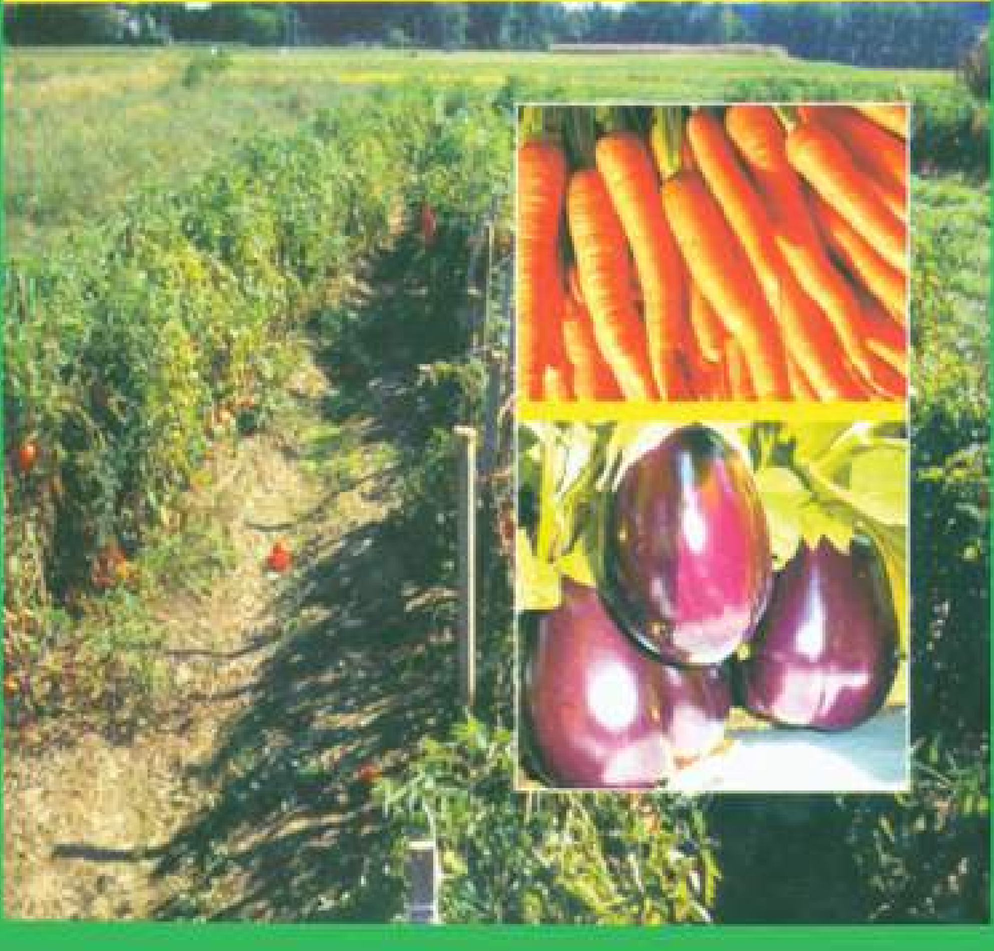
Agricultural Production

Organic and Conventional Systems



Okoro M. Akinyemi

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Dedication

This book is dedicated to my late mother, *Mrs. Amuzi Alice – Okeno*, who worked diligently and provided me constant love and encouragement to achieve my noble aspiration.

Foreword

This book examines production efficiency and economic benefits of agricultural production, comparing both organic and conventional systems with specific emphasis to some crops and animal production. Most of the material in this book has been collected from already existing books of other authors and essayists, as well as personal experience gained during the author's teaching career.

It dwells on the production systems with special emphasis on some vegetable crops as well as cattle and chicken breeding. Diseases and pest outbreaks are looked into with a view of recommending the appropriate methods of control. Definition of land and its uses are discussed. Factors affecting soil formation and methods of replenishing lost nutrients are enumerated in an attempt to educate students and farmers on the modern techniques of retaining soil nutrients without environmental destruction. Experiments conducted on soil to investigate the effects and factors affecting nutrients mineralization have been described. Descriptions of forest trees have been given to explain their roles in economic expansion. Methods of planting, rules and regulations implemented by communities, states and countries are also discussed.

This book critically reviews the effects of agricultural chemicals on soil organisms and other agricultural practices. A case study for replacing chemicals with ecologically sound alternatives and comments on how this might be implemented, has been put forward. The framework for considering these aspects emphasizes a normative, rather than an extrapolative approach, and collaboration with nature to reach optimal levels of productivity.

The major aspects of agricultural production are presented in 12 chapters. Chapter 1 reviews organic agricultural practices, and Chapters 2 and 3 focus on agricultural sustainability and factors affecting land tenure systems and uses. Chapters 4 and 5 examine the effects of chemicals on agricultural practice and pests and disease control. Chapters 6 and 7 present strategies of weed management and plant nutrients utilization. Chapters 8 and 9 discuss agricultural mechanization and methods of vegetative propagation. Chapter 10 is a thorough guide to some vegetable production, while Chapter 11 emphasizes strengths and constraints in marketing organic fruits. Chapter 12 portrays an overview of livestock production. A separate section is included at the end which provides meaningful recommendations on production practices and quality control methods for the benefit of the readers.

Alexandra Angela Baltatu

Preface

Organic farming is essentially an agricultural management practice that avoids usage of pesticides, fertilizers produced synthetically, livestock feed additive, etc. Organic farming is characterized by the use of crop rotation, mulch materials, and composting materials. The foundation of organic farming lies in the health of the soil. A fertile soil provides essential nutrients to crop plants and helps support diverse and active biotic communities. Strategic transitional methods that are required for the farmer to build up crop nutrients in organic agriculture are crop rotations, animal and green manures, and cover cropping systems. Cover crops maintain the nutrient balance in the soil and on the other hand, promote biological pest control to maintain soil balance and reduction of pest population and weeds.

Currently, organic agriculture is practised in almost all parts of the world, and its share of agricultural land and farms is growing. The total organically managed area as of 2004 is more than 24 million hectares world-wide. The essence of organic growing is soil management and fertility maintenance. Many farmers do not understand the phenomena behind organic agriculture and soil. The primary goal of organic agriculture is to feed the soil but not to feed the plant. The food given to the soil will nourish the plant better than nutrients can.

Organic farmers have seized the opportunity provided by the potential positive qualities of organic products. For many farmers, the primary reason for switching to organic production systems is to improve (1) the process and quality of food produced, and (2) practices involved (Vaarst et al., 2004). Private and organic researchers support farmers' aspirations in many countries, and advisory organizations combine the farmers' objectives with the overall organic goals in a close-knit circle of shared interests and ambitions (Vaarst and Hovi, 2004).

With the current development of organic certification and legislation, (Organic Standards), the control of quality produce has shifted from farmers and producers to certification bodies and to the legislatives. It has been suggested that the development of goals and principles has also shifted from farmers, with the onus being well informed to the consumers (Lockeretz and

Lund, 2003). Farmers are expected to focus more on process quality as the primary consumers' interest is product quality. Several surveys revealed that consumers have some interest in process issues, as this calls for hazard analytical for critical control point (HACCP).

Biodynamic agriculture was the first ecological farming system which arose from the effect of commercial fertilizers. Yet it remains largely unknown to the modern farmers and land-grant university systems. However, the contribution of biodynamics to organic agriculture is significant (Diver, 1999).

When the development of organic agriculture began, it was Rudolf Steiner, an Austrian Scientist and a philosopher, who understood the need for naturalness in agricultural production. He put forward a theory that was adopted by H. Pfeiffer at the end of the 1920s in Germany, Switzerland, Denmark, England and Netherlands; he is acknowledged as the initiator of biodynamic farming.

Currently, the organic movement is represented commercially by Demeter in Germany and other countries. However, it differs from several other movements in today's world and in a certain degree of idealism, a philosophical twist, as well as specific cropping methods, linking agricultural activities to the lunar and astral cycles.

At the end of the World War II (1940s), this movement led to formation of "The Soil Association" in England. The Soil Association (based on the theory of Sir Albert Howard in 1940), carries out research and development. (Viandes, 1999).

In 1930, the Swiss politician H. Müller gave impetus to this new movement. His objectives were directed at the economic, social and political concern as they envisioned autarchy of the farmer, and towards more direct and less cluttered connections between the production and consumption stages (Viandes, 1999). Austrian doctor Hans Peter Rush also adapted this idea and incorporated it in a manner which was based on maximum utilization of renewable resources in 1930s.

In the 1950s, the expansion and dual polarity of organic agriculture began to spread. It finally called for organic farming, which later started in France. Since the beginning of the organic movement in the 1950s, consumers have become aware of the constant growth regarding food and its effect on human health. In 1968, the ideological upheaval in France and growing sensitivity to ecological issues started spreading. This has now spread to the whole of Europe. Besides, EU's regulations stipulate that from 2012 the use of chemical substances (in poultry) will not be allowed in the European Union. The social and cultural context and general propagation of ideas has also exerted a strong influence throughout many steps in the development of organic farming in today's production systems.

In the 1970s, protest movements and alternative life styles of organic farming led to a definite change in the farming practices, resulting in new ideas, and significant sociological transformations.

Modern-day ecological movement has also gained momentum and benefited from an additional boost due to the oil crisis of 1973. It was the epoch of the "return to the earth" and life in alternative communities (Viandes, 1999). The Soil Association has designed a logo to identify the product they certify. The formulation specifications and quality control norms of Soil Association give legal binding guarantee to consumers on organic products. In France, farmers trade syndicates have joined hands to form federations (Fédération Nationale d'Agriculteurs Biologiques) in an attempt to promote organic agriculture worldwide. Major national organic farming organizations joined forces in the formation of IFOAM (International Federation of Organic Agriculture Movements) in the early 1980s.

Acknowledgement

This book epitomizes a perfect creation—the result of the collective efforts of committed minds. I, therefore, owe a debt of gratitude to a number of people for their collaborative work towards the completion of this book.

Firstly, my sincere gratitude goes to Prof. Dr. Peter von Fragstein, Prof. Dr. Holger Wildhagen, Ms. Penelope Pohlner, James Thompson, Mary Catherine Apolot (Schulz), Mrs. Kalpana Sharma and Mr. Dandamaraju Srikanth, for Proofreading the relance pages that requires both Scientific and linguistic skills. I also express my sincere thanks and appreciation to: PG; Dr. Gerold Rahmann, Head of Institute of Organic Farming (OEL) and Federal Agricultural Research Centre (FAL), Germany, and Prof. (Dr.) Ute Knierim, Department of Farm Animal Behaviour and Husbandry, University of Kassel, for providing all the assistance and guidance during my studies at the University of Kassel.

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Above all, I wish to express my profound gratitude and appreciation to the Almighty God for providing me the inspiration, energy and encouragement to complete this work despite all odds.

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Introduction to Organic Agricultural Practices

Chapter 1

Organic agriculture by definition is referred to as a "natural production management system which promotes and enhances biodiversity, soil biological activities and biological cycles." The production is based on minimal use of off-farm inputs and good management practices that restore, maintain, or enhance ecological harmony. The main goal of organic agriculture is to optimize productivity of interdependent communities of soil life, plants, animals and people with the use of synthetic elements. The term "organic", as defined by law, is "natural" and "eco-friendly". Most "natural" products do not contain synthetic products, but may have been produced conventionally (using synthetic substances).

From ancient times, organic agriculture is regarded as the most traditional form of agricultural management system in the universe. Farming without usage of petroleum-based chemicals (fertilizers and pesticides) was the sole option for farmers until the World War II. The war brought with it technologies that were useful for agricultural production (the use of ammonium nitrate fertilizer). The ***organophosphate nerve gas production*** at this stage led to the development of powerful insecticides that were used in the eradication of insects after the end of the World War II. The significant economic benefits of agriculture, as well as the environmental and social detriments, resulted in the advancement of this technique.

Organic agriculture, therefore, seeks to utilize advances that consistently yield benefits (new varieties of crops, crop rotation, mulching, technologies; more efficient machinery) during these periods, and has discarded the methods that lead to negative impacts on society and environment.

Due to the adverse effects of using synthetic fertilizers and pesticides, *organic farmers prefer utilizing crop rotations, cover crops, and natural-based products to maintain and enhance soil fertility*. Currently, farmers rely on biological, cultural and physical methods to limit pest expansion and increase populations of beneficial insects on their farms. Genetically modified organisms (GMOs) constitute synthetic inputs and pose unknown risks to both crops and animal production. Presently, GMOs such as herbicide-resistant seeds, plants, and product ingredients, like GM-lecithin, are disallowed in organic agriculture.

1.1 FACTORS

Organic Products Consumption

Several statistical analyses have proved that worldwide consumption of organic products has experienced a significant growth over the years, and most of the increase in global consumption has been fueled by consumers' demand for GMO-free products. As a result of banning GMOs in organic production and processing, the crops and livestock have been classified as GMO- free at the marketplaces. This has evinced keen interest by consumers in organic production. In Europe (Netherlands and Scandinavia) and other parts of the world, consumers are demanding organic products because of their naturalness. Numerous publications have shown that 2% of total German farmland, 4% of Italian farmland, 10% of Austrian farmland, respectively is managed organically. Though, the higher demand for organic consumption in Europe is Germany. Prince Charles of Great Britain has also developed a model of an organic farm, and established a system of government support for transitional organic farmers. Major supermarket chains and restaurants in Europe offer a wide variety of organic products for sale in the market, and on their menus (Delate, 2005) to combat competition.

1.2 THE IDEAL OF PHILOSOPHERS IN ORGANIC AGRICULTURE INPUTS

The basic purpose of using natural elements in organic agriculture is attributed to the protection of environment, concern for the economy and food safety. Organic producers differ in their methods adapted to achieve the idea systems. Some organic farmers entirely neglect external inputs and concentrate on native biological insect controls on their farms by conserving beneficial insects' food and nesting sites, instead of importing natural pesticides. They create compost on the farms for fertilization needs. Others do not make a distinction in inputs, and rely on imported inputs for soil fertility and pest management. Organic farming seeks to eliminate any chemical substance not in compliance with the rules and regulations of organic farming practices. They rely mainly on products produced on farms.

