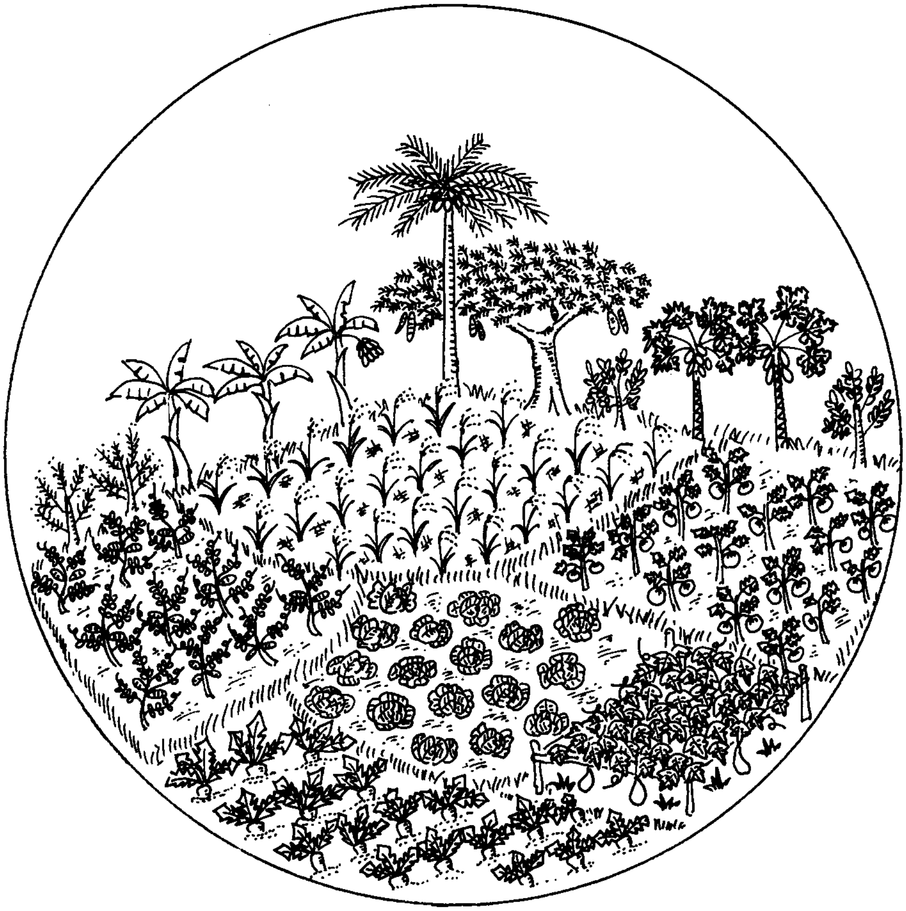
<u>Leaf crop</u>
leaf vegetable crop, cabbage (banda kopi), cauliflower (phulkopi), amaranthus (lalshak, data), Indian spinach (puishak), spinach (palonshak), etc.

<u>Root crop</u>
has a root or stem underground which can be eaten - potato (alu), sweet potato (mistialu), yam (metealu), clocasia (kochu), radish (mula), ginger (ada), etc.

<u>Fruit crop</u>
fruit vegetable crop, eg plant (begun), tomato, okra (dherosh), bottle gourd (Lau), cucumber (shosha), etc.

6.3 Diverse Cropping

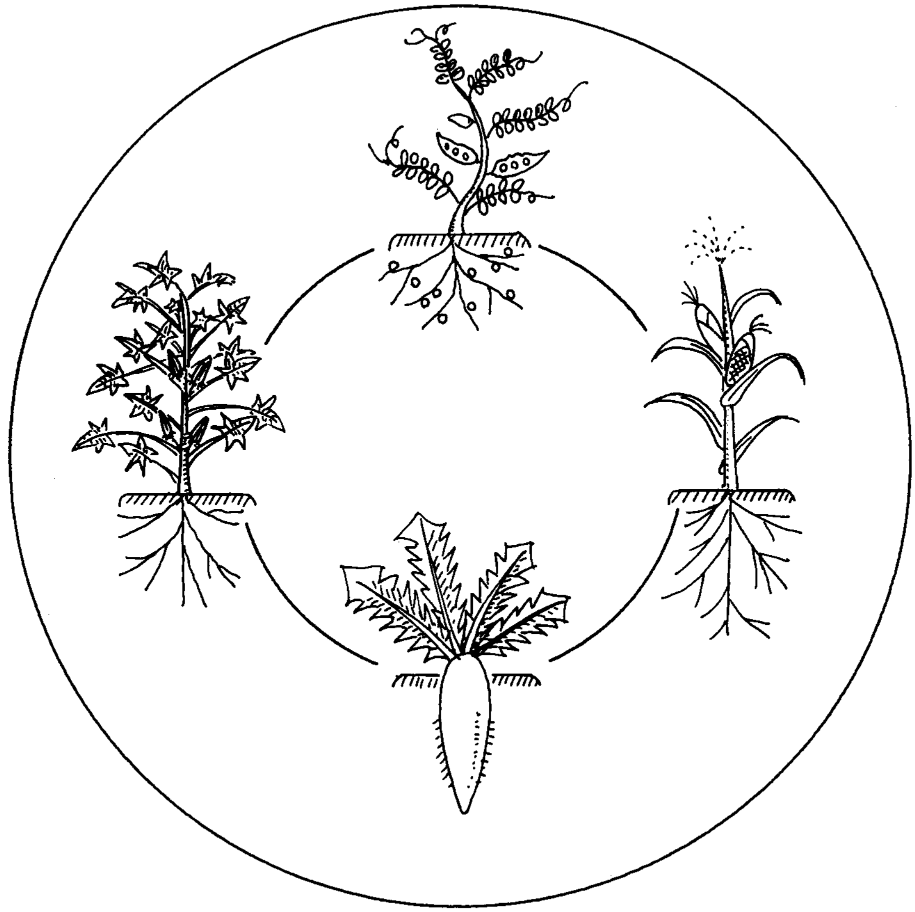
This cropping system involves planting as many species (different crops) and varieties (e.g. different rice varieties) as possible on the farm land. This reduces pest problems and the risk of complete failure of the farm. To implement diverse cropping, it is necessary to divide the farm into plots and number each plot. A plot of less than one bigha (1/3 acre) is suitable in terms of average farm size in Bangladesh and ecological requirements.



6.4 Crop Rotation

This cropping system involves rotating various kinds of crops in turn on the same land. It reduces fertility degradation, micro-nutrient deficiency and the outbreak of specific diseases.

To develop a good crop rotation plan, it is important to consider the character of each crop. There are mainly two factors to consider.



One is the degree of consumption of nutrients. For example, after or before a high nutrient consuming crop, growing a low nutrient consuming crop is appropriate.

<u>Nutrient Consumption (from low to high consumption)</u>

1) Leguminous crop
2) Root crop
3) Leaf crop
4) Fruit crop
5) Cereal crop

Cereal crops have the highest nutrient consumption. Legumes consume the least. In addition, legumes supply nitrogen (N) to the soil. So a key point for soil fertility maintenance is to put leguminous crops in the rotation.

The other factor is disease tolerance. If soil becomes contaminated by a pest or disease, it is necessary to plant a disease tolerant crop (e.g. cereal).

<u>Disease Tolerance (from strong to weak)</u>

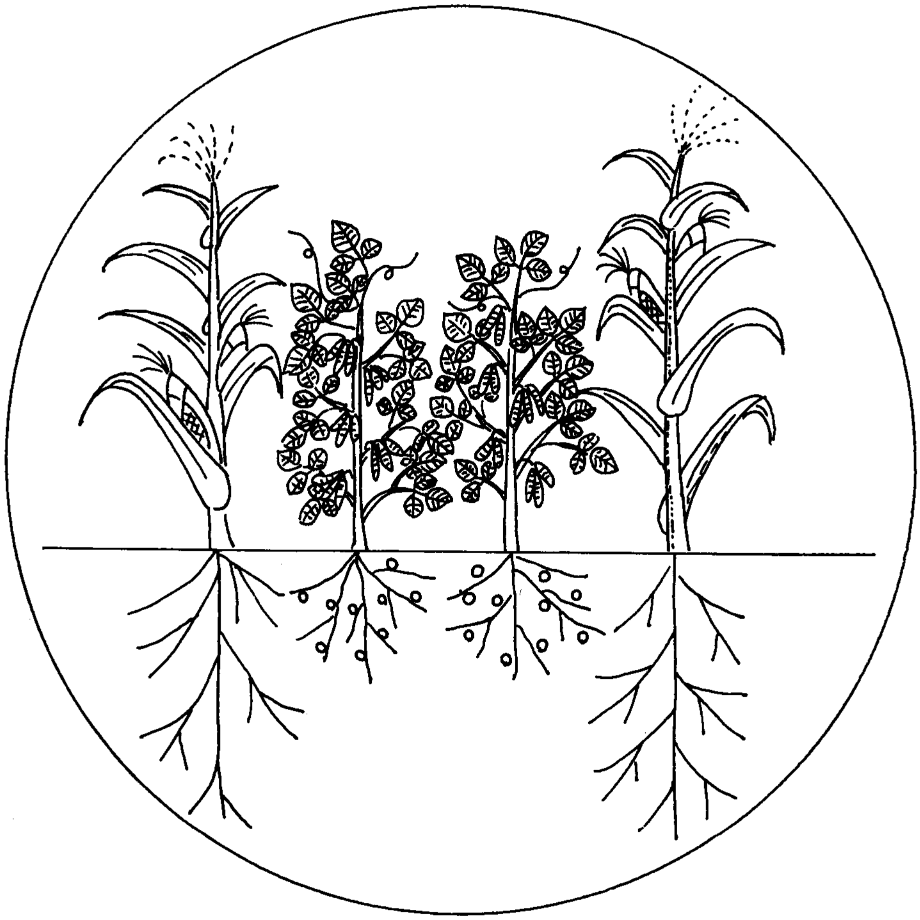
1) Cereal crop
2) Root crop
3) Legume crop
4) Leaf crop
5) Fruit crop

Cereals are the most disease tolerant while fruit is the weakest crop. Cereals clean or "heal" the soil subsequently minimizing disease problems. (Note: This is applicable to the land where mainly vegetable crops are planted, not to the paddy where continuous cereal cropping is practiced.) So, a key point in minimizing disease problems is to put a cereal crop in the rotation.

6.5 Mixed Cropping

A mixed cropping system is a variation of diverse cropping and involves planting various kinds of crops together in a plot. For instance, planting maize with bean is found in many countries as a local farming practice. Maize (cereal crop) is tall, deep rooted and a high nutrient consuming crop while the bean is short, shallow rooted and a low nutrient consuming crop which also provides nitrogen to the soil. There is no competition between the maize and the bean and the maize can use nitrogen fixed by the bean. The total production of maize and bean together is higher than that of maize or bean alone. There are many other good combinations of plants like this.

The advantages of mixed cropping include decreasing pest problems, better use of land, sunlight and rain fall.



Factors to consider in plant combinations include:

<u>Nutrient Consumption</u>

As mentioned above, the combination of the cereal and the legume is appropriate in terms of the soil fertility maintenance. The cereal is a high nutrient consuming crop, while the legume is a low nutrient consuming crop which provides nitrogen to the soil by the N-fixing bacteria.

<u>Root Depth</u>

If a deep rooted crop is planted together with another deep rooted crop, both crops will compete with each other and not grow well. A shallow rooted crop with another shallow rooted crop causes more or less the same problem. The combination of a deep rooted crop and a shallow rooted crop is appropriate. Planting maize with pumpkin is a good example. The maize is the deep rooted crop and consumes nutrients in the sub soil (deeper zone). The pumpkin is the shallow rooted crop and consumes nutrients in shallow soil. There is less competition between the maize and the pumpkin. The deep rooted crop is usually a standing type of crop and the shallow rooted crop is generally spreading type crop.