1.3 ORGANIC MOTIVATION

The motivation for organic production is based on economic consideration, food safety and environmental concerns. It is essential that all organic farmers avoid the use of synthetic chemicals in their farming systems if they are expected to sell their product as "organic". Philosophers among organic farmers regard organic farming as the best method of producing crops and animals, and as the most ideal management method in farming systems. Organic farmers span the spectrum from those who completely eschew external inputs and create on-farm sources of compost for fertilization and encourage the activity of beneficial insects through conservation of food and nesting sites, for farmers who import their fertility and pest management inputs. The philosophy of "input substitution" is discredited by many long-time advocates of organic agriculture. A truly sustainable method of organic farming would be to seek elimination, as far as possible, of external inputs (Delate, 2005)

1.4 NECESSITY IN ORGANIC FARMING

Organic products must be certified as "organic", so as to ensure farmers do not use substances prohibited according to organic regulations. Farmers growing organic crops and raising organic animals must follow a set of prescribed practices that include avoidance of synthetic chemicals in crops and livestock production, and in the manufacture of processed products. Organic certification agencies have been established in different parts of the world to educate farmers and to deal with required elements needed in organic production. The certification bodies range from state to third party certification agencies. Some of the certification bodies in Europe include AMAB, IMC, Diameter, Bioland, Codex Alimetarous, Associazone per Bioagricoop and Associazone per I'Agricoltura Biodinamica (AIAB). The International Federation for Organic Movement (IFOAM) is also a certification body representing and certifying organic products worldwide. States or countries have the right to set up well-defined organic standards to suit organic production, but the standards must meet the international guidelines so that the organic produce can be exported to other countries where they are in demand. The standards set by states must specifically spell out penalties for producers falsely identifying their products as "organic". The law must also allow private certification bodies to operate. More information on organic agriculture and organizations can be found on the homepage *http://www.organic-europe.net/*.

The rules set by states or countries should include a clause, whereby all farmers, whose gross income from organic sales is more than US$ 5,000 per year, in conversion to the country's currency, must be certified as "organic farmers" through an accredited agency. The small scale producers are allowed to receive the benefits of premium prices (provided produce is raised organically) while avoiding certification fees. However, farmers are encouraged to join a certifying association in order to participate in the benefits of sharing information among members.

1.5 CERTIFICATION REQUIREMENTS

To sell a product as "organic", it must be raised on land free from synthetic chemicals (any fertilizers, herbicides, insecticides or fungicides) and inputs. No GMOs should be allowed in the raising of crops and livestock. According to the regulatory system, conventional and organic fields can be located on the same farm, but special care, including a border of 30 m between organic and conventional fields is necessary in mixed operations. Only naturally-occurring materials are allowed in production and processing operations and all treatments must be noted in the farm records.

Diverse crop rotation plan is extremely essential as it protects crops against pests and supports the recycling of soil nutrients, thereby keeping the soil biologically active and rich in organic matter. The rotation should not be practised for more than four out of six years and the crops should be in rows. The same row crop must not be grown in consecutive years on the same land. Legumes such as alfalfa, red clover, berseem clover, and hairy vetch, alone or in combination with small grains like wheat, oats, or barley are recommended to be rotated with row crops like corn, soybeans, amaranth, and vegetables, so as to ensure a healthy system. It is also recommended that horticultural crops be rotated with leguminous cover crops at least once every five years. Other practices are specifically disallowed in organic production in most regulations. The use of "biosolids" or sewage sludge is not encouraged as it may result in undesirable bacteria and heavy metal contamination. Farmers should be made aware that irradiated products are prohibited because of the harmful elements that occur in irradiated substances. They should also be well versed with products used in organic cropping systems and animal production, in order to be fully classified as "organic" producers.

Like other livestock, organic livestock, must be fed with 100% organic food or feed in their production unit. Synthetic hormones and antibiotics are strictly discouraged in organic livestock production. However, the natural bacteria present in vaccinations are permissible in organic livestock production and instead, synthetic parasiticides are prohibited. Organic farmers should rely on natural parasiticides like diatomaceous earth.

Purchasing parasite-free stock, and providing access to ample pasture, water, and nutritional feed should be allowed for healthy organic livestock production (Delate, 2005). It is highly recommended for livestock to be provided with access to pasture in order to be certified "organic". Alternative health therapies such as botanical remedies and manipulation technologies should be used by organic livestock producers.

1.6 TRADE IN ORGANIC FOOD

Trade in organic food differs from other food commodity networks because of the need for organic certification. Certification of organic produce within the European Union, whether produced domestically or imported, is regulated by Regulation (EEC) 2092/91(Barrett et al., 2002). This regulation came into force in 1991 with the aim of protecting consumers, and harmonizing producers with the definition of 'organic' production among EU member states. This provides the legal framework for accrediting private sector certification bodies (Willer and Yussefi, 2001).

It is mandatory for organic certification bodies to fulfil the requirements of the European Norm 45011. This norm was incorporated as an amendment to the EU organic legislation, and specifies requirements for third-party organizations who operate certification systems (Marian and Felipe, 2004).

Exports of organic products from third countries into the EU market, as indicated under Article 11 of EU regulation 2092/91, have to meet two options (Barret et al., 2002). Firstly, the exporting country should be recognized as having equivalent standards to the EU regulations with regard to agricultural production, processing, documentation and inspection. Secondly, if approval is granted, the country will be added to the List of Third Countries (Marian and Felipe, 2004). Currently, there are only seven countries recognized under Regulation (EEC) 2092/91 Article 11(1) Annex (EEC) 94/92. Argentina, Australia, Czech Republic, Hungary, Israel, Switzerland and New Zealand (Barret et al., 2002).

1.7 MARKETING

Over the last ten years, there has been increased awareness in organic food produce and its marketing by mainstream retailers (Barrett et al., 2002). As a consequence of the recent food safety, consumers are enquiring about the methods used in producing organic food and marketing, which has resulted in increased worldwide demand for organic products. In Europe, the trade of organic products has significantly increased in the recent years (Marian and Felipe, 2004). Barrett et al. (2002), states that the global market for organic products is estimated at US$ 11 billion, the equivalent of 2% of the total world food market. Organic imports from developing countries are worth about US$ 500 million (according to IIED, 1997; Blowfield, 1999; Robins et al., 2000). Europe is the leading and largest world organic market with an estimated share of US$ 5 billion in 1997 (Willer and Yussefi, 2000). Currently, the most important organic products within the EU market are vegetables, fruits, potatoes, milk products and cereals (Michelson et al., 1999).

Supermarkets in the UK, for example, are currently boosting the range of organic products in their stores and investing heavily in advertising and promotion of organic food (Barrett et al., 2002). Presently, sale of 70% of all organic fruits and vegetables are routed through supermarkets (FAO, ITC and CTA, 2001). It is extremely necessary for organic producers in developing countries to increase their produce, keeping in view the long-term environmental benefits of organic farming.

Basic Concepts for Sustainable Agriculture and Rural Development

Chapter 2

The World Commission on Environment and Development under the United Nations has drawn attention to the challenge of population growth over the years, which is currently affecting food availability for world consumption. The conclusion of the world summit on sustainable development held in Johannesburg in South Africa in 2002, recommended that strategies should be formulated for sustainable food security and environmental conservation of natural resources, so as to meet the food requirements of the present and future population growth. In an attempt to mitigate the constraints currently faced by producers and consumers, the following plan of action was put forward:

- Plan of action should be implemented for sustainable development.
- There should be adjustments in agricultural production, environmental management and macroeconomic policy at both national and international levels.
- There should be a necessity to create conditions for sustainable agriculture and rural development.

The major focus of sustainable agriculture and the promotion of rural development should be to increase food production in a sustainable manner with the intention of enhancing food security and environmental protection. The attainment of this act will involve educational initiatives, utilization of economic incentives and development of appropriate and new technologies, thus ensuring stable supplies of adequate food, having access to those vulnerable groups to whom the products were supplied for marketing, and income generation for the rural people to alleviate poverty.

Sustainable agriculture is generally associated with the need for agricultural practices to be economically viable to meet human requirements, to be environmentally positive, and to improve the quality of life. The objective of sustainability can be met in a number of ways. Sustainable agriculture is not affiliated to any particular technological practice, but is the exclusive domain of organic farming. The salient features of sustainable agriculture are its adaptability and flexibility over a period of time to respond to the demands for food and fibre. Sustainability helps to protect soil quality and improve food availability.

2.1 KEY CHALLENGES TO AGRICULTURAL SYSTEMS

Agriculture can make significant contributions towards attaining maximum advancement of a country when given more attention. It is through the agricultural sector that most of the rural poor in developing countries derive their income and daily meals. As organic agriculture depends heavily on natural resources, its influence contributes to environmental sustainability. However, to attain the best results from farming, producers should understand the following key challenges:

2.1.1 Eradicating Poverty and Hunger

The best way in which the international development community has tried to engage with the politics of achieving poverty reduction over the past decade has been through the notions of good governance and social capital (World Bank, 2001). Good governance is associated with the accountability and responsiveness of political systems, to be achieved through reforms such as democratic decentralization. To achieve this aim, agriculture should not be neglected, as food production is essential for consumption, export and income generation to boost the country's economy.

It was estimated by the United Nations that the world population living on less than US$ 1 per day is 1.2 billion people. It was additionally supported that the world population living on less than US$ 2 per day is about 70%. Currently, about 800 million people worldwide go hungry each day out of which approximately 75% of the poor people are from developing countries and most of them live in rural areas, where they depend mostly on agriculture for their livelihood. The reduction of poverty and hunger in both rural and urban areas will depend on sustainable development of agriculture. To achieve these goals, there must be promotion of pro-poor economic growth in proportion to the population growth rates. This will require raising agricultural productivity, integrating agriculture into local and international markets and creating productive on- and off-farm employment for the rural dwellers.

2.1.2 Promoting Gender Equality and Women Empowerment

Several researches have drawn the attention of the world to the fact that women are responsible for half of the world's food production. It was estimated that female workers contribute between 60-80% of the food produced in developing countries. Women predominantly occupy the labour forces. Their specialized knowledge on genetic resources also makes them essential custodians of biodiversity for food and agriculture.

However, women's fundamental contribution is continually under-appreciated and under-supported, and is often adversely affected by prevailing economic policies and other developmental conditions. These circumstances must be reversed, as sustainable rural development through agriculture cannot be achieved without the full participation of women.

2.1.3 Achieving Environmental Sustainability

The natural resource base of suitable land, water, forests, and biodiversity largely determines the potential of agriculture. These resource endowments have a major influence on human activities in agriculture. Historically, agriculture was believed to respond only to the need of man for food, but it was later understood to respond to poverty reduction. Now it seeks to simultaneously meet the triple objectives of poverty reduction, food security, and environmental sustainability.

Most of the land suitable for agriculture is already being used as farmlands. Therefore, meeting current and future food requirements will need rapid increase in productivity; otherwise, it will result in an undesirable expansion onto fragile and marginal lands. There is widespread concern that deforestation and land degradation are severely diminishing the potential of ecosystems. The main causes of these conditions go well beyond agriculture; agriculture does play a role when policies are inappropriate, unsustainable agricultural practices are used and property rights are insecure.

Biodiversity supports the production of an ecosystem's goods and services essential for life as well as many cultural values. Improving crops, livestock and feeds; soil fertility; and controlling pests and diseases often depend on these resources, however, increasing population pressure, deforestation, and unsustainable agricultural practices are contributing to degradation of these "life insurance policies."

2.1.4 Promoting Human Health and Education

Good health and education are two prerequisites for sustainable development, and agriculture contributes to these aspects both in positive and negative forms.

Adequate nutrition is indispensable for attaining good health. An adequate supply of food is a key determinant of adequate nutrition. This factor alone can drastically reduce malnutrition in adults and children, and increases the birth weight of newborn babies. Improving incomes, nutrition and provision of seeds for agricultural productivity can help prevent the cycle of passing malnutrition from one generation to another. Savings from agriculture provide means of education for farmers' children

Agricultural practices, no doubt, may have a negative correlation on human health and education. For example, overexposing adults and children to dangerous chemicals and harmful forms of farm implements and tools may affect child labour in both the family and commercial scenario. In addition to exposure to dangerous chemicals, children may suffer long working hours, lack of access to education, very low or no pay, and injury due to heavy loads and dangerous machinery, as previously mentioned. If children must work to support themselves, they should be assisted not only with programmes that reduce the physical risks they face, but also with leisure time, flexible schooling, and attractive payment.

2.1.5 Water

Water is an indispensable resource for agriculture and has played a pivotal role in the development of this sector. It is also scarce and unevenly distributed both regionally and among certain marginalized populations, especially in developing countries. Agriculture is the largest user of water, accounting for about 70–75% of the total freshwater withdrawal globally, and between 85–95% in developing countries. Currently, water used for agriculture may not be sustainable because of both scarcity and competition for use by other sectors such as human consumption, health, sanitation, and various industries. As a result, many innovations to improve water use efficiency are being tried, and others such as more water efficient crops are also needed.

Water, by definition, is very vital for all living organisms. In plants, it serves as a mineral dissolvent and a medium for nutrients absorption. It helps in nutrients transportation, regulates plant and soil temperature, keeps plant cells turgid and gives them their natural shape and support. It also plays a great role in plants food synthesis. As a result, large quantities of water are needed to satisfy plant requirements.

Soil water is classified into three major types according to (Akinsanmi, 1994). Water may appear in the form of gravity (gravitational water) which is held at field capacity level. It is usually stored in the macro pores. This type of water affects plant growth and causes poor aeration that restricts roots and soil organisms of oxygen (O_2). Its movement is in the form of gravity and may cause the leaching of soil nutrients. Capillary water is stored in medium pores and found between capacity and hydroscopic or the wilting points. It usually follows a flow movement from higher concentrated regions to lower concentrated regions. **Hydroscopic water** is usually at the equilibrium level. It is found in hydroscopic coefficient. It is not a liquid, but usually moves in the form of vapour.

It is recognized that the absorption of water occurs in the form of osmosis which involves the movement from higher regions to lower region concentration. It is recommended that further research be conducted to investigate if there is any other form in which water is absorbed by plants.

2.1.6 Forestry

Forests have historically provided shelter, food, fuel, medicines, and building materials for both man and animals. More recently, forests have become sources for new goods and services such as pharmaceuticals, raw materials, recreation, and carbon sequestration. However, forests now cover only 24% of the world's land surface and a net loss occur in developing countries. There are no simple answers to deforestation, but developing sustainable agricultural systems will help ensure that forests continue to provide both traditional and new goods and services.

Forestry, by its nature and location, is rurally based and conservative (Asmal, 1995). It is defined as the study and management of forests and their resources. Forest industries that are spawned have become successful, powerful and dominant. Forests supply a country's needs. The products obtained from forest such as wood is used for clothing and book manufacturing. Wood products are major export items for some countries in Africa, as they generate foreign exchange and to boost the country's economy.

The policy on the future of forestry must continue, not only to foster and encourage industries that play a vital role in a country's economy but also to ensure that forestry, hitherto almost reclusive, is brought to people in a manner so as to enhance their quality of life as a result of reconstruction and development programmes.

The policy on forestry should be based on the common vision of achieving national benefits. Laws should be enforced on forest exploitation in order to avoid misuse of the resources. Laws can help bring harmony in the relationships between the different elements that lay claims to forestland and scarce water resources, and bring equity into forest allocation. Forest laws help preserve flora and fauna and the natural environments as people are prohibited from harvesting from certain forests.

Environmental concerns regarding forestry emerged from the mid-18th century in South Africa. This was focused on the ecological and hydrological effects of fire hazards, and the need to conserve forests for a greater influence of their products have become imperative, especially as a source of income for a country.

Controversy about the effects of afforestation on water supplies started in the early 1920s, and it still remains unresolved. This has resulted in great control on afforestation that has been applied over the years in most African countries. From analyses and results of demonstrations, only a small percentage of land is afforested in Africa. This has led to an intense controversy about the broader environmental impacts of forestland, and not just the effect on water alone.