<u>Insect Repellent Plants</u>

There are some crops which have a unique smell that repels some kinds of insects. For example, onion has a specific smell that butterflies dislike. If onion is planted with cabbage, the smell prevents the insects (worms) from attacking the cabbage. Combinations like onion and cabbage are called companion plants. The companion plant is a very effective pest prevention measure.

<u>Shade Tolerance</u>

There are some crops which can grow well in the shade. The crops are called shade tolerant crops or shade loving crops. Planting shade tolerant crops under tree crops or tall crop plants increases the utilization of the land. Planting Anarosh (pineapple) under Katal (jack fruit) and Ada (ginger) under Am (mango) are some good examples.

Mixed Crop Combinations in Bangladesh

Main Crop	Companion Crops
Mustard (shorisha)	lentil, radish, grass pea (khesari)
Chili (marich)	black gram (mashkalai), radish, okra (dherosh), egg plant
Cabbage (bandakopi) Cauliflower (phulkopi)	onion (piaj), tomato, coriander (dhaniya), potato
Maize (bhuta)	ground nuts, Indian bean, lentil, mung bean (mug), black gram, pumpkin (mistikumra)
Tomato	onion, garlic (rashun), carrot (gajar), cucumber
Cucumber (shosha)	radish, maize, beans (dal), tomato
Sugar cane (ak)	lentil, ground nuts, grass pea
Egg plant (begun)	beans, chili, potato
Potato (alu)	beans, cabbage, peas (matar), maize, egg plant
Indian bean (seem)	maize
Ground nuts (badam)	maize, sugar cane
Radish (mula)	cucumber, mustard, tomato, chili
Lentil (mashuri)	mustard, maize, sugar cane

Chapter - 7

Pest Management

The outbreak of pests or so-called harmful insects and diseases is now a very serious problem in agricultural practice. Though farmers have been using chemical pesticides to control them, the problems have not been solved, or rather, the situation has been getting worse in a vicious cycle. Why is this happening?

First, agricultural research has been emphasizing how to control the pest problem when it appears, not understanding the root causes of the problem. No problem can be solved without considering the root causes. Second, it is man's lack of understanding of the fact that in a healthy environment, plants grow well, and pests do not attack plants easily. Even if pests do attack, damage is minimal.

We need to break out of the vicious cycle of pest problems and discover a permanent solution.

In addition, we need to reconsider weeds which are regarded by many as a pest.

In this chapter we explore:

1) the nature of the "pest problem"

2) the vicious cycle of chemical pest control

3) natural pest management including -

*preventive measures

*control measures

4) weeds and what they tell us

7.1 What is the Pest and What is the Problem?

Man thinks that pests (insects and diseases which attack crops) are absolutely harmful. But is this idea really true? From the perspective of man's benefit, it seems to be right. However, from an ecological point of view, it is completely wrong. Everything in an ecosystem interacts and all elements are necessary to keep ecological balance in the natural environment.

So-called harmful insects are, in ecological terms, consumers of the first order. As we learned in Section 1.1, the role of the insects in the food chain, is not harmful but rather important and in dispensable. If there are no insects, consumers of the second order cannot survive, and the food chain will be disturbed.

In a well balanced ecosystem, the numbers of the insects are kept within certain limits which are not harmful to plants. But when disturbances come from outside, the insects may break out suddenly and become harmful to plants (crops). If we observe this fact carefully we can realize that the problem is not the insects, but the cause of the imbalance in the ecosystem which allows the insects to increase. The insects should be seen as teachers who tell us that we have done something wrong to the ecosystem. Therefore, before deciding that the insects are bad and should be removed, we must discover why the insects has broken out.

The same thing can be said about plant diseases. Plant diseases occur as a result of the outbreak of specific micro-organisms or so-called disease germs (e.g. some kinds of nematode, fungi, virus, etc.). These disease germs are usually limited in numbers, so they are not harmful to plants. But when the soil ecosystem is disturbed and conditions are created in which disease germs can easily break out, then plant diseases occur. The problem is not the existence of the disease germs in the soil but the disturbing factors which create the imbalanced soil ecosystem. Therefore, it is very important for disease prevention to remove the disturbing factors (e.g. continuous cropping, use of agricultural chemicals, etc.) and create a balanced soil ecosystem.

7.2 The Vicious Cycle of Chemical Pest Control

The present chemical agricultural practice utilizes chemical pest control. The practice involves the following:

1) use of chemical poisons which are harmful to all living things
2) dealing with immediate problems (symptomatic cure only)
3) no consideration of the root causes.

Let us see in more detail why it is impossible to control so-called harmful insects and diseases by chemical pesticides and why they make the situation worse.

7.2.1 Insects

A quick generation cycle and the production of a huge numbers of eggs at once is a characteristic of insects. This very characteristic enables the insects to develop resistance to the chemical insecticide quickly. So farmers are forced to use more pesticide or other stronger pesticides to control the insects. But again, the new insect generations become resistant to the pesticide. A second factor is the disappearance of natural enemies (e.g. spiders, frogs, birds, etc.) which eat the insects. The natural enemies are fewer in number and have a slower generation cycle and therefore are less productive than the insects. They cannot develop the same resistance against chemical pesticide and consequently are killed and disappear. The result is the creation an imbalanced ecosystem in which only the insects can break out.

This vicious cycle caused by the use of chemical pesticide not only makes the pest problem worse but also creates health hazards. The farmers who use the chemical pesticide (poison) are affected first, and those who eat the poisoned products are affected consequently.