In a nutshell, a new forest policy must be addressed by the people in African countries, in order to meet its benefits and demands and generate foreign exchange earnings.

(a) Fundamental Challenges to African Forests

In a research conducted on African forests, it was observed that there is a lot of negligence in the proper management practices of forest products and their resources. The inappropriate management, however, may continue to pose a serious catastrophe to its expansion if a change is not implemented. It is imperative to find a solution that would resolve these problems in order to promote sustainable forest resources. Recognizing the role of forests in economic development, conservation of biological resources, and maintenance of natural systems is highly imperative. Governments, private sectors and citizens should be aware of the importance of forests and their resources. Citizens and individuals should be acquainted with the fundamental challenges faced by countries and meaningful recommendations should be implemental with a view to ratifying the problems for further advancement. In most countries, there are three basic challenges faced. The challenges include.

- Prevention of wasteful deforestation and forest degradation of tropical dry forests through. (a) correction of distortioned policies; and (b) conservation and sustainable use.
- Revitalization of the wood industry to enhance efficiency and competitiveness.
- Augmentation of the resource base through tree planting and regeneration.

(b) Forest Zones in Africa

Forest vegetation is usually found in areas where there is abundant rainfall and the humidity at 8–9 am ranges between 70–80%. Forest zones are basically divided into four major parts in West Africa. The zones include fresh water swamp, mangrove swamp, rain forest and savannah.

1. Fresh Water Swamp

The fresh water swamp is mainly found behind mangrove swamps. The annual rainfall ranges from 2,500 to approximately 3,000 mm. The land may be seasonally flooded by rivers when the temperature rises above 12°C. The relative humidity range is between 70–75% at 9 am.

2. Mangrove Swamp

The mangrove swamp receives more rain than the inland areas. In West Africa, the coast of Guinea, Sierra Leone, Nigeria and Liberia are usually under the influence of southwest trade winds. The average rainfall in these regions is over 3,000 mm. The yearly temperature is just 3°C. However, Akinsanmi (1994) pointed out that the daily temperature range is usually higher than the annual temperature range. The relative temperature is high and helps in protecting excessive evapo-transpiration. Short, red and white mangroves trees with prop roots and raffia palm are found in this zone. The animals found in this area include crocodiles, birds, fish, snakes and rodents.

3. Rain Forest

This zone stretches through Ghana, Sierra Leone, and Nigeria in the southeastern border upto the Cameroon Mountain. The animals found here include monkeys, grass cutters, snails, antelopes, deers, porcupines and warthogs. The plants include rubber, kola nut trees, palm trees, cocoa, and timber such as obeche (triplochiton scleroxlon), ebony (*Diospyros* spp), teak (tectona grandis), iroko (chlorophora) and mahogany (khaya grandifolia)

4. Savannah Zone

This zone can be divided into Guinea savannah, Sudan savannah and Sahel savannah. The Guinea savannah occupies a large area in West Africa. It stretches from southern Senegal, covering 75% of the total area from Guinea to Ghana, with the centre located in Nigeria. Its vegetation is identified by tall grasses and short trees. Its annual rainfall ranges from 1,500 mm in the south and about 1,000 mm in the north (Akinsanmi, 1994). The area has about four to six months of dry season and six to eight months of rain.

The Sudan savannah is found in the northern part of the Guinea savannah. It spans from West Africa through Senegal, to northern Nigeria. It has an annual rainfall of about 600 mm spread over a period of three to four months. The relative humidity is usually low while the temperature is high. The vegetation contains seasonal short grasses and wild fruits like baobab, scientifically known as "Adansonia". This plant is common in The Gambia, Senegal, Mali and Guinea

The Sahel savannah is found in the northern part of the Sudan savannah. Its rainfall is only for a period of one to two months throughout the year. The vegetation consists of sparse thorny trees, acacia, data palms, neem trees, millet and short grasses.

(c) Policies on Forest Conservation

A policy is a statement of intents or objectives that government sets out as part of its overall vision. It provides a framework that guides and determines the action of government. A policy is set to show what is to be done in particular situation that has been agreed officially by a group of people (Asmal, 1995).

Policies have been formulated on forests in African countries, but as yet a well-documented and defined programme has not been implemented to check the mismanagement of forestland. With a view to implementing a well-defined policy, some of the following prominent aspects of current forest plans have been put forward in this book, based on research results of other publications:

- Devolved management of wilderness areas and other extensive conservation areas on state forests under the responsibility of Provinces should be implemented.
- Responsibility for management, or oversight of management, of natural forests in a country retained by the Department of Water Affairs and Forestry should be re-visited.
- Annual national inventory of commercial plantation forest resources and wood-processing industries should be well-documented.
- National self-sufficiency in wood for commercial purposes should be looked into.
- Incentives should be offered for afforestation.
- Control of afforestation in favour of water resources, with provision for other environmental impacts through environmental impact assessment where necessary, should be focused on.
- Social forestry responsibility for government, pursued through a nursery and a woodlot programme in Department of Water Affairs and Forestry and the Biomass Initiative of the Department of Mineral Resources and Energy Affairs, should be implemented.
- Recognition of self-regulation by companies and farmers with respect to environmental management and sustainability should be emphasized.

- All elements of the policy should be tested against a set of principles that would allow the determination of the appropriate policy.

(d) Reforming Forest Laws

Several factors determine the need for a new Forest Act. These include:

- the need for a democratically-based law,
- existence of certain incongruencies in the present Act, and
- the need to incorporate relevant provisions arising from international laws and customs.

(e) Scope of Forest Laws and Policy

In many African countries, the existing policy on environment encourages inappropriate forest use by undervaluing and underpricing forest resources. To rectify this situation, it is essential to make markets for forest products work better and more effectively for producers, and to take account of non-marketed benefits in decisions on forest utilization. Failure to comply with this policy will result in disaster. It is, however, recommended that the issue affecting these factors be addressed through a process of dialogue among various stakeholders.

Forest laws and policy reflect an integrated approach to protection, management, and use of forest resources of any kind. This approach has the advantage that forest resources are specifically identified on the national agenda, with clear responsibilities in accordance with the international customs and "soft" law (Asmal, 1995).

The alternative is to separate the portfolio of resource conservation from the portfolio of resource exploitation and the conservation provisions of Forest Act. Through forest laws, industries could operate independently within the framework, and simultaneously be controlled by environmental legislations. This will help check the conflict of interest currently posing problems to forestry.

(f) Forest Development

Plantation of important trees should be encouraged in diverse vegetation through regeneration, reforestation and afforestation. To have a precise and appropriate forest development, the following have a great role to play:

- **Farmers and Community Involvement**

Through policy and legal change, training in participatory planning will enable forest agencies to develop a partnership in forest management and reforestation with local communities and NGOs. Government support for participatory negotiation processes involving forest users will facilitate sustainable forest management by local people and eradicate conflicts among community members.

- **Private Sector Involvement**

Governments should shift their role from direct involvement in production towards providing a policy and legal environment, and information services that would stimulate the interest of private investment in forests as a means to provide more efficient wood industry. The involvement of private sectors on policy making will, no doubt, promote efficient management of forests.

- **Improving Knowledge and Technology of Forest Production**

The need to conduct forest inventories in any country will serve as a basic tool for planning, monitoring, implementing and evaluating forest activities. Information gathered from the field should be disseminated in a wide array for the benefit of the public. Due to the importance of forest, the need for a comprehensive research geared towards forest improvement and development will serve as the basic catalyst for sustainability.

- **The Role of Investors in Forest Development**

The role of investors in future forest development is to ensure that four key factors are met. The key areas identified are:

  - Promoting policy reforms
  - Supporting capacity building and human resources development
  - Supporting investments in critical areas
  - Promoting better donor coordination in the forest sector through investment

In order to obtain maximum developmental impact, forest sector operations should be part of an integrated long-term programme. Long-term programme approach would embrace a broad range of lending instruments for improving forest sectors including structural and sectoral adjustment loans that may be given by the World Bank or other interested organizations.

- **Conservation of Forests and their Resources**

  - Conservation of forests should be protected irrespective of their ownership.
  - State forests should be privatized.
  - Nature reserves, wilderness areas and national parks, in terms of the Forest Act and other statutes, would need to be properly recognized, and the role of a new forest act with regard to these lands must be clarified.
  - Recognition of the rights of local communities is imperative.

- Provide a comprehensive overview and analysis of the forest sector.
- Map out a corresponding set of actions for consideration.

- **Sustainable Forest Management**
  - Protection of water resources and soil, conservation of biodiversity and cultural heritage.
  - Forest management within protected forests should be described as multiple functions and sustainable use of forest lands.
  - Public access to forests for recreation, grazing of animals, collection of wood and other forest products should be treated at par with the provisions for joint or participatory forest management.

- **Control of Afforestation**
  - Providing guidelines and regulations for the protection of water resources and nature.
  - Planting new trees by the Department of Agriculture and Forestry.

- **Forest Protection**
  - Providing protection against fire hazards, management of pests and diseases, consistent with the provisions of plant protection legislation

(g) Government's Role and Support Institutions

- Recognition of delegation to local government, community-based organizations, and others.
- Forest research and training programmes should be included in: (1) the Act, (2) school curriculum for students' awareness on forest management and government, and (3) legislation.
- Forest inventories, forest statistics and other monitoring of forest resources
- Incentives like tax exemptions, grants and soft loans to support afforestation for conservation and recreation, to support public access and recreation facilities, restoration of degraded lands, and related matters.
- Financing of administration, grants, loan interests, research and training may be included through tariffs and charges.

(h) Uses of Forests and their Products

Forests are used by a number of user and interest groups, each extracting specific products. Long-term security of forest resources depends on the activities of stakeholders. However, the continuous degradation and depletion of forests is still very rampant in Africa, yet the concerned authorities have not been successful in stopping this act. With the depletion of communal forests and increasing pressure on the remaining state-owned forests, a better arrangement has to be made to guarantee the future of existing forests (Joseph and Ngwasiri, 1995).

Forest products can be classified in terms of proximity to the forest resource. The classification of forest is based on the national population and the international community. Forests and their products can be used in the following varied ways:

- **Productive uses:** Products including timber, bark, vegetables, fruits, medicinal plants and wildlife. These products can be exported for earning foreign exchange.
- **Aesthetic uses:** They can be used for tourism attraction, which in turn generates foreign exchange and rural development.
- **Protective uses:** They serve as a means of environmental protection, steep slopes, biodiversity, etc. This is the primary concern for the international community.
- Conservation: They play a great role in agricultural production. The roles include increasing of rainfall the amount of, soil fertility, nutrient turnover and replacing lost nutrients from the soil.
- **Employment and income:** Forest provides employment for certain group of people called forest guards. These people are recruited or employed by the Ministry of Forestry with the intention to secure forest and its resources. In addition, forest provides income for hunters as they sell the animals hunted in the forest. On the other hand, hunting of animals do not promote agricultural production as it affects the biodiversity. It is recommended that forest should be protected as hunting and destruction of forest may affect our environment. Moreover, preventing forest exploitation is a way of beautifying our environment and increasing the amount of rainfall.

(I) *Types of Forests*

- **State-owned Forests**

State-owned forests are exclusively preserved for the purpose of future development. In some countries, these types of forests are only the relic forests available. However, in the face of increasing population and economic recession, these types of forests are controlled under mounting pressure by the State Ministry of Agriculture as increase population requires some of the forest product.

States should draw up work plans for forests and follow up the operations such as silvicultural activities, harvesting, law enforcement, revenue collection, granting concessions, etc. Local people may enjoy some customary rights, but if they frequently inhabit the forests, they are considered as encroachers (Joseph, 1995).

It is becoming obvious to many governmental organizations responsible for state-owned forests that they can no longer successfully implement the management practices of forests without involving the people staying in the surrounding area, whose livelihood is forest-based. In addition, democratization and current multi-party politics in many countries have resulted in government authorities being deprived of the power to stop the act of involving people in managing forests. Governments are advised to look into this issue critically.

- **Communal Forests**

A community controls communal forests as they stand on communal lands. These forests are usually freer for all, bringing revenue to the people directly, as they extract and use or sell the products. These forests are rare and have fewer restrictions than state-owned or private forests. The communities have greater freedom of access to these types of forests as they belong to the entire community in a specific location. Communal forests are prone to a higher degree of degradation than the forests under management regimes, as they are usually exploited by the local people, who use the land and forest resources as they consider suitable.

- **Private Forests**

Private forests belong to individual people who may do whatever they wish to the land, as it is their personal property. However, in some cases they are legally bound to comply with certain regulations guiding the state or community. Occasionally, government agents check whether the activities being carried out by the individual owners are lawful, and not detrimental to the public interest. This restriction helps in proper management and promotion of biodiversity.

2.2 AGRICULTURAL ADVANCEMENT

The challenges in agricultural production are faced mainly by five basic principles. Without the understanding of these principles, agricultural development will be continually on the decline.

The challenges include:

(i) Creating New Options for the Poor

Agricultural productivity, which is currently low, must be steeply increased. Appropriate technologies and sustainable production techniques can do much to meet this challenge. As agricultural productivity rises, it will almost inevitably displace farm labour. Therefore, more opportunities must be created for off-farm employment. Agro-based processing is one route that can add value to primary agricultural products and help reduce unacceptable high post-harvest losses.

Three requirements must be met to create these new opportunities for the rural poor:

- Avoid destabilizing local prices
- Market access must be facilitated
- Concerted long-term efforts must be made to achieve the principal objectives

(ii) Empowering Developing Countries

Sustainable agricultural development requires strong institutions (both public and private) and an appropriate enabling environment. Developing countries are also required to expediently respond to agriculture and other global governance mechanisms related to trade, environment, genetic resources, and others. Many countries have little capacity to do so. Successful developmental efforts will increasingly depend on implementation of the appropriate policies and institutional capacity to manage the complex rural environment in which agriculture must develop.

(iii) Building and Sharing Knowledge

Over the years, it has been predicted that agricultural growth would fail to meet the food needs of growing populations, leading to starvation and death on a global scale. Those predictions were averted because of rapid progress in technology and use of information. Even with such progress, poverty is widespread among rural people. Reduction in agriculture in developing countries has led millions of people to die of hunger and famine. Overcoming these challenges is made progressively more difficult by rapid population growth on the fixed natural resource base. Agricultural innovation, therefore, must clearly continue at an accelerated rate in order to respond to these challenges. Unfortunately, investments in research suffered most during the past decade of low investments in agriculture. There is an increasing fear that creation of the requisite new knowledge and agricultural techniques of particular interest to developing countries is lagging. Without the ratification of these problems, food shortage will continue to increase.

(iv) Relying on Partnerships

Creating opportunities to allow the poor to escape poverty and hunger through sustainable agricultural development is an undertaking beyond the scope of any single donor. However this can be overcome if donors, international development institutions, and developing-country partners work in a more coordinated way. When countries and different institutions want to work independently, solutions to these problems will be impeded.