7.2.2 Disease

Disease follows more or less the same pattern. Disease will never be controlled by chemical pesticides (fungicide, etc.). Use of agricultural chemicals to control diseases causes the same vicious cycle in the following ways:

1) specific micro-organisms (the disease germs) which cause plant disease are very flexible in changing their character to adjust to the change of circumstance. They can easily grow resistant to the pesticide.
2) beneficial micro-organisms which control the disease germs are also killed by the pesticide. An imbalance in micro-organisms occurs.
3) the resurgence of new and resistant diseases creates a further imbalance of micro-organisms.

Though chemical pest control temporarily demonstrates quick action, it cannot solve the problem permanently. The only permanent solution is pest management which considers the root causes and deals with the problems based on the rules of nature.

7.3 Natural Pest Management

The basic guiding principle of natural pest management is that there is no such thing as a pest problem. If the ecological balance in the agricultural land is not disturbed then the appearance of the pest is not a problem but a symptom. If the symptoms appear, we should try to find out the causes (disturbing factors) and remove them in order to recover the ecological balance. Only this approach can avoid the same mistake the next time. There are two measures, preventive and control. The most emphasis should be put on preventive measures, however, control measures may be necessary in the initial stages of ecological agricultural practice. If proper preventive measures are taken, control measures will not be necessary.

7.3.1 Preventive Measures

Preventive measures have indirect effects and are a long term process. That is why farmers are not very interested in using these methods. From the ecological point of view it is the only way to permanent solution of pest problems. Therefore, much emphasis (more than 90%) should be put on preventive measures.

Create a Balanced Agro-Ecosystem

It is diversity which has the most important role in building up ecological balance in agricultural land. The elimination of disturbing factors is also very important. Methods include.

1) Diverse cropping (Section 6.3)
2) Mixed cropping, including insect repelling herbs and medicinal plants (Section 6.5)
3) Planting perennial trees and grasses (Section 5.5)
4) No use of agricultural chemicals (Section 5.1)

Create a Balanced Soil Ecosystem

A balanced soil ecosystem (balance in micro-organisms) is the key element in the health of plants. Almost all plant diseases come from this imbalance which is mainly created by a lack of organic matter, continuous cropping and use of agricultural chemicals which kill micro-organisms. Methods maintain this balance include:

1) Crop Rotation (Section 6.4)
2) Regular supply of organic matter (Section 5.1)
3) Avoid mixing raw organic matter with soil (Section 5.1)
4) No use of agricultural chemicals (Section 5.1)

Other

1) Good seed selection (no disease contamination, etc.)
2) Planting at appropriate time
3) Appropriate spacing etc.

Actually, the cause of pest outbreak is not simple but very diverse and complicated. If we face a pest outbreak, we should reconsider the methods we are using for growing our crops and find out what is wrong. The insects and diseases are the indicator, not the problem.

7.3.2 Control Measures

Despite preventive measures, some pest problems may occur in the early stages of ecological agricultural practice because the health of the soil is not fully recovered from the effects of chemical agricultural practice and the ecosystem is not yet balanced. In this case, it may be necessary to undertake control measures to protect the crops.

<u>Physical Control</u>

This method is very simple and easy, and effective in the early stages of insect outbreak.

1) Hand picking - remove / catch the insects by hand or net.
2) Light trap - put a light above the water of a bucket; insects come and fall into the water.
3) Stick setting - becomes a place for birds that eat the insects
4) Scare crow - something which scares birds that eat grain
5) Net cover to protect crops (e.g. cabbage) from insect attack.

<u>Natural Pesticide</u>

There are many natural things which repel or kill insects. Common natural pesticides in Bangladesh include:

1) Ash (powder)
2) Neem leaves and seeds
3) Tobacco leaves
4) Jute seeds (powder)
5) Chili
6) Bishkathali (Hydro Piper)
7) Other locally adapted plant leaves

A way of using the plant leaves is to soak them in water for a night or so to take out extracts. The extract water is then used as a natural pesticide.

<u>Natural Crop Protection in the Tropics</u> by Gaby Stoll is a very appropriate book for natural pesticides. (Margraf Publishers, Mühlstr. 9, D-6992 Weikersheim, Germany)

7.4 Weeds

Man's attitude towards so-called weeds is more or less the same as his attitude towards so-called harmful insects. Farmers say weeds are enemies. They always try to clean a field or farming by clearing the weeds so that there are none left. This is thought of as beautiful. But is it beautiful for nature and really beautiful for man?

> *"Weeds are WEEDS only from our human egotistical point of view, because they grow where we do not want them. In nature, however, they play an important and interesting role. They resist conditions which cultivated plants cannot resist, such as drought, acidity of soil, lack of humus, mineral deficiencies, as well as a one-sidedness of minerals, etc. They are witness of Man's failure to master the soil, and they grow abundantly wherever man has missed the train - they only indicate our errors and nature's corrections. Weeds want to tell a story - they are nature's means of teaching man, and their story is interesting. If we would only listen to it we could apprehend a great deal of the finer forces through which Nature helps and heals and balances and, sometimes, also has fun with us."*
>
> *Ehrenfried E. Pfeiffer (Weeds and what they tell)*

7.4.1 The Nature of weeds

Soil erosion checker

The most important role of weeds is to conserve the soil. In heavy rain, we can observe that there is muddy water running away from farm land which is plowed with no or few weeds. On the other hand, we can observe that on land which is weed covered, the water running away is clear with no topsoil erosion.

Weed is nature's first aid

Weed is nature's first aid. When our skin is injured, at first thin skin covers the flesh where the original skin has been broken in order to stop bleeding. When the wound is recovered, the thin skin is removed.

Bare soil is like a wound in nature and weeds are the thin skin of protection - covering the bare soil to stop soil erosion. When other plants and trees come to take their place, the weeds disappear.

As soil becomes fertile, the types of weeds change. In less fertile land, the same weed species appear again and again. The more the farmer weeds out, the more the same weeds appear. In three years applying mulch, with no plowing, at Proshika farm, we have observed that the types of weeds are changing and weeds are becoming less harmful to the crops.

Indicator of soil fertility

Each weed has its own characteristics. Some grow in infertile soil and others in relatively fertile soil. From these characteristics, we can get a sense of the farm land's fertility, Ph, etc. Chan (Imperata cylindrica) is a very common weed in Bangladesh, growing only where soil is very infertile and hence it is an indicator of infertile soil. There are many other weeds which give us valuable information.

Source of fertility for soil

Weeds are good compost materials as well as mulch material. It is completely wrong to throw away weeded plants, because they have consumed nutrients from the soil and produced much carbohydrate through photosynthesis. Both can be returned. By recycling the weeds soil, becomes fertile.

7.4.2 Weeds Management Tips

A basic technique of weed management is to cover the soil so that weeds have no chance to grow. The following are some methods we have tried with good results.

Mulch with less tillage

As we saw in Section 5.2.1, thick mulch (more than 2 inch) controls 90% of weeds. Living mulch and using a cover crop are also effective weed control. Seem or Velvet Bean as a cover crop is a very effective control of Chan which cannot grow in insufficient sunlight.

Green manure

Green manure reduces weeds. First weeds cannot grow well with the green manure crop because it is fast growing and densely planted. Second, when the green crop is plowed into soil, weeds are also mixed with soil. Third, green manure changes the soil quality which makes the types of weeds change. In these way, weeds are reduced.

Relay crop

Relay cropping means sowing seeds for the next crop before the standing crop is harvested. Common relay crops in Bangladesh are Aman rice and Khesari (grass pea). The Khesari seeds are broadcast a week before the Aman harvest. This does not provide enough time for weeds to grow.

[Farming among the weeds]

Many different kinds of weeds are growing with the grain and clover in these fields. A local farmer who had expected to see my fields completely overgrown by weeds was surprised to find the barley growing so vigorously among the many other plants. Technical experts have also come here, seen the weeds, seen the watercress and clover growing all around, and have gone away shaking their heads in amazement. Twenty years ago, when I was encouraging the use of permanent ground cover in fruit orchards, there was not a blade of grass to be seen in fields or orchards anywhere in the country. Seeing orchards such as mine, people came to understand that fruit trees could grow quite well among the weeds and grasses. Today orchards covered with grasses are common throughout Japan and those without grass cover have become rare. It is the same with fields of grain. Rice, barley, and rye can be successfully grown while the fields are covered with clover and weeds all year long.

– Masanobu Fukuoka–
(The One Straw Revolution)

Chapter - 8

Self Seed Production

Self seed production is usually not emphasized very much but it is very important and necessary for those who practice ecological agriculture.

First, seeds available in local markets often have problems such as poor quality, unreliability, low adaptability, high cost, etc. Second, good indigenous crops from traditional varieties are being replaced by the extension of a few HYV and hybrid crops. This causes erosion of the genetic base which will create a big problem in the future.

In this chapter we explore:

1) the problems with purchased seeds
2) the importance and advantages of self seed production
3) methods of seed collection and preservation

8.1 The Problems with HYV, Hybrid (FI) and Purchased Seeds

Low Reliability and Quality

Almost all farmers have bitter experience with purchasing low quality or incorrect seeds from the seed seller. For instance, buying seeds named cabbage, but after germination realizing that it is musterd. Farmers also suffer from seeds of low quality - low germination, low yielding variety, disease-contamination, old, etc. Those problems are not unique but very common and serious for farmers in Bangladesh. If a farmer misses the right time for sowing seeds due to purchase of wrong or low quality supply, it causes the failure of his/her crop.

Low Adaptability

Adaptability of seeds is quite important for ecological agriculture. HYV and hybrid (FI) seeds in particular have problems with low adaptability. The HYV seeds are developed in research institutes and hybrid seeds are developed in seed company farms. Both are highly artificial conditions using high doses of agricultural chemicals. They sometimes do not respond well to organic fertilizer because the character of the seed is changed and adjusted for chemical fertilizer. As well, seed crops have been grown in these artificial conditions for many generations. Therefore, the seeds are spoiled and lose their adaptability to local conditions. In addition, most hybrid seeds come from foreign countries such as Japan, the USA and Holland which have completely different climatic conditions (temperate) from Bangladesh's tropical climate.

High Cost

The cost of seed is not at all cheap for farmers. Local seeds are quite expensive in the local bazaar while the prices of HYV and hybrid seeds are usually 3 to 5 times those prices. Hybrid seeds, from which it is impossible to get the same quality of seeds in the next generation, are especially expensive. If a farmer gets used to using hybrid seeds, they purchase the seeds all the time. It is the aim of seed companies that farmers become dependent on hybrid seeds which are almost all imported.

Uncertain Availability

The seed sowing time for each crop is fixed in a year. If the seeds are not sown at the right time, it causes failure of the crop. Therefore, availability of the seeds at the necessary time is very important. It is uncertain whether or not the seeds will be available in the market at the sowing time. Many farmers sometimes face this problem and need to spend a lot of time searching for seeds.

Genetic Base (Local Varieties) Erosion

Though it is not widely realized among agriculturalists, farmers and others in Bangladesh, the conservation of the genetic base (local varieties) is very, very important. There are two main reasons. One is that local varieties play a big role in enrichment of diversity in crop varieties. Diversity in crop varieties is key to a stable agro-ecosystem. The other reason is that the local varieties are real genetic resources for the country. Local good yielding seeds have been developed from original local varieties by farmers. The local varieties are original and essential. Without them, no improvement of seeds is possible. Even HYV and hybrid seeds cannot be developed without local varieties.

As well, local varieties are very important resources for the future. [Note: Some scientists of industrialized countries and big multi-national companies are fully aware of the potential of local varieties as resources and they have already started to collect a genetic base (local varieties) from tropical countries where there are the most rich resources in genetic base.]

If we could realize the potential of local varieties, we would never allow the present situation, where valuable local varieties are rapidly being lost to continue.