Women are crucial partners in the fight against hunger and poverty. Women farmers contribute substantially as casual labourers and unpaid family workers in both commercial and subsistence agriculture, including livestock and fishing. They bear a disproportionate burden of agricultural production. Even intensive tasks such as tilling and clearing, which are often combined with childcare and meeting basic family needs. Advancement in agriculture production will be achieved when international community see a need to provide technical assistance and teaching women and other agricultural workers the modern methods of farming.

(v) **New Knowledge for Forest Development**

Indigenous and modern knowledge play a key role in agricultural development. Such knowledge has historically supported food security's objectives. Attaining potential contributions of agriculture to the world growing population will depend on continued creation and use of new, as well as existing agricultural knowledge at an accelerated rate.

New science in the areas of genomic and biotechnology, and biological control of diseases can potentially improve crop and livestock adaptation to environmental stress, including climatic change, which in turn will improve yields and conserve natural resources. These avenues must be approached in a balanced way. The benefit of this method must be weighed carefully to ensure that its applications would avert the problems affecting food production.

Contemporary research and transfer organizations have not been as effective as they could have been. Improving them will require greater attention to the role of women in agriculture and to the appropriateness of innovations, which must be designed, tested, and transferred to farmers using participatory approaches.

2.3 ENHANCING FOOD SECURITY

Agriculture in developing countries is increasingly moving away from a subsistence orientation and government dominance to commercialization. There are opportunities to accelerate this process in such a way that producers, particularly women, who produce a dominant share of the world's food, become equal partners in the development process and share the benefits.

The rural poor, particularly women, own or have secured access to few assets which they can use to escape poverty. Secured access to land, for example, is often a binding constraint, and the poor are often left to cultivate the marginal areas. The productivity of their two main assets, i.e. land and labour, is very low, but can be significantly improved through intensification and diversification of production systems. Potential strategies include matching production with natural resource endowments, integrating crop and livestock production, and employing agro-forestry technologies.

To achieve the above, the following steps are recommended:

- Improve access, good management, and land administration
- Diversify and intensify agricultural systems
- Reduce post-harvest losses
- Improve food safety, nutrition education, and use of available foods

2.4 AGRICULTURAL SUSTAINABILITY

Livingstone (1975) clearly states that during the past decade, emphasis in ecology has shifted from ecosystem studies to the evolutionary background of natural communities. This shift to natural community should include the use of school gardens and periurban farming in agricultural intensification. The growing evidence of systematic and evolutionary complexity of ecological environment, where farmers and students are to utilize limited resources in farming practices within the community, requires immediate attention by the local and international communities. Looking at the current population strength of the world, utilization of every resource for the production of crops and animals would be vital in sustainable systems.

The recognition of systematic and evolutionary complexity of ecological phenomena has been a major factor affecting agricultural production as ecologists sometimes lose sight of the organisms and ways of remineralizing the lost nutrients, while in pursuit of transferred calories or cycled geochemical (Livingstone, 1975). Recognition of this complexity would result in dealing with all the factors affecting sustainable agriculture more realistically, as indicated by Livingstone (1975). To better understand the ecosystems, agriculture education should start from the grassroot level where secondary and high school students are introduced to the new scientific methods of food production. The implementation of this would mean setting up of demonstration farms in schools at all levels where research should be conducted on more vulnerable garden crops and testing various nutrients using natural methods in amending the soil fertility. This would create an awareness among the students at secondary and high school levels of the phenomena governing food production.

Pearce's (1994) review indicated that only a few groups of individuals and institutions/organizations have recognized the concepts that have attracted the attention of political, popular, and academic institutions to sustainable development. Significantly, "sustainable development" now figures as a goal in dozens of national environmental policy statements by various research institutes and young scientists.

Due to a long-term use of soil by humans in different communities for agricultural production, most of the nutrients have been depleted. There is a growing recognition, amongst both policy makers and specialists, that soil degradation is one of the root causes of declining agricultural productivity in Sub-Saharan Africa and other parts of the world. Soil is much more an integral component of natural and human managed ecosystems that there exists a multitude of concepts relative to the nature and functions (Buol, 1995). The diversity of concepts of soil is compounded by the continuance of its properties on the landscape, and geographical limitations of each person's scientific experience. The consequences of allowing productivity of African soil resources to continue on its present downward spiral would be severe, not only for the economies of individual countries, but also for the welfare of millions of rural households depending on agriculture for meeting the requirements for their welfare (Expert Consultation, 1999).

2.4.1 Future Pace of Agricultural Production

No question is more important for the future of humanity than whether growth in agricultural production can keep pace with the increasing population and income driven demand for food (Naylor, 1996). This concern is certainly not new; for several decades scholarly attention has been devoted to issues of agricultural productivity, land use change, and population growth. The vulnerability of agricultural systems throughout the world has increased the number of natural resource constraints and global environmental changes which spawned a new era of literature. As the world is currently posing questions on sustainable agriculture, would there be a contribution when there are challenges on setting up vegetable farms in high schools? Would the establishment of school gardens provide food for nearby communities? The answer is yes. The growing of crops within schools will provide food for both the school community and nearby community people. This has been evident from my 10 years of teaching experience in high schools and with the establishment of demonstration plots, as food for both teachers and students within the community was provided at more reasonable prices.

The review conducted by FAO (1994) states that there should be an intensification of agriculture in a global form. The intensification of agriculture over the years has shown an impressive production of grains and crop yields in the past decades (FAO, 1994). Intensification of agriculture without adequate restoration of soil fertility may threaten the sustainability of agriculture (Roy et al., 2003). Continuous cropping without adequate restorative practices may endanger the sustainability of agriculture. Farmers and students should understand that nutrient depletion is a major form of soil degradation. A quantitative knowledge on the depletion of plant nutrients from soils will help them understand the state of soil degradation and may be helpful in devising nutrient management strategies (Roy et al., 2003). This group can acquire this knowledge when being involved in a research either through school garden demonstration or participating in improved agricultural programmes.

World population is increasing daily, and as the population increases more food is needed to satisfy their needs. The involvement of high school students will contribute towards food availability and help in further research for the advancement of agriculture. As clearly pointed out by FAO, the intensification of agriculture in a global form has increased the production threefold of cereal crops during the past 60 years. The growth of grains has risen even in many Sub-Saharan African countries over the past decade (FAO, 1994). However, the production per capita has remained stagnant mainly due to extremely large population increases. The current research should focus on involving students at all levels in agricultural production, as it will definitely help in the eradication of food shortage in future.

2.4.2 Assessing Agricultural Sustainability

FAO (2002) indicates that the global population will continue to expand at a rate of 1.1% until 2015 and decrease thereafter. United Nations population projection also states that world population has continuing growing from 5.7 billion in 1995 and it is expected to reach 9.4 billion in 2050, 10.4 billion in 2100, and 10.8 billion by the year 2150. The projection is said to stabilize within the range of 11 billion in 2200 (Gold, 1999). Today, the rate of population increase is very high in many developing countries. In these countries, population factor is combined with rapid industrialization, poverty, political instability, and large food imports and debt burden which have made long-term food security very urgent for the world growing population.

As clarion calls for the new generations, the need for growing more food for the world population has called for sustainable agriculture. As defined by FAO and other agricultural institutions and scientists, sustainable development is the management and conservation of natural resource and it is based on the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Sustainable development conserves land, preserves water, plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO, 1994a).

Lynam and Herdt (1989), defined sustainability in agriculture as systems rather than doing singular analyses of inputs and outputs, just because crop varieties and inputs produce nothing in isolation. But only when combined as components of a system do they produce output (quoted in Herdt and Steiner, 1995)

The concept of agricultural sustainability has three dimensions (biological, economic, and social) that are important in determining the future viability of intensive agricultural production (Herdt and Steiner, 1995). Evidence presented in literature indicates that a number of physical constraints, particularly those related to the depletion and degradation of soil, water, and energy resources, threaten future agricultural growth (Smil, 1994). Literature also shows that farmers and society face large costs with respect to declining resources in agriculture[1]. To date, the synergistic effects among inputs have worked in favour of agriculture (Loomis and Connor, 1992; Evans, 1993; Pluckneth, 1994, Plunknett, 1995). A major social limitation militating against agriculture is how much society is willing to pay in terms of health and ecosystem damages from increased fertilizer and pesticide use in agriculture (Ruttan, 1992; Naylor, 1997). As stipulated in the EU organic regulations, the use of synthetic substances in crop and animal production will be phased out in 2012. Africa is currently advancing in food production, as the world is currently advancing in agricultural discipline, the need to educate future leaders on the modern methods of food production is highly imperative. The involvement of both higher and secondary school students will play a role in this demand not just to embark only on universities, research institutions and individual farmers.

Changes in agricultural technology, infrastructure, and farm management are needed now more than ever in Africa, literature review indicates that investments on agriculture are not keeping pace of meeting the growing world population. Defining new dimension in the modern world is a new challenge for agricultural improvement.

2.4.3 Sustainability of Food

Farming systems are the meeting point of natural economic and social systems, each of which has its own dynamics. For farming systems to meet the demand there should be simultaneous sustainability in each of the

[1] Literature review as used in this book means nearly all the literature used in preparing the materials in this book.

dimensions. Adjusting the dimension to reach a lasting period may be incompactible with sustainability in some parts of the world (Marsh, 1997). Adjustment of these dimensions must take into consideration the environment which is the fundamental factor affecting food production.

The environment has become a major constraint to agricultural progress. Fundamentally, agricultural environment should be able to support sustainability: environment is a prerequisite for social and agricultural sustainability. Redclift (1987) claims that poverty reduction is the primary goal of sustainable development, even prior to addressing environmental quality. Poverty is increasing in the world in spite of global and national economic growth. Poverty reduction has to come from qualitative development, from redistribution and sharing, from population stability, and from community sodality, rather than from throughput growth (Redclift, 1986, 1994).

Politicians are determined to achieve difficult task of increasing food production. Meeting these tasks require sustainable development, social integration, environmental and economic sustainability. The moment the term development is introduced, the discussion becomes quite ambiguous. The achievement of sustainable agriculture would only be possible when certain conditions are overcome. There include understanding the relationship between plant and soil, using the right crops on the suitable soil, having a sound knowledge on nutrient remineralization, controlling pests and diseases and introducing school gardens at all levels.

2.4.4 Can Undernourishment be Strengthened in Africa?

As the world renews its efforts towards alleviating food insecurity in developing countries following the 1996 World Food Summit, the availability of an accurate national level indicator of food insecurity that is comparable across countries has become extremely imperative (Smith, 1998). Just as monitoring food insecurity within countries is fundamental for generating adequate information for programme planning and policy making for individual countries (Babu and Quinn, 1994), monitoring food insecurity at national, regional and global levels is essential for such planning and policy making across countries. Policy planning for the projection of more available food in the world should cover three main purposes: (1) identifying where food insecurity exists and where it is most severe; (2) tracking changes in food insecurity over a period of time; and (3) understanding its causes so that the most effective interventions can be chosen to alleviate it. Food security has been discussed in several articles, however, there is enough food in the world but the developing countries have not got the right tools to secure food for the growing populations. The major aspect international community should focus on, is the identification of areas where efforts are required for the alleviation of hunger in developing countries. Currently, the most widely employed national level indicator of the prevalence of food insecurity is a measure of 'chronic undernourishment' developed by the Food and Agriculture Organization (FAO) of the United Nations. The measure gives the number and proportion of people in each country who consume insufficient dietary energy to meet their requirements.

The issue of undernourishment in Africa led to a research conducted by Ghana and Nigeria on cassava production. Over the years, the research carried out on this crop has helped reduction of undernourishment by 10% since 1990 (FAO, 2000). The undernourishment, which was over 30% points in Africa, has drastically reduced due to the intensive research conducted for more conducive conditions needed for the development of cassava.

Like in the case of cassava, high school students can be exposed to the management and production of different crops through the establishment of vegetable gardens in their respective schools. The introduction of gardens in schools will guide them on the overall strategies needed to improve crop production, and the production of more nutritious crops in particular. Producing more food may not be the only yardstick for the introduction of gardens in schools, but also to establish means of preserving food crop in a natural form without the involvement of chemical substances (organic). Beside, as the world calls for sustainability, their contribution will, no doubt, assist in sustainable agriculture in future.

Recommendation

Development requires a sound land use planning. Land use planning needs a biophysical and socio-economic evaluation component, since socio-economic conditions may change instantly and the biophysical environment is more stable.

In developing countries, information is required at three levels corresponding to approximate resolutions of 1:200,000 (department), 1:50,000 (district) and 1:10,000 (village). An appropriate tool for inventory at these scales is SOTER which offers corresponding map units (terrain unit, terrain component, soil component). Experiences at three different sites based on Geographic Information Systems (GIS) and relational databases (RDBMS) have been recently reviewed (van Engelen, 1993). Overall, SOTER is an adequate tool, but in order to ensure consistency and applicability, some changes with regard to the original structure are necessary.

To aid the contribution of students towards sustainability, community people would have to play a role by making more land available for schools.

The problem developing countries face in agriculture is caused by rapid urban growth. This has claimed most of the land supposed to be made available for community schools for carrying out research on suitable crops to be grown within the communities. By controlling this growth and paying proper attention to students' agricultural land, the problem of food insecurity may be resolved.

2.5 SUGGESTIONS ON HOW TO PROMOTE AGRICULTURAL DEVELOPMENT

- Governments must commit themselves to a coherent and comprehensive vision of agricultural and rural development.
- Maintaining sound and stable macroeconomic and trade policies that encourage investment in agriculture.
- Strengthening human capital in rural areas through health and educational services and access to productive resources.
- Establishing a strong institutional environment that improves access to markets, ensuring dissemination of information, standards setting, and provides an adequate legal and regulatory framework for development.
- Enabling research and extension services to develop productive and robust technologies under farm conditions.
- Upgrading marketing systems, transport and communication infrastructure to support farmers' access to seasonal and longer-term capital and inputs, and providing them with strong price incentives
- Safeguarding natural resources and environment capacity.
- Providing marketing assistance.

2.6 FACTORS AFFECTING FARMERS

The factors affecting farmers today may be much more complex than those faced by developing countries which achieved sustained agricultural growth in the last three decades. New and emerging challenges confronting them can be identified under three broad headings.

- Overcoming their marginalization resulting from integration of markets due to globalization and liberalization.
- Adapting to technological change.
- Coping with the new institutional environment.

2.6.1 Globalization of Markets

Globalization and liberalization are becoming more vulnerable to changes in the world market conditions, on account of their small economic size and their increasing reliance on imports for food supplies. Their problems have been compounded by the long-term decline in real prices of their major primary commodity exports, despite some temporary increases experienced in the early 1990s (http://www.fao.org). The consequent decline in the commodity terms of trade has reduced both the incentives to engage in the production of tradeable gains and economic stimulus of agricultural products.

2.6.2 Technological Challenges

Keeping pace with the increasing domestic demand for food, meeting requirements for enhancing competitiveness and ultimately raising rural incomes, necessitate raising agricultural productivity. Sustained agricultural growth requires more ingredients than that of 'the green revolution'. Investment in irrigation and rural infrastructure, human development and institutions will contribute immensely towards overcoming these challenges. New developments in biotechnology may also pose further threats to technological challenges.

2.6.3 Measures to Accelerate Agricultural Development

- Emphasis needs to be given for increasing the production of tradeable products (cash crops).
- Determining the most appropriate roles relevant to government agencies, donors, civil organizations, and commercial entities.

2.6.4 Recommendations for National and International Actions

- Meeting the new challenges facing agriculture will further accelerate development.
- Further emphasis on macroeconomic and sectoral incentives has a great role to play in agricultural sustainability.
- Strengthening institutional capabilities will promote further research on agricultural advancement.
- Raising and sustaining productivity and competitiveness will broaden markets.
- Diversifying production and trade should be the focus of investors, government and individuals.
- Improving access to foreign markets will encourage more farmers to enter into the agricultural domain.

Land

Chapter 3

Land is the top layer of earth's surface containing essential elements needed in nature to support the growth of crops and animal life. Land is a very important asset for the majority of people in the world especially in Africa. Current estimates show that about 70–80% of Africa's population relies directly on agriculture for subsistence, existence and income generation.

Africa's landscape and environment perform a variety of essential ecological functions in providing water for drinking and fisheries for the population. Land plays a great role in a country, as it is used for growing crops, animal production and erection of buildings. Despite the relatively low proportion of people living in Africa, a lot of town-dwellers retain a very high level of interest and possession of their land.

In Africa, distribution of land is an issue of discussion and cultural inheritance. Many West African systems are still based on customary rights associated with cutting a field and settling especially in areas where land is relatively abundant. The need to sort out the contradictions between customary and statutory tenure systems, provide communities with greater formal decision-making powers over how the resources on which they depend on may be used. Strengthening local capacities to carry out these tasks effectively is the main issue of concern (Toulmin and Simon, 2000).

3.1 LAND TENURE

Land tenure refers to the methods in which land, other natural resources, etc. are held and used by communities, individuals and governments. It refers to the rights, obligations of landholders and their users. Land tenure is one of the crucial determinants of how land management and resources are used. Rights are always balanced by obligations or duties. For example, fines may be imposed on a livestock owner if his animals damage crops on the fields of the landholder. Security of rights always involves some authorities enforcing these obligations, imposing sanctions that protect land right holders, and mediating between conflicting claims. Land tenure, therefore, involves some methods of governance, that encouraged land administrative functions like record keeping and management principles.

Land tenure in Africa has undergone an evolutionary transformation from simple systems to complex ones since the humanization of Africa. The political independence in Africa, land use and land tenure have been characterized as simple subsistence modes of production, which is based on communal or egalitarian land tenure systems (Yudelman, 1964; July, 1975)

Subsistence production and communal land tenure systems are still prevalent in many parts of sub-Saharan Africa. Land use over the years has evolved in certain regions from simple subsistence and shifting cultivation to sedentary or permanent types. Land tenure evolved over the passage of time from communal forms to those types in which emphasis is given to individual landowners. Land can be owned and controlled by the government of a country, which in turn places it under the control of local government ministries. Beside government land, a group of persons can temporarily own a piece of land for a certain number of years on rental basis, however, in this kind of ownership, permanent crops or buildings are not permitted.

3.2 LAND USE

Land use in Africa refers to the usage of any given piece of land for a period of time, under prevailing environmental conditions. Land use can be classified into agricultural use and non-agricultural use. The technological conditions of land use have undergone an evolutionary transformation from simple game hunting and gathering, to the more complex sedentary commercial cultivation systems in modern agriculture.

Pritchard (1979) explained in theory and publication that land use in tropical Africa evolved from game hunting by the Bushmen in the Kalahari Desert. Other nomads in Zaire especially where population is sparse to bush fallowing, do returned to the abandoned patches of land to cultivate crops as soon as the soil and vegetation have been replenished. However, bush fallowing practices are only possible in an area where there is less population.

3.2.1 Types of Land Tenure Systems

Land tenure may be defined as the terms and conditions on which land is held, used and transacted. Land tenure reform is the planned changes in the terms and conditions of land found in a location. The fundamental goal of land reform is to enhance and to secure people's land rights. This may be necessary to avoid arbitrary evictions and landlessness.

According to FAO (2002) definition, land tenure is the relationship, whether legally or customarily defined, among people, as individuals or groups. Land tenure is an institution, like rules, invented by societies to regulate behaviour. Rules of tenure define how property rights to land are to be allocated within societies. Rules define how access can be granted to rights to use a specific land and its control, and also the transfer of land from generation to generation, or from one individual to another, as well as the associated responsibilities and restraints. In simple terms, land tenure systems determine who may use the resources within a given period under certain conditions.

Land tenure is an important part of social, political and economic structures. It is multi-dimensional, bringing into play social, technical, economic, institutional, legal and political aspects that are often ignored but must be taken into consideration. Land tenure relationships may be well defined and enforceable in a formal court of law or through customary structures in a community. Alternatively, they may be relatively poorly defined with ambiguities open to exploitation (FAO, 2002a).

3.2.2 Land Rights

On the issue of land rights, this is brought about in response to concern for food security and poverty alleviation. Development agencies and organizations have introduced strategies that help to build assets and promote self-reliance of poor people and communities. Interventions include helping poor people protect and enhance their natural resource base, improving access to agricultural land through resettlement schemes, and ensuring food security of the vulnerable, including women, minorities and indigenous groups (FAO, 2002). The most important issue is helping them protect their rights in the various communities.

(a) Individual Land Rights

The most prevalent type of land tenure systems in pre-colonial Africa are generally abundant lands and sparse populations. The individual families under these conditions within a given village usually acquire land by clearing virgin bushes. Land transfers could also be obtained by inheritance (Conroy, 1945). Once an individual acquires a piece of land under inheritance, the community protects his/her rights.

In this method of land rights, members who traced their heritage from a common ancestry were exclusively reserved access to agricultural land for use. As a rule, transfer of land rights among families between matrilineal relatives or friends, and the land rights of a deceased person were in all probability taken over by matrilineal relatives.

The advantage in this system is that land can be sold when the owner is facing financial difficulty. The individual persons can also use it to obtain loans from banks when money is needed and the land will serve as a coelenterate. The owner has right to grow tree crops without any restriction. Buildings can also be erected on the piece of land. The major disadvantage is that the land can be fragmented as generations pass. It also discourages large scale farming as some individuals may not be willing to carry out farming and would not be interested in giving their piece of land to those interested in farming.

(b) Communal Land Tenure Systems

This form of land tenure is associated with the community right. Skinner (1964) shows that in the pre-colonial semi-feudal agrarian-social structure of the Mossi Empire in Burkina Faso, the King and the chief classes controlled land and assigned land rights to individual community members. Anyone living in the community must acquire land through the Kings or chiefs. Sometimes this kind of land tenure system brings enmity among community members when the land is not equally shared. However, the system does increase agricultural production as most members living in the community have access to a portion of land.

(c) Landlords and Tenants

Feudal systems of land tenure and feudal relations of production emerged in many different parts of Africa. In the south and west of Ethiopia, feudal land tenure emerged especially towards the end of the 19th century. The tenants/serfs usually paid rent in kind, which varied depending on the demands of the landlord. Usually tenants were expected to pay 50% of the harvest. In some cases, the rent would be higher than the cost expected to be harvested by the tenants. Tenants who defaulted in their obligations could be evicted by the landlords and become landless (Gilks, 1975). This method, however, discouraged a lot of farmers who were interested in large scale farming, as a result of exorbitant prices in land rent.

(d) Leasehold System

A lease is a document that is a legal binding agreement between the government and the lessee. It is a written document that sets out the rights and obligations of lessees and states the purpose for which the land can be used.

One of the key obligations of lessees is to develop the land in the time prescribed in the lease document. Leasehold system under the control of government warrants the lessee to have access and use the land that is described in the lease for his or her benefit and can remain as the owner of that land for the term of the lease period. The person under this system is, however, bound by certain rules and regulations. In most cases, the person using this type of land is advised not to erect permanent buildings as the land may be returned back to the rightful owner at the end of the lease period.

3.2.3 Factors Affecting Land Availability

The most important factors affecting land availability in West African countries are:

- Physical factors like topography, soil type, etc.
- Socio-economic factors which include industrial development and population pressure.
- Environmental factors like climate, etc.

Weathering

Weathering is a term used to describe the changes which rocks undergo to form soil. It involves a complex series of changes that in turn result in disintegration of rocks. The disintegration from mineral particles forms soil. Weathering processes may be classified into three categories, namely, physical, chemical and biological. The physical process involves the activities of water or ice and wind disintegrating rocks into smaller fragments. The biological process involves the activities of living organisms such as earthworms, termites and other soil organisms, whereas the chemical weathering usually involves dissolution of minerals in water and atmospheric air like carbon dioxide and oxygen.

Physical or Mechanical Weathering

Physical Weathering

This breaks down rocks into smaller pieces thereby increasing the surface area in which chemical weathering can occur. Chemical weathering promotes decomposition of minerals in rocks to a lesser resistant mineral. Physical and chemical weatherings reduce rocks to easily erodable weaker materials.

Many agents such as temperature, frost action, organic activity, and abrasion cause mechanical weathering. Due to temperature variations over a period of time, it allows the rock to expand and contract repeatedly causing curved-shaped pieces to break off. Dumas (1997) explained that frost action occurs as water seeps into tiny cracks in the rocks that freeze at night. When the ice expands, it breaks down rock fragments. Biological activity also occurs as plant roots slowly pry apart the rock, as the plant grows larger.

Biological Weathering

Rocks undergo a process of weathering which is a primary source of some essential elements for organisms, except nitrogen and carbon. Weathering has been accelerated under the influence of biota. The study of biological weathering began in the end of 19th century. However, the role of bacteria (Eubacteria and Archaea) has attracted interest on weathering over the past years. Fungi in rock weathering were not given special attention in the past. But current research on weathering has been focused on fungal and bacteria, as their role in breaking down of rocks is increasingly an important focus of biogeochemical research. The breaking down of rocks by algae and bacteria has been recognized for some time in a variety of environment. However, further research on weathering may reveal the roles of organisms in weathering processes.

Mellor, 1922; Palmer, (1989) mentioned that various biological agencies are considered very significant in the deterioration of building materials. The effects of rock breakdown in different environments, particularly in hot deserts and Antarctica according to Friedmann et al., 1947, Friedmann, 1971; Broady, 1981, Kappen et al., 1981; Friedmann and Weed, (1987) are seen to be aided by the activities of soil organisms. The absence of organisms during weathering may impede the process of biological weathering which gradually reduces the rate of soil formation.

Chemical Weathering

This is the process by which rocks are decomposed, dissolved or loosened by chemical processes to form residual materials. It involves the breaking down of minerals resulting to changes in rock composition thereby replacing strong minerals with weaker ones. Most chemical weathering is caused by water. Water can dissolve most minerals that hold rocks together. There are different chemical reactions associated with chemical weathering. These include:

Carbonation

Carbonation is the process whereby carbon dioxide is dissolved in rainwater or moisture in surrounding air to form carbonic acid and which later reacts with the minerals in the rock. This process thus weakens the rock. The slightly acidic rainwater is then capable of dissolving certain minerals in the rocks.

Chemical reaction: Calcium Carbonate + Water + Carbon Dioxide → Calcium Carbonate (soluble).

$$H_2O + CO_2 \rightarrow H_2CO_3$$

Though weak, when carbonic acid is combined with a mineral like calcite ($CaCO_3$) common to limestone, calcium and bicarbonate ions are released and carried off by ground water (Thornbury, 1969).

Chemical equation for carbonation: $CaCO_3 + H_2CO_3 \rightarrow Ca^{+2} + 2\ HCO_{-3}$

Dissolution

It is believed that dissolution occurs when rocks and/or minerals are dissolved by water (McConnell, 1998). The minerals dissolved are transported from the area of breaking down leaving a space in the rock resulting in the formation of caves in limestone areas.

$$\text{Rain + carbon dioxide} \rightarrow \text{carbonic acid}$$
$$H_2O + CO_2 \rightarrow H_2CO_3$$

Hydrolysis

This is the chemical reaction between minerals in the rock and hydrogen in rain water. For example, during hydrolysis, the feldspar in granite changes to clay mineral which crumbles easily, weakening the rock and causing it to break down. It may also be described as the ionisation of carbonic acid into two ions (hydrogen (H^+) and bicarbonate (HCO_3^{-1})). Feldspar is the most common mineral in rocks on the earth's surface that usually reacts with water to form a secondary material like kaolinite.

Chemical combination:

$$\text{feldspar + hydrogen ions + water} \rightarrow \text{clay + dissolved ions}$$
$$4KAlSi_3O_8 + 4H^+ + 2H_2O \rightarrow Al_4Si_4O_{10}(OH)_8 + 4K^+ + 8SiO_2$$

Oxidation

Oxidation is the process in which oxygen chemically combines with another substance. The result of oxidation is the formation of an entirely different substance. When carbon dioxide dissolves in water, a weak acid called carbonic acid is formed. This acid can dissolve some types of minerals (Dumas, 1997). In this process, oxygen reacts with iron in minerals to form iron oxide minerals such as hematite (rust) leading to the weathering process of rocks. When oxygen combines with iron, the reddish iron oxide hematite (Fe_2O_3) is formed (Thornbury, 1969):

Chemical equation for oxidation: $4Fe^{+3} + 3O_2 \rightarrow 2Fe_2O_3$

3.3 ROCK FORMATION PROCESSES

Rocks are described as the physical mixture of two or more minerals, though they may consist of a single mineral variety. The proportion of various minerals combined during formation determines the type of rocks formed. The mineral composition can be classified as primary rock forming minerals and secondary rock forming minerals. Usually, the mineral compositions of rocks are inorganic and have a definite chemical composition.

Primary rock forming minerals usually include, quartz, feldspar, micas and olivine. The secondary rock forming minerals include oxides of aluminum and iron, clay minerals, carborates and sulphates, sulphates of calcium, magnesium and phosphate.

In general, rocks are basically of three types and include igneous, sedimentary and metamorphic. As the earth cooled, great masses of rock of varying weight and composition buried many kilometres deep in the earth were converted in rocks. These rock materials are believed to surround the molten mass known as magma. Magma is the term usually used to describe molten material lying on the earth. However, molten rock may contain some suspended crystals or dissolved gases as well.

Igneous Rocks

The formation of igneous rocks was due to the effect of high temperature (5,000°C) on molten materials lying on the earth's interior for years. When molten rock cools and solidifies, it becomes mineral crystals which are then called igneous. There is a variation of melting temperature for different compositions of magma. Some of this molten rock remains inside the earth and some are ejected as lava onto the earth's surface during volcanic eruptions. The process of forming mineral crystals is called crystallization. As the mineral crystals form, they join together or interlock into masses of igneous rocks. The further breakage of the igneous during change of weather and transformation led to the formation of sedimentary and metamorphic rocks.