8.2 Advantages of Self Seed Production

If we are fully aware of the problems of purchased, HYV and hybrid seeds, we can understand the importance and advantage of self seed production.

High Reliability and Quality

This is ensured because the user (farmer) collects and preserves the seeds and therefore knows everything about them (variety, collection & processing method).

High Adaptability

This is ensured because the plants have grown many generation in the local circumstances. Changing the seeds from chemical responding to organic responding is important in ecological agriculture.

Almost No Cost

The farmer collects and preserves the seeds for him - or herself. Only minimum cost for materials is sometimes needed. Production costs also decrease as a result.

Availability

The farmer who will use the seeds, preserves them and can use them as needed.

Genetic Conservation

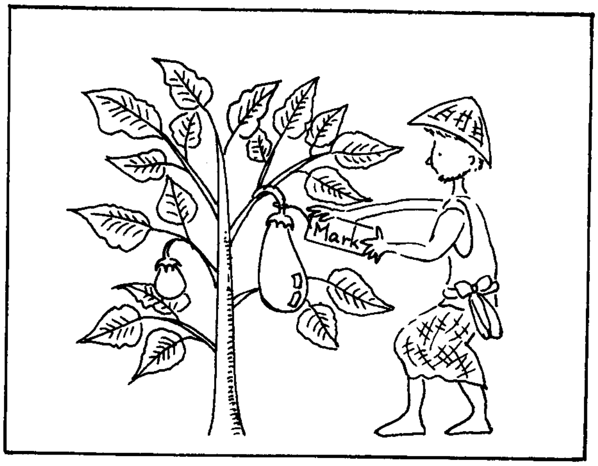
The best way to conserve local varieties is for farmers to grow and preserve seeds for their own use.

8.3 The Process of Self Seed Production

To carry out self seed production, learning the basics of how to process the seeds is necessary. Below, the process of self seed production is described from plant selection to storage and documentation.

Stage 1: Plant Selection and Marking

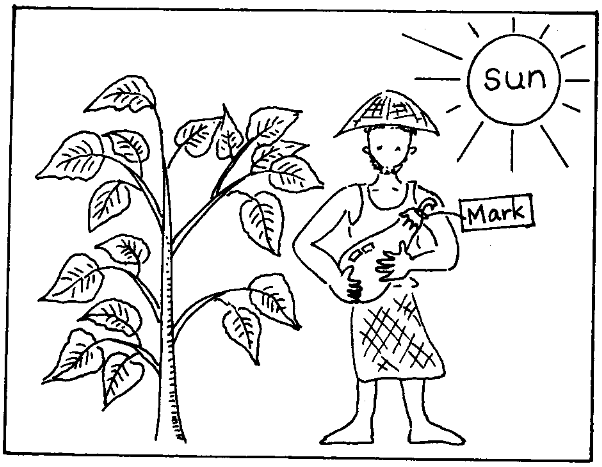
Identifying the plants from which the seeds will be collected and making an identification mark on them are the first tasks. The marking is very important to save the plants from being harvested by mistake. Steps for choosing plants are:



1) healthy plants (no pest attack, healthy location)
2) good yielding plants (good in size, shape, color etc.)
3) good taste

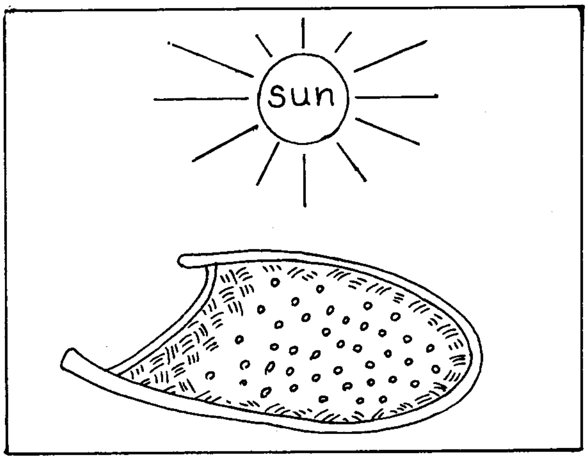
Stage 2: Collection of Seed

When the identified plants become mature, it is time to collect. Important steps are:



1) identify the right time (mature enough)
2) collect the seeds on a fine day (avoid rainy days)

Stage 3: Drying Seed



The seeds collected must be dried as soon as possible. Some seeds (tomato, papaya, etc.) need to be washed first. The drying process is the deciding point as to whether or not good quality and disease free seeds will result.

Steps:

1) dry the seeds by sunlight not heater
2) dry the seeds sufficiently

Stage 4: Cleaning and treatment

After drying the seeds sufficiently, cleaning and treatment of the seeds are necessary. The steps in this process are:

1) remove waste and bad seeds, and select the fine seeds only
2) treat seeds by mixing with materials against insect attack.

The material for treatment include:

1) Dry ash
2) Dry neem leaves
3) Other locally adapted leaves
4) Other

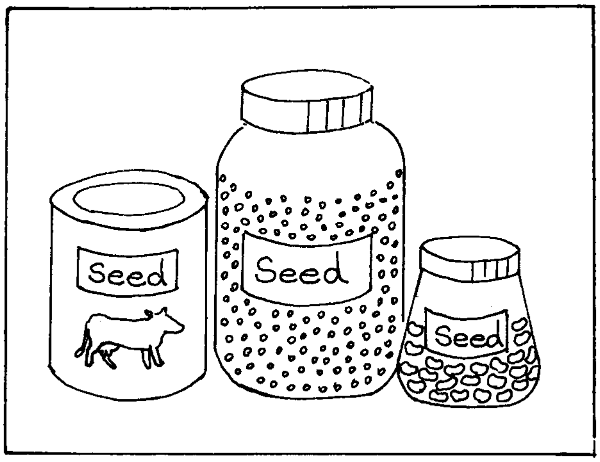
Stage 5: Storage

After treatment, the seeds should be kept under clean, dry, dark and low temperature conditions as soon as possible.