As a result of variation of melting temperatures of magma during cooling, several compositions are formed. It is highly typical for silicon tetrahedra to form first, and later join with other ions to form nuclei for crystal growth. The minerals with the highest melting points crystalize first and their crystal growth continues unimpeded as long as the surrounding material remains molten. As crystallization gets completed, a solid mass of interlocking crystals of different sizes become igneous. Igneous rocks include granite, gabbro, rhyolite, and basalt.

Sedimentary Rocks

These are derived from pre-existing rocks of all types. The rocks forming sedimentary types were broken down by the activities of weathering agents like frost, wind, rain, river, ice and sea. The elements produced by these agents were moved from their origin to be deposited elsewhere. The materials derived from the broken elements by river, sea and sand were cemented together by the process of diagenesis. The consolidated materials constituted the sedimentary rocks. The ones not consolidated were the sediments. Sedimentary rocks can be distinguished on the basis of their origin. This class of rocks is divided in clastic, chemical and organic sediment.

The clastic sediments are usually the fragments of other existing rocks transported by wind, ice or water. They can be grouped corresponding to size of the fragments in conglomerates, sandstones, siltstones and mudstones. The chemical sediments are the results of high evaporation in shallow area basins and the chemical precipitation of dissolved materials as carbonated limestone, dolomite, sulphate (gypsum) and chloride (NaCl, KCl). The organically formed rocks are derived from animal and plant materials. The materials include peat, coal and lignite that are deposited as a result of accumulation of plant materials (Akinsanmi, 1975).

Metamorphic Rocks

These are derived from pre-existing sedimentary or igneous rocks. They are formed by the activities of the agent of pressure, heat and chemicals. This group of rocks is classified into two, i.e., foliated and non-foliated. The individual mineral grains are usually parallel to one another in foliated type. Examples of foliated type include muscovite and biotite. The non-foliated rocks do not possess cleavage while the foliated rocks possess cleavage. Examples of non-foliated type include gneiss made from quartz, feldspar and some dark minerals. Schist is another example, but its origin is affiliated to sandstone, shale, limestone and buried larva. This rock possesses undulating planes that have been formed by cleavage as a result of pressure. Examples of metamorphic rocks include quartzite, marble and slate.

3.4 SOIL AND ITS FORMATION

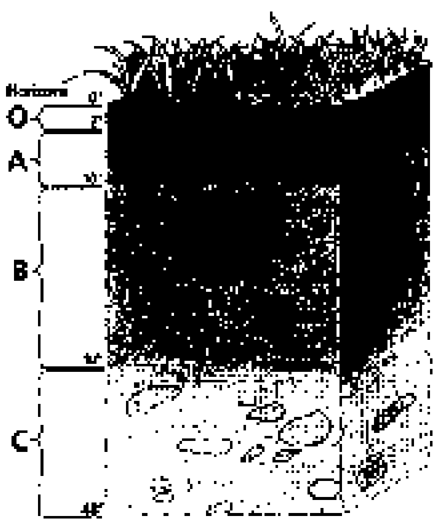
Soil is a central basis for all agricultural activities (Alfoeldi et al., 2002). It is one of the most important natural resources for crops. Proper attention must be paid to it for the maximum support of agriculture. Most organic farmers do not compensate for a loss in fertility of soil by inputs of synthetic nutrients, therefore, the building and maintenance of soil fertily should be the central objective of organic agriculturists (Lampkin, 1990; Stolton et al., 2000). The impacts of organic farming on soil properties have been covered extensively by researchers over the years with a special focus on the relevant parameters of organic matter content, biological activity and soil erosion.

Thorough comparisons of relevant soil parameters of conventionally and organically managed soils in Switzerland proved the following:

- Organic matter content is seen to be higher in organically managed soils than in exclusively mineral fertilized conventionally managed soil, as a result of organic fertilization methods. High organic matter content can help avoid soil acidification.
- Organic soil management improves soil structure by increasing soil activity, therefore, reducing the risk of soil erosion.
- Organic crops profit more from root symbiosis, and are better able to exploit soil.
- Organically farmed soils have significantly higher biological activity than those of conventionally managed soils, due to the presence of a large number of earthworms, fungi, bacteria, and other micro-organisms.
- Organic management promotes the development of soil fauna like earthworms and other ground arthropods, thereby improving the growth conditions of crops.

3.4.1 Factors Affecting Soil Formation

Soil research has proved that soil profiles are influenced by five separate, yet interacting, factors: parent material, climate, topography, organisms, and time. Soil scientists call these the *factors of soil formation*. These factors give soil profile their distinctive characters.



Source: http://www.nesoil.com/properties/formation.html

Fig. 1 A soil profile

The interaction of the five soil-forming factors (time, climate, parent material, topography and organisms, i.e. plants' and animals' life) results in the development of a soil profile. Soil profile is a vertical section of the soil layer beginning from the surface and extending downward into the unconsolidated underlying material to a soil depth of 60 inches or more. The topsoil called "A horizon" is the outermost layer of soil; it is parallel to the soil surface, with distinct characteristics produced by soil-forming processes as illustrated in the above Figure 1. It usually includes the organic layer in which plants have their roots and the farmer turn over during ploughing. The physical and chemical characteristics observed within the soil profile are the basis for differentiating soil from another.

(a) Parent Materials

Soil parent material is the material that soil develops, it may be a rock that has decomposed in place, or material that has been deposited by wind, water, or ice. The character and chemical composition of the parent material plays an important role in determining soil properties, especially during the early stages of development (Ritter, 2003).

Soils developed on parent material that is coarse grained and composed of minerals resistant to weathering are likely to exhibit coarse grain texture. Fine grain soils develop where the parent material is composed of unstable minerals that are readily weathered (Ritter, 2003).

Parent material composition has a direct impact on soil chemistry and fertility. It is rich in soluble ions (calcium, magnesium, potassium and sodium) which are easily dissolved in water and made available to plants. Limestone and basaltic lava both have a high content of soluble bases and produce fertile soil in humid climates. If parent materials are low in soluble ions, water moving through the soil removes the bases and substitutes them with hydrogen ions making the soil acidic and unsuitable for agriculture. Soils developed over sandstone are low in soluble bases and coarse in texture, which facilitates leaching. Parent materials influence on soil properties tend to decrease with time as it is altered and climate becomes more important (Ritter, 2003).

(b) Climatic Factors

Soils are assumed to show strong geographical correlation with climate, especially at the global scale. Energy and precipitation, however, strongly influence physical and chemical reactions on parent materials (Ritter, 2003). Climate determines vegetation cover, which influences soil development. Precipitation in the atmosphere does affect horizon developmental factors in relation to translocation of dissolved ions through the soil. Climate is also believed to influence soil properties since the influence of parent material during soil formation is low.

(c) Soil Topography

Topography describes the shape of a land in a particular location. The shape of land surface, its slope and position on the landscape, greatly influence the kinds of soils formed. Topography has a significant impact on soil formation as it determines runoff of water, and its orientation influences microclimate which consequently affects vegetation. The formation of soil depends on the parent materials which need to lie relatively undisturbed to enable soil horizon processes to continue. Water moving across the surface strips parent material away impeding soil development. Water erosion is more effective on steeper land according to soils investigated by various scientists.

(d) Time

The formation of soils is a continuing process and it generally takes several thousands of years for significant changes to occur. It takes approximately 14,000 years for American soil to form, 10,000 years in Europe and 100,000 years in Africa. This formation is however depending on the region and location. Plymouth soils are considered to be relatively young soils with slight alteration of parent material and weak soil horizon development. Most of the soil orders mapped in Plymouth County are Inceptisols, Entisols, and Spodisols. In general, time is considered to be the most important factor affecting the formation of soil, as the length of time taken during soil formation determines the type of soil that would be formed.

(e) Soil Organisms

Plants, animals, microorganisms, and humans affect soil formation. Animals and microorganisms mix soils and form burrows and pores. Plant roots open channels in the soils. Different types of roots have diverse effects on soils. Grass roots are "fibrous" near the soil surface and decompose easily, adding organic matter. Taproots open pathways through dense layers. Microorganisms affect chemical exchanges between roots and soil. Humans can mix the soil so extensively that the soil material is again considered parent material (United States Department of Agriculture, USDA, 2005).

The native vegetation depends on climate, topography, and biological factors plus many soil factors such as soil density, depth, chemistry, temperature, and moisture. Leaves from plants fall on the surface and decompose on the soil. Organisms decompose these leaves and mix them with the upper segment of the soil. Trees and shrubs have large roots that may grow to considerable depths (USDA, 2005).

3.5 SOIL COMPOSITION AND PROPERTY

The physical properties of soil largely determine the manner in which it can be used. Properties such as waterholding capacity, permeability to water, aeration, plasticity and nutrient-supplying ability are influenced by the size, proportion, arrangement and mineral composition of soil particles. The proportion of the four major components of soil—inorganic or mineral particles, organic material, water and air, vary greatly from place to place and with depth. The amount of water and air in the soil fluctuates from season to season, but the proportion of primary solid components of the soil, however, remains unchanged. The universal components of soil in percentage are listed in Fig. 2:

Soil = rock materials + organic materials + water + air

Source: McConnol, 1999

Fig. 2 Soil Composition

Particle Shape and Size

The particles of soil vary in shape (spherical to angular) and structure. The size is different from gravel, it varies between sand and fine clay. The effective international sizes considered are illustrated in Table 1.

Table 1: Particle sizes based on USDA and International Classification Systems

Soil	*International system*	*Atterberg System*
	(Particle diameter in mm)	Particle diameter in mm
Gravel	2 and more	2 and more
Very coarse sand	2-1	-
Coarse sand	1.0-0.5	2.0-0.2
Medium sand	0.5-0.25	-
Fine sand	0.25-1	0.2-0.02
Very fine sand	0.10-0.05	-
Silt	0.05-0.002	0.02-0.002
Clay	Less than 0.002	Less than 0.002

Textural Classes

The proportions of various particles of different size groups of soil constituents are called soil texture. The main soil texture classes include: clay, sandy clay, silty clay, clay loam, sandy clay loam, silty clay loam, loam, sandy loam, silt loam, sand, loamy sand and silt.

The silt particles are found intermediate between sand and clay particles. Mineralogically, the particles of silt are similar to those of sand and are largely composed of primary minerals. They are more reactive than sands particles because of the higher specific surface (http://www.krishiworld.com/html//soils3.html)

Silt

Silt consists mainly of very small quartz particles. Each particle has a large surface area; it is smooth and powdery. Silt is found in between sand and clay particles. When water is applied to silty soil, the air is trapped in the pores thereby preventing it from moving freely into subsoil, leaving the moisture in the topsoil. The higher the amount of silt in the soil, the greater the amount of water available in the soil and the greater the amount of water available to plants (Akinsanmi, 1994).

Clay

The clay fraction controls the important properties of the soil and it is composed of secondary minerals —crystalline alumino silicates. It has high specific surface which is more reactive. Its ability to retain water and nutrient is very high. The textural classes are different not only in the particle size analysis, but also in their bearing on some of the important factors affecting plant growth. The clayey soils can hold more moisture, but have high wilting percentage:

Factors affecting plant growth include:

(i) Moveability and availability of water
(ii) Aeration
(iii) Workability
(iv) Content of plant nutrients

Sand

Sandy soils are very permeable and are well drained with less water retention. They require frequent irrigation for successful crop growth compared to fine textured soils. The rate of water capacity of sandy soil is low. Unlike clay soil, it is usually waterlogged resulting in poor aeration and workability. The moderately fine textured soils, e.g. loams, clay loams, or silt loams, are by far the excellent soils for plant growth, as they have the advantages of both sand and clay soils.

Soil Colour

Colour is a ready indicator of soil conditions and some important properties. The colour of soil can be used to determine its strength, i.e., either rich or poor. Red, yellow or brown colours are usually related to the different degrees of oxidation, hydration and diffusion of iron oxides in the soil. Dark colours are associated with one or a combination of several factors, including impeded drainage conditions, content and state of decomposition of organic matter.

Soil Pore Spaces

The portion of soil occupied by air, water between minerals is referred to as soil pore spaces. Pore spaces are usually determined largely by the structural conditions of the soil. Results of several researchers clearly show that sandy soil has low pore space of about 30%, and that of clay is approximately 50–60%. However, clays possess greater total porosity for plant growth than sands. The pore spaces in sand are considered larger. Water passes through easily without retention.

Soil Density

From several investigations carried out by soil scientists, it was discovered that soils with larger particles are usually heavier in weight per unit volume than those with smaller particles. Different soils are based on individual densities and their constituents according to their proportionate contribution. The bulk density or apparent density is the weight per unit volume of dry soil as a whole.

In mineral soils, the true density of minerals varies within narrow limits of about 2.5 to 2.7 and the apparent density range is between 1.2 and 1.6. This is also determined based on regions.

Soil Temperature and Heat

Soil temperature is described as one of the most important factors that control microbiological activities in the soil and all the processes involved in plant growth. For seed germination and other biological activities, heat is imperative.

The required temperature needed by seeds for germination varies from crop to crop. Crops like wheat, barley, and peas are grown India and Europe during winter with relatively low temperatures as compared with maize, groundnut, cassava and cotton grown in tropical regions with high temperature. Microbiological activities are retarded by low soil temperature. Low temperature retards nitrification processes and other activities of microorganisms for decomposition processes. This effect will no doubt slow down the nutrient usage by the plant, and growth will be adversely affected.

As a result, soil temperature is considered to be very important in soil taxonomy and the provision to use it as a differentiating criterion at the family level of categorization should be encouraged.

Soil Air

Soil air is an important component of soil. The restriction of soil aeration adversely affects root development, processes of respiration and other essential biological processes involved in biomass turnover and nitrification process by symbiotic and non-symbiotic activities. It is, therefore, important to understand the content of soil air and its composition. Experimental results of authors have previously mentioned that soil air depends on its texture. Soil may have pore space of 30–60%, but the pore space that is not filled by water is usually occupied by air.

Plasticity and Cohesion

Plasticity enables a moist soil to change shape on the application of force and retain its shape even when the force is withdrawn. Looking at this aspect, sandy soils may be considered to be non-plastic and clayey soils are plastic. Cohesion helps particles to stick to another, while adhesion helps particles to detach. Plastic soils are cohesive. Plasticity and cohesion reflect the soil consistency and workability of the soil in terms of quality and the tendency to be used for agricultural purpose.

3.6 SOIL ORGANIC MATTER IN SUSTAINING SOIL FERTILITY

Tropical soils are poor in inorganic nutrients and rely on the recycling of nutrients from soil organic matter to maintain fertility. In undisturbed rainforests, such nutrients are recycled via the litter (Medina and Cuevas, 1989). Soil nutrients depend on the mineralization of organic nutrients from plant remains (Mueller-Harvey et al., 1985; Tiessen et al., 1992). Effects of fertilization can be inconsistent because of leaching or fixation of inorganic nutrients.

Farmers should be aware that organic resources play a crucial role in both short-term nutrient availability and long-term maintenance of soil organic matter in smaller holder farming systems in the tropical regions (Palm et al., 2001). Despite this importance, there is little predictive understanding for the management of organic inputs in tropical agroecosystems (Palm et al., 2001).

In West African semi-arid tropics, the continuous cultivation of the soil has led to a drastic reduction of soil organic matter (Bationo and Mokwunye, 1991). Such reductions in the level of soil organic matter have resulted in decreased soil productivity over the years. The addition of organic materials either in the form of manures or crop residue has beneficial effects on the soil's chemical and physical properties (Bationo and Mokwunye, 1991). The amounts of nutrients in crops and crop residue are often several orders of magnitude but higher than the quantity of the same nutrients applied as fertilizers. The return of crop residue for soil fertility improvement cannot be overstressed but it is essential to gather more information on the rates of organic matter decomposition with a view to have a better production through healthy and a fertile soil.

However, despite the adverse effects caused by chemical fertilizers, the use of vermin-compost is still used in Maharashtra, Karnataka and Gujarat States and other parts of the world to improve soil conditions and increasing crop yield and crop quality. The people of Maharashtra, Karnataka and Gujarat States believe that the adoption of vermin-culture technology not only helps in improving soil fertility on a sustainable basis, but it also helps in minimizing the use of chemical fertilizers to the extent of 25 to 50% and increase crop yield by 15 to 20% due to increased supply of all essential elements.

Crop rotations are crucial for organic systems because the leguminous crops used (such as alfalfa and red clover) provide nitrogen (N) and help recycle nutrients, like phosphorus (P) and potassium (K). The presence of deep-rooted crops in the systems of the rotation helps extract nutrients from lower soil depths and return to the surface when the vegetation dies. Crop residues provide carbonaceous biomass upon which soil microfauna (e.g., earthworms and beetles) and microorganisms embark on.

3.7 SOIL MANAGEMENT PRINCIPLES

International agricultural research institutes and researchers from different institutes have significantly contributed towards the development of sound soil management principles to enhance production techniques that are sustainable to both rural and urban development without compromising the ecosystem functions of soil. Some of the recommendations put forward for soil management after numerous researches and investigations include:

- Nutrient enhancement
- Practising tillage
- Integrating cover crops with multiple purposes
- Practising soil conservation with a view to control soil loss through erosion
- Application of organic matter with plant and animal origin
- Enhancing soil organic carbon pool as an integrator of various soil base functions
- Integrating sustainability of nutrient cycles

3.7.1 Nutrient Enhancement

In addition to nitrogen from legumes, cover crops help recycle other nutrients on the farm. Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), and other nutrients are accumulated by cover crops during a growing season. When green manure is incorporated, or laid down as no-till mulch, these plant-essential nutrients become slowly available during decomposition. Dr. Greg Hoyt once developed a method for estimating nutrient accruement by cover crops in order to reduce the soil test recommendation of fertilizer.

Farmers should be encouraged to grow leguminous cover crops because of their ability to biologically fix nitrogen to the soil through symbiotic relationship with *Rhizobia* bacteria living in nodules of roots. The amount of nitrogen that may contribute to nitrogen fixing crops depends on environmental conditions, carbon to nitrogen (C:N) ratios of the cover crop, available nitrogen in the soil and soil microbial activity.

In addition to the quantity of nitrogen available in a legume and cover crop, the rate of decomposition, or mineralization, must be matched with crop N- uptake requirements for optimum yield

3.7.2 Tillage

Tillage offers a variety of advantages for optimizing crop yield and maintaining soil conditions that promote soil and water conservation. The use of string tillage allows in-row soil disturbance and subsurface nutrient management for optimum crop production. Strips of "no-tillage" rows help reduce runoff and erosion losses compared to more intense tillage systems. Single pass preplanting tillage is less costly than multiple pass options. Tillage contributes towards soil aeration improves soil water holding capacity. It promotes activities of soil organisms and root penetration in the soil. The use of tillage on a farm adversely (or controls) affects disease outbreak on the field.

Reduced tillage practices help to suppress diseases, most diseases can be favoured as a result of more residues of plant materials on the surface. The major factor by which reduced tillage affects diseases is through the increase of inoculums. Inoculums are terms used for the pathogen propagules that initiate epidemic. The practice of reduced tillage decreases crop debris, which serves as a refuge for many pathogens and destroys voluntary plants that act as a reservoir of pathogens, such as viruses or rusts that require a living host (Bowden, 2000).

Tillage can also affect diseases through changes in microenvironment. Recent studies show that reduced tillage increases soil moisture and decreases soil temperature. The changes, however, help suppress some diseases like dryland foot rot or common root rot. There are numerous other changes in the soil bulk density, porosity, and microbial activity. Tillage has an effect on behaviour of vectors that carry diseases. For instance, aphids that carry barley yellow dwarf virus are less likely to land in fields with abundant crop residue on the soil surface (Bowden, 2000).

3.7.3 Cover Crop Practices/Soil Structure Enhancement

Annual cover crops like rye, barley, oats, ryegrass, vetch, Austrian field peas, and crimson clover are grown during cold season in the northern latitudes to prevent erosion and improve soil nutrients. These crops are grown and destroyed in the early stage with a view to improve soil quality. These crops can be incorporated into the soil as a green manure crop

Warm season annual cover crops like buckwheat, foxtail millet and Sudan grasses can be used to fill openings in crop rotation sequences. Perennial grass and legume cover crops are commonly used in orchards and vineyards as living mulches. Living mulch systems involving chemically or mechanically suppressed cover crops have also been used successfully in vegetable and field crop systems through temporary suppression of the cover crop with herbicide or mowing (Sullivan, 2003).

Cover crops play a role in soil structure improvement and act as a protective cover to the soil surface by contributing to soil organic matter and biological processes occurring within the soil (Fig. 3). Physical covering of the soil surface by a cover crop provides protection from the impact of raindrop and shearing force of overland water flow. Cover crops can reduce soil compaction impact of rainfall as well as preventing the crusting and sealing of the soil surface

Source: Kristiansen 2003

Fig. 3 Picture showing a particular cover crop (Echinacea)

Incorporation of cover crops into soil as green manure accelerates the activities of soil microorganisms and the formation of soil aggregates. During the microbial degradation of organic material, polysaccharide gums are released to serve as glue which attract soil particles together into a stable aggregate. This aggregate stability helps reduce soil erosion and improves soil structural properties related to soil aeration, water infiltration and water holding capacity (Sullivan, 2003).

3.7.4 Effects of Cover Crops in Rotation Scheme

Vegetable crop rotation is a six-year rotation. During the first six years, one year should be used for green manure to study how optimal N husbandry can be applied in any manure on a rotation system. Nitrogen supply is based entirely on legume N fixation and its measure is to reduce N losses from the soil. Vegetable rotation should include cereal crops, as problems with weeds, pests, diseases, and soil structure often become serious in very intensive vegetable rotations (Stolze et al., 2000).

The strategy of growing cover crops during dry season aims at retaining N within the growing system, and in the topsoil. Where this is not possible, the strategy of growing deep-rooted main crops or cover crops aim at recovering some of the N leached to larger soil depths.

Generally, the N management strategies have worked well, and have produced good vegetable crops without adding any external N sources to fields in rotation cycle. This assertions is based on an investigation conducted for a period of eight years experiment. This is based on the author's investigations within a period of eight years. The results of these investigations revealed that N supply for crops was not very high, but it was high enough to obtain good yields from several crops as a lot of plants such as legumes have the capability of adding nutrient back to soil when included in crop rotation.

Research results on N usage in crop rotation scheme have shown that only vegetable crops seem to have significant N limitation when compared to cabbage. The result, however, clearly shows that vegetable crops contain high amounts of nitrogen. However, result of the several investigations, were not different from other researchers.

Considering the result of investigation which include vegetables in rotation, the conclusion is that the need for the import of N containing manures to vegetable crop rotations would be strongly reduced, as it is added back to the soil. Many of the techniques used to obtain this result can, of course, be used to improve N management in other types of organic crop rotations.

3.7.5 Environmental Impacts of Cover Crops

Most research on cover crop clearly confirms that environmental impact contributes to soil fertility and improves the concentration of nitrogen cycling. Several researche's also pointed out that cover crops store some major plant nutrients in their tissues. The decomposition of cover crop tissues following incorporation of the plant as green manure crop helps make the nutrients available for subsequent crop uptake. Organic acids released during decomposition of organic matter in the soil usually help to accelerate the transformation of mineral phosphorus for plant availability (Stevenson, 1986).

Cover crops transform solar energy into food for a diverse community of detritivorus arthropods, earthworms, and microorganisms. Additions of organic matter to soil stimulate microbial activities, growth and development. The diversity and abundance of living biota in a soil is a critical component in soil quality assessment.

3.7.6 Benefits of Cover Crops and Green Manures

Organic Matter and Soil Structure

The major benefit obtained from green manures is the addition of organic matter to the soil. The breakdown of organic matter by microorganisms leads to the formation of resistance compounds. The compounds (mycelia, mucus, and slime) produced by the microorganisms assist in binding together soil particles to form granules. A well aggregated soil tills easily, is well aerated, and has high water infiltration rate. The increased levels of organic matter content greatly influence soil humus.

It is important to note that annual green manures have a negligible effect on humus levels as tillage and cultivation are practised each year. They replenish the supply of active and rapidly decomposing organic matters.

3.7.7 Soil and Water Conservation

When cover crops are planted solely for soil conservation, they provide a high percentage of ground coverage as fast as possible (Sullivan, 1991). Most grassy and non-legume cover crops, like buckwheat and rye, fulfil this need. Among legumes, hairy vetch provides the least ground cover because most of its above ground growth takes place in spring (Sullivan, 1991). However, hairy vetch offers little ground cover during erosion period. Growing a mixture of leguminous crops and grassy-type cover crops increases ground coverage and provides a specific quantity of nitrogen to some crops.

Soil conservation with the addition of cover crop provides beneficial protection to bare soil during non-crop periods. Soil cover reduces soil crusting and subsequent surface water runoff during rainy periods. It also helps to conserve soil water when used as mulch material.

3.7.8 Soil Amendments

Organic certification bodies recommend naturally mined lime products for the adjustment of soil pH to within a range of 6.0 to 7.0 (depending on crop requirements). Lime and composted manure are regarded as the most common forms of soil amendments in organic operations. Raw manure could be obtained from organic or conventional farms, provided the manure is applied at least three months prior to the harvest of agronomic crops and a minimum of four months prior to the harvest of horticultural crops. The implemented regulation provides adequate time for proper decomposition of manure and avoids bacterial contamination of produce. In order to prevent contamination of waterways, raw manure cannot be applied to frozen or snow-covered ground. It has been recommended by organic certifiers that manure should be composted prior to land application. Composting is a very good method of stabilizing manure in the soil.

Adequate moisture and temperature should be maintained for proper decomposition of the materials used in the process. Most organic farmers utilize front-end loaders or windrow turners to construct outdoor composting systems. Other composting systems include vermi-composting (utilization of earthworms in "beds" to decompose manure and other wastes), in-vessel digesters, and anaerobic systems (Delate et al., 1999).

Soil amendments are available for organic farming. It is important that the materials are naturally based and artificial substances prohibited.

3.8 SOIL QUALITY IN ORGANIC SYSTEMS

The basic concept for organic farming is the soil health. Its main aim or focus is to ensure maximum maintenance of adequate soil fertility. Organic farmers advocate for biologically active soil containing microbial populations required for nutrient cycling to be able to support crop growth. Organic farmers support crop rotation systems in organic farming systems as nutrient like nitrogen from legumes (alfalfa and red clover) as well as carbonaceous biomass in the soil, are beneficial to soil microorganisms for survival. Naturally mined lime products can be used to adjust soil pH to 6-7 based on crop requirements. Additionally, lime, manure and composted manure are known to be the most common forms of soil amendments for organic operations. Iowa State laws in the United States of America requires that raw manure be applied to soil three months prior to harvest for agronomic crops and four months for horticultural crops, in order to allow adequate decomposition, and avoid any problems of bacterial contamination to the produce (Delate, 2005). Raw manure cannot be applied to frozen or snow-covered ground. Composting is the most preferred method of stabilizing manure. Composting is a controlled process where nitrogen-containing materials (manure, yard/kitchen waste) are mixed with carbon-containing residues (corn stalks/cobs, straw and wood chips) to produce a substance preferably in a carbon-to-nitrogen ratio (C:N) of 30 to 1 (Delate, 2005). Delate pointed out that compost mixture used should be at a temperature of about 140°F for at least three days for composting process. Other authors' investigation results also suggested that there should be adequate moisture and temperature to enhance activity of soil microorganisms for an effective composition of compost materials.

Building and maintaining soil quality is the basis for successful organic farming. However, before developing a soil management plan, emphasis should be laid on soil quality, and farmers should be acquainted with the overall philosophies, legalities, and marketing opportunities of organic agriculture.

The publication of Sivapalan et al. (1993) explained that for many years, there has been increasing public concern about the use of synthetic fertilizers and other agrochemicals on conventionally managed farms. This has motivated the interest of organic farmers in organic agricultural management as it prohibits synthetic inputs.

Research has shown that organic horticulture and agricultural systems are associated with enhancing soil qualities and microbial populations (Sivapalan et al., 1993). Aeration, soil-water relations and access to organic matter are improved in soils under organic management. Soil characteristics can lead to heightened microbial biomass and activity, and therefore a faster rate of soil organic matter (SOM) decomposition and nutrient release (Brown et al., 2000). In addition, when organic farms include regular inputs of organic matter in their rotations, they often have a larger soil microbial biomass than conventional neighbours (Ryan, 1999).

However, an enhanced soil microbial community does not only occur under organically managed systems (Ryan, 1999). The management history of a soil can influence soil microbial biomass and activity in both conventionally and organically managed soils (Armstrong et al., 2000).

There are a number of other major indicators of soil health and quality. These include soil organic matter content, soil microorganisms, soil pH, aeration/bulk density, basal respiration, SOM, microbial biomass C and N levels, ergosterol levels, water holding capacity and N-mineralization levels. Management practices have the potential to affect indicators, health and quality of the soil.

3.9 ORGANIC MATTER CONTENT

The environmental importance of organic matter content relies on its capacity to limit physical damage and to improve nutrient availability along with biological activities. Research on organic matter concentrated on measuring the parameter of soil organic carbon content (Alfoeldi et al., 2002).

Soil organic matter or carbon (C) inputs improve soil physical properties, such as aggregate stability, and provide food, habitat, and shelter for billions of soil organisms. Increased aggregate stability, improved soil structure, and surface protection provided by crop residues. The use of manure or compost, and cover crops on farm land reduces soil erosion losses and increase water-holding capacity, soil porosity and aeration. Proper and good management of soil organic matter content helps promote soil biological activity and the healthy microbial and macrofaunal populations that are required for efficient nutrient cycling. These populations include bacteria, fungi, actinomycetes, nematodes and earthworms. The absence of these organisms in the soil will affect agricultural production.

Research conducted by Stolze et al. (2000) concluded that the conditions of organic farming has beneficial effects on the characteristics of soil organic matter due to high rate of organic carbon content in the organically farmed soils than on the conventional ones.