1) use a bottle or air tight container
2) put seeds with drying materials such as roasted rice dry ash, etc.
3) keep the bottles and containers in a dry, dark, cool place.

Stage 6: Documentation and Labelling

Documentation (recording the details about the seed) and labeling (putting names on bottles and containers) is very important for identification in the next season and retaining the details of the seeds for future reference.



The label should include the record number, name and date of collection

In addition, the following information should be recorded on a form:

i) record number
ii) plant name (local and English/botanical)
iii) variety name
iv) collection date
v) place of collection
vi) name of collector
vii) remarks (description of the character of seeds).

For a farmer, only labeling may be enough. But for an organization and a community seed bank, keeping documentation is a must.

References

Common Multi-Purpose Trees in Bangladesh

	Name	Sowing Time	Transplant Time	Remarks
1	Pigeon pea (Arohor) *Cajanus cajan*	Mar. - May	-	Direct sowing
2	Ipil Ipil (Ipil Ipil) *Leucaena lucocephala*	Mar. - Aug	Apr. - Sep.	
3	Sesbania sesban (Joyanti) *Sesbania sesban*	Mar. - May	Apr. - Aug.	
4	Tephrosia (Bogamedula) *Tephrosia candida*	Mar. - Aug.	-	Direc sowing
5	Dram-stick (Shojina) *Moringa oleifera*	-	May - Aug.	
6	Indian gum (Babula) *Acacia arabica*	Feb. - Apr.	-	Direct sowing
7	Erithriana (Mandar) *Erithriana indica*	-	Mar. - Sep.	Stem cutting
8	Pongamia (Pithacora) *Pongamia pinnata*	Feb. - Apr.	Apr. - Aug.	
9	Sesbania grandiflora (Bokphul) *Sesbania grandiflora*	Mar. - Jun.	Apr. - Aug.	
10	Rain tree (Rentri Koroi) *Samanea saman*	Apr. - Jun.	May - Aug.	
11	Bauhinia (Kanchon) *Bauhinia acuminata*	Apr. - Jun.	May - Aug.	
12*	Gliricidia *Gliricidia sepium*	Apr. - Jun.	May - Aug.	Stem cutting possible
13*	Flemingia *Flemingia macrophyla*	Apr. - Jun.	May - Aug.	
14*	Calliandra *Calliandra calothyrsus*	Apr. - Jun.	May - Aug.	

* These are not common in Bangladesh but suitable.
Seeds are available at Proshika Koitta farm.

Common Timber Trees in Bangladesh

	Name	Sowing Time	Transplant Time	Normal Distance (ft.)	Remarks Height (ft.)
1	Sisson (Sisu) *Dalbergia sisso*	Mar. - Apr.	Jun. - Aug.	30	70
2	Mahogany (Mehogani) *Swietenia mahagoni*	Mar. - Apr.	Jun. - Aug.	30	80
3	Arjuna tree (Arjun) *Triminalia arjuna*	Mar. - Apr.	Jun. - Aug.	30	70
4	Neem (Nim) *Azadirachta indica*	Feb. - Apr.	May - Aug.	30	80
5	Sal tree (Sal) *Shorea robusta*	-	May - Aug.	50	100
6	White siris (Sada Koroi) *Albizia prosera*	Mar. - Apr.	Jun. - Aug.	30	50
7	(Radha chura) *Caesalpinia pulcherrima*	-	Jun. - Aug.	30	50
8	Peacock tree *(Krishna chura)* *Delonix regia*	Feb. - May	Jun. - Aug.	40	50
9	Teck (Segun) *Tectona grandis*	Mar. - May	Jun. - Aug.	40	70
10	Chaplash (Chambal) *Artocarpus chaplasha*	-	Jun. - Aug.	60	120
11	Golden shoer (Sonail) *Cassia fistula*	Apr. - Jun.	Jun. - Aug.	25	35
12	Queen flower (Jarul) *Lagerstroimia speciosa*	-	Jun. - Aug.	35	60
13	(Bakul) *Mimusops elengi*	May - Jun.	Jun. - Aug.	25	50
14	Black myrobalan (Horitoki) *Terminalia chebula*	-	Jun. - Aug.	20	40
15	Bedda nut (Bahera) *Terminallia belerica*	-	Jun. - Aug.	30	60
16	Red santal (Lal chandon)	Feb. - May	Jun. - Aug.	25	50

Common Shade Tolerant Crops in Bangladesh

	Name	Sowing Time	Transplant Time	Normal Distance (ft.)	Remarks
1	Zinger (Ada) *Zingiber officinale*		Mar. - Apr.	1.5 x 0.7	Rhizom
2	Termeric (Holud) *Curcuma domestica*		Mar. - Apr.	1.5 x 0.7	Rhizom
3	Colocasia (Kochu) *Colocasia esculenta*		Feb. - Apr.	3.0 x 1.5	Corm
4	Chili (Morich) *Capsicum annuun*	Oct. - Dec. Mar. - May	Nov. - Jan	3.0 x 1.5	
5	Elephant's foot (OI) *Amorphophallus campanulatus*		Feb. - Mar.	3.0 x 1.5	Corm
6	Yam (Mete alu) *Dioscorea glabra*		Mar. - Apr.	5	Support
7	Knakon (kalmi Shak) *Ipomoea acuatica*	Apr. - Jun.		1.0 x 0.5	
8	Pineapple (Anarosh) *Ananas comosus*		Jun. - Aug.	3.0 x 1.5	Crown
9	Betel Pepper (Pan) *Piper betle*		Sep. - Oct. Jun. - Jly.	1.5 x 1.5	Cutting
10	Piper chaba (Choi) *Piper chaba*		Jun. - Jly.	3.0 x 3.0	Cutting
11	Banana (Kola) *Musa sapientum*		Feb. - Apr. Sep. - Nov.	6.0	Sucker

Common Fruit Trees in Bangladesh

	Name	Sowing Time	Transplant Time	Normal Distance (ft).	Normal Height (ft.)	Years to bear
1	Banana (Kola) *Musa sapientum*	-	Feb. - Nov.	6	10	1
2	Papaya (Pepe) *Carica papaya*	Feb. - Mar.	Mar. - May	5	8	0.5
3	Jack fruit (Katal) *Artocarpus heterophyllus*	May - Jly.	Apr. - Sep.	30	45	4
4	Mango (Am) *Mangifera indica*	Apr. - Jly.	Jun. - Sep.	35	65	4
5	Coconuts (Narikel) *Cocos nucifera*	Aug. - Oct.	Jun. - Sep.	25	80	6
6	Betel Nut (Shupari) *Areca catechu*	Sep. - Oct.	Jun. - Sep.	7	50	5
7	Date sugar (Khejur) *Phownix sylvestris*	May - Jun.	D. sowing	12	30	5
8	Palmyra (Tal) *Borasus flabellifer*	Jun. - Aug.	D. sowing	30	80	12
9	Sugar apple (Ata phol) *Annona squamosa*	May - Aug.	May - Aug.	12	15	3
10	Guava (Peara) *Psidium guayava*	Apr. - May.	May - Jun.	12	10	2
11	Hog Plum (Amra) *Sapondias pinnata*	Oct. - Nov.	May - Aug.	30	45	3
12	Pummelo (Jambura) *Citrus garandis*	Aug. - Nov.	May - Aug.	20	30	5
13	Wood apple (Bel) *Feronia Limonia*	Feb. - May	May - Aug.	25	35	5
14	Sapodilla (Shopeta) *Achras zapota*	Grafting	May - Aug.	25	35	5
15	Pomegranate (Dalim) *Punica granatum*	Mar. - Jly.	May - Aug.	15	10	2

Continued next page

Common Fruit Trees in Bangladesh

	Name	Sowing Time	Transplant Time	Normal Distance (ft).	Normal Height (ft.)	Years to bear
16	Lime (Lebu) *Citrus aurantifolia*	Layer	May - Aug.	10	10	2
17	Olive (Jalpai) *Elacosarpus robustus*	Feb. - Mar.	May - Aug.	25	40	5
18	Star fruit (Kamranga) *Averrhoa carambola*	Feb. - Mar.	May - Aug.	20	30	4
19	Tamarind (Tetul) *Tamarindus indica*	Feb. - Apr.	May - Aug.	35	40	5
20	Litchi (Lichu) *Litchi chinensis*	layer	May - Aug.	30	25	4
21	Black plum (Jam) *Eugenia jambolana*	May - Jly.	May - Aug.	30	40	5
22	Cowa fruit (Kau) *Garcinia cowa*	May - Jly.	May - Aug.	20	25	6
23	Jujube (Boroi) *Zizyphus jujuba*	Feb. - Apr.	May - Aug.	16	20	5
24	Artocarpus (Deuphal) *Artocarpus lakoocha*	May - Jly.	May - Aug.	25	30	5
25	Emblica (Amloki) *Emblica officinalis*	Feb. - Apr.	May - Aug.	20	25	5
26	Longan (Ash Phal) *Euphoria longana*	May - Jly.	May - Aug.	25	35	5
27	Ebony (Gab) *Diospyros embroyopteris*	Jun. - Jly.	D. sowing	15	25	4
28	Wax Jambu (Jamrul) *Eugenia javanica*	Layer	May - Aug.	20	30	3
29	Rose apple (Golap Jam) *Eugenia jambos*	Layer	May - Aug.	12	20	4
30	Indian almond (Katbadam) *Terminalia catappa*		May - Aug.	30	50	5

Reading List

Basic Books

Masanobu Fukuoka,
The One Straw Revolution,
Rodale Press, 1978.

Masanobu Fukuoka,
The Natural Way of Farming,
Japan Publications, 1985.

Bill Mollison,
Permaculture One and Permaculture Two,
Tagari Publications, 1978 and 1979.

Bill Mollison,
Permaculture. A designers' manual,
Tagari Publications, 1988.

J.I. Rodale,
Pay Dirt,
Rodale Press, 1945.

Sir Albert Howard,
An Agricultural Testament,
Oxford University Press, 1940.

Sir Albert Howard,
The Soil and Health,
Schocken Books, 1956.

Additional Useful Books

Anna Carr,
Good Neighbors : Companion planting for gardeners,
World Neighbours, 1985.

Miguel A. Altieri,
Agroecology : The scientific basis of alternative agriculture,
IT Publications, 1984.

Gaby Stoll,
Natural crop protection in the tropics,
Margraf Publishers, 1988.

Vandana Shiva,
Staying Alive : Women, Ecology and Survival in India,
Kali for Women, 1988.

J. Russel Smith,
Tree crops : A permanent Agriculture,
Devube - Adaur, 1977.

Ehrenfried E. Pfeiffer,
Weeds and what they tell,
Rodale Press, 1970.

John Jeavons,
How to Grow More Vegetables,
Ecology Action, 1982.

Masao Maeda and Yoshiro Mastuo,
The basic knowledge of soil,
Nobunkyo, 1974.

Tatuo Kira,
Ecology and the nature,
Kawaide Shobou, 1971.

John Seymour and Hervert Girardet,
Far from Paradise : The story of man's impact on the environment,
BBC publications, 1987.

Susan George,
How the other half dies,
Penguin Books, 1976.

Carter and Dale,
Topsoil and Civilization
University of Oklahoma Press, 1955.

Wes Jackson,
New Roots from Agriculture,
University of Nebraska Press, 1980.

Tropical legumes : Resources for the future,
National Academy of Sciences, 1979.

Ecological visions : Exploring Alternatives for Co-evolution
Classic Books and Service Center in Calcutta India, 1989.

Wolf. D. Storl
Culture and Horticulture: A philosophy of gardening
Bio-Dynamic Literature, 1979.

Notes

Notes