Fertilizers recommended for organic farming systems are based on farmyard manure, compost, green manure, rock dust, plant residues and commercial organic N-fertilizers. Consequently, there is an extensive supply of organic matter passing through aerobic decomposition processes (Alfoeldi et al., 2002). Mineralization and decomposition processes are mainly influenced by temperature, humidity and oxygen. Under humid tropical conditions, these processes run faster than the Northern conditions during the colder months. Soil type plays a role in soil mineralization process as well. Sandy soils easily dry up quickly, therefore, slow down decomposition processes. It is important for all farmers to be aware that ferralitic soils are not very fertile, but they can encourage fast decomposition and build up stable organic matter in the soil.

3.10 SOIL BIOLOGICAL ACTIVITIES/MICROORGANISMS

High level of biological activities in the soil promotes metabolism between soil and plants. In contrast to conventional farming, organic farmers depend on high and sustained supply of organic substances while the conventional farmers base their farming on synthetic elements. The aim of organic farmers is to ensure the use of organic fertilization management which is based on crop rotations with clover/grass ley, underseeds, catch crops, green and animal manure (Stolze et al., 2000). From the analysis of several research and investigations, organic farming performs better than conventional farming. This result is based on relevant parameters of several investigations.

Soil is the habitat for plants, animals and microorganisms. As plants build up organic matter, soil animals feed on them and their debris simultaneously, microbes decompose the complex organic compounds to their mineral component and to CO_2 (Alfoeldi et al., 2002). The living soil is a central part of soil fertility as activity of soil organisms promotes available elements in plant residues and organic debris entering the soil. Part of this material remains in the soil and contributes to the stabilization of humus build up. Earthworms are other important soil organisms contributing tremendously in aerating and improving the quality of soil, as they work together with fungi, bacteria and numerous other microorganisms present in the soil.

Several research results have shown that activities of microorganisms are higher in organically managed soil than in conventionally managed soil. As a consequence of the higher activities of microorganisms in organically managed soils, nutrients are recycled faster and soil structure is improved rapidly.

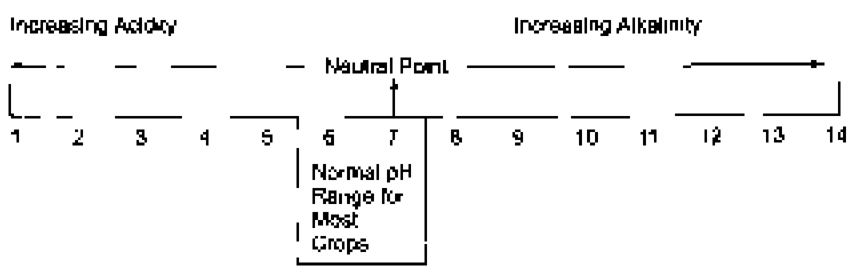
An important representative of soil fungi are mycorrhizae, which build up symbiosis between fungus and plant. The degree of mycorrhizae root colonization was found to be distinctly higher in organic plots as compared to conventional plots (Mäder et al., 2000; Smith and Read, 1997).

The process of nutrients mineralization takes place much faster on ferallitic soils of the tropics and subtropics than on soils typical of temperate and continental zones: a high organic matter content and high biological activities are seen as the prerequisite for sustainable soil fertility. The positive impacts of organic farming on biololgical activity, micro-organisms and soil organic matter are very vital for soils in the tropic and subtropic regions.

3.11 SOIL pH

Soil pH is also an indicator of soil quality as it is a measure of soil acidity or alkalinity. Due to its effect on availability of nutrients and toxic elements, soil pH is considered one of the most important factors affecting soil quality and productivity (Akinyemi et al., 2005). The normal pH range for most plants is between 5.5 and 7.5. Soil acidity and alkalinity can influence both soil microbial activity and physical properties. Soil fungi are more active at a lower pH level, compared to soil microbial bacteria (McCauley et al., 2003). Effects of reduced soil microbial activity are observed through reduced plant biomass and production (Bates et al., 2002). Agricultural management systems can alter the pH of soils. Patriquin et al. (1993) suggest that conventionally managed soils are significantly lower in pH as compared to soils managed organically.

This may be due to the acidifying effects of nitrogenous fertilizers and other agrochemicals that are present in conventionally managed agricultural systems. In general, organic farming practices are less acidifying (Patriquin et al., 1993).



The requirements of plants vary widely according to the soil type. The pH of a soil can also be judged based on nature of usage and purpose. Investigations reveal that soils on which organic farming practices are carried out are less acidic. This is as a result of the nutrients made available for both cropping methods and farming systems.

3.12 AVAILABILITY OF NITROGEN TO PLANTS

An understanding of a soil's N-mineralization capacity can be of particular value because of the importance of nitrogen in crop growth and yields. To estimate the availability of soil N to plants, the factors involved in the process of organic matter degradation and the associated N turnover in the soil must be understood. Plant available N in soils originates from either artificial nitrogen fertilizers (conventional agricultural system) or mineralization of inherent and applied organic matter and plant residues (both conventional and organic agricultural systems). N-mineralization is the process whereby this organic nitrogen is converted to inorganic nitrogen via the microbial degradation of soil organic matters (SOM). N-mineralization occurs in two successive steps: (i) ammonification and (ii) nitrification. During ammonification, nitrogen within the SOM (amino acids, amino sugars, nucleic acids and animal residues) is converted to ammonia via the activities of heterotrophic fungus and chemoautoterotrophic bacteria. Under aerobic conditions, the ammonia is then converted to nitrate (NO_3^-) during nitrification. N-mineralization can be affected by physical, chemical, biochemical and microbiological soil parameters (Carter and Rennie, 1982; Franzleubbers et al., 1994; Ladd et al., 1994; Vavel, 1994; Omay et al., 1997; Vinten et al., 2002). Research has shown that soil structure, moisture, temperature and aeration can alter the rate of N-mineralization in the soil. These factors not only affect N-mineralization, but also other N transformation processes like denitrification, volatilization and immobilization. Nitrogen immobilization can also contribute to alterations in the mineralization processes (Rees, 1989). In order to determine the effect of mineralization process in organic and conventionally managed soils, the research experiment conducted at the University of Kassel in the Faculty of Soil Microbiology in February 2005 aimed at.

- Investigating mineralization process of nutrients in the soil
- Investigating selected biological, physical and chemical soil characteristics, in particular N-mineralization
- Examining differences between soils managed at two different sites i.e., conventionally and organically managed soil

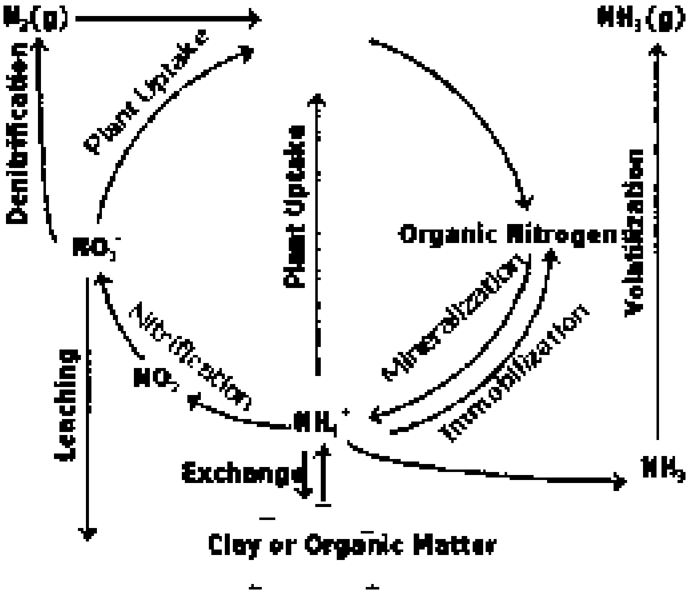


Fig. 4 Nitrogen Fixation

Nitrogen Cycle/Mineralization Process

Before the start of the experiment, the hypothesis was that when organic and conventional soils are compared, the organically managed soils would display higher microbial biomass and activity and there would be higher N-mineralization (Akinyemi et al., 2005).

3.12.1 Materials and Methods

Study Site

The study area was located near the town of Witzenhausen in central Germany. The soils sampled were from plains flooded by the river Werra, mainly developed in the last 1200 years. The conventionally managed soils had been cultivated lately and sown with wheat. In contrast, the organically managed soils were uncultivated.

3.12.2 Soil Sampling Technique

Soil samples were taken on 14 February 2005 at a 0–15 cm depth, from organically and conventionally managed fields, at two different sites. Four core samples of 408 cm^3 and a further two samples (taken as bulk samples using a vertical corer) were collected from each of the fields. All samples were transferred to the laboratory where the bulk samples were sieved (<5 mm), pre-incubated at room temperature for two hours and stored in polyethylene bags at 4°C until the analyses commenced (Akinyemi et al., 2003).

3.12.3 General Soil Properties

Bulk density was determined using the core samples. Soil pH (tested using a soil to water ratio of 1:2.5), water holding capacity (% dry weight) and dry matter (% dry weight) were measured using bulk samples.

3.12.4 Soil Microbial Properties

The basal respiration was measured as evolved CO_2 using the titration method described by Anderson (1982). Fifty grams of moist soil were placed into 1 litre stoppered glass jars and adjusted to 50% water-holding capacity. A polypropylene vial containing 10 ml of 0.3 M NaOH was added to each of the soil samples and to three empty bottles, and the contents were incubated at 22°C for three days. After this time, fresh NaOH solution was added to each of the jars and the contents were incubated at 22°C for four days. The CO_2 evolved during each of the incubation periods was calculated from the quantity of 0.1 M HCl required to bring the NaOH solution to pH 8.3. The evolved CO_2 was calculated as follows. Evolved CO_2-C = (B-S) × M × E/DW, where B is the amount of HCl (ml) needed to titrate the NaOH in the empty bottles to pH 8.3, S is the amount of HCl (ul) needed to titrate the NaOH in the bottles containing soil to pH 8.3, M is the molarity of the HCl, E=6 (equivalent weight to express the data as carbon) and DW is the dry weight of the soil sample (g).

Microbial biomass C and biomass N were estimated using the chloroform-fumigation extraction method (Brookes et al., 1985; Vance et al., 1987). One 10 g portion was fumigated with ethanol-free $CHCl_3$ for 24 hours at 22°C. Following fumigant removal, the soil was extracted with 40 ml 0.5 M K_2SO_4 for 30 minutes by oscillating and shaking at 200 rev min^{-1} and filtered through a folded filter paper (Joergensen, 1995). The non-fumigated 10 g portion was extracted similarly when fumigation commenced.

Following the removal of inorganic C by acidification, samples were combusted at 850°C in the presence of a platinum catalyzer. The organic C in the extracts was then measured as CO_2 by infrared absorption using a Dimatoc automatic analyzer. Microbial biomass C was calculated as follows: Microbial biomass C = E_c/k_{EC}, where E_c = (organic C extracted from fumigated soils)−(organic C extracted from non-fumigated soils) and k_{EC} = 0.45 (Wu et al., 1990; Joergensen, 1996).

Total N in the extracts was measured as NO_2^- by chemoluminescence detection after combustion at 850°C. Total N was again measured using a Dimatoc automatic analyzer. Microbial biomass N was calculated as follows: microbial biomass N = E_N/k_{EN}, where E_N = (total N extracted from fumigated soils) – (total N extracted from non-fumigated soils) and k_{EN} = 0.54 (Brookes et al., 1985; Joergensen and Mueller, 1996).

The 0.5 M K_2SO_4 extracts of non-fumigated soil samples were also used to quantitatively measure ninhydrin-reactive N at 570 nm absorbance using a spectrophotometer. The control blank was determined from L-leucine standard curve using linear regression. Microbial ninhydrin-reactive N was calculated as follows: Microbial ninhydrin-reactive N = (ninhydrin-reactive N extracted from fumigated soils) – (ninhydrin-reactive N extracted from non-fumigated soils). As the soil pH was greater than 5.0, the microbial biomass C values were calculated as follows. Biomass C = microbial ninhydrin-reactive N × 22 (Joergensen, 1996a).

Ergosterol was measured according to Djajakirana et al. (1996). Two grams of moist soil were extracted with 100 ml ethanol for 30 minutes by oscillating shaking at 200 rev min^{-1} and filtered. The filtered solution was then evaporated and the remaining ergosterol washed with methanol. A final filtration (0.45 μm) occurred before the ergosterol content was quantitatively determined by reverse-phase HPLC analysis. This occurred at 26°C using a C 18 column of 125 × 4.6 mm and a 282 nm resolution of detection.

3.12.5 Aerobic N-mineralization

Duplicate samples of 15 g moist soil were weighed into polyethylene bottles and 5 ml water added. One portion was incubated at 22°C for six days. Following incubation, the soil was extracted with 60 ml 0.0125 M $CaCl_2$ (4:1 extractant to soil ratio) for 30 minutes by oscillating and shaking at 200 rev min^{-1} and filtered through a folded filter paper. A non-incubated portion was extracted similarly when incubation commenced. Extractable NO_3^--N was measured using segmented continuous flow analysis followed by spectrometric detection (540 nm) according to the manual of the manufacturer. Extractable organic N (μg g^{-1}) for both incubation periods and net N-mineralization (μg $g^{-1}d^{-1}$) were calculated as follows.

$$\text{Extractable } NO_3^-\text{-N} = \frac{(A-B)\times(C\times SW)}{(DW-SW)}$$

A = NO_3^--N of the sample
B = NO_3^--N of the blank
C = Vol extractant (ml)

Calculation of net N-min:

$$N = \frac{\text{Extractable } NO_3^- - N}{\text{Days incubated}}$$

SW = Total amount of water in soil sample (ml)

DW = Total weight of moist soil sample (g)

3.12.6 Statistical Analysis

The results presented in the tables and graphs are arithmetic means. The significance of variation between the different sites and management practices was tested by simple analysis of variance (ANOVA) and analysis of covariance (ANCOVA). All statistical evaluations were performed using the StatView 5.0 program (SAS Inc.).

3.12.7 Results

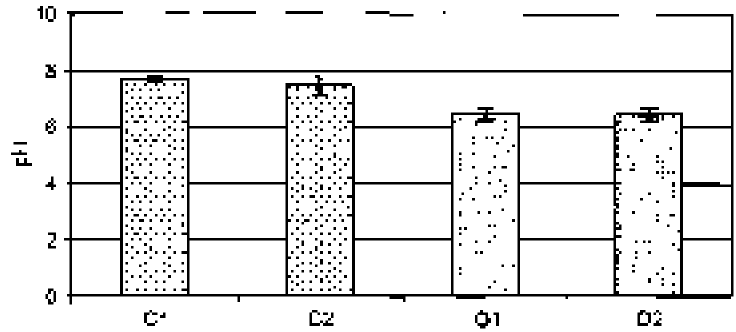
Measured parameters included pH, bulk density, basal respiration, Cmik, Nmik, dry matter, ergosterol, respiratory quotient, water holding capacity, and aerobic N-mineralization. As indicated in the table below, neither field nor soil management practice was found to significantly affected most of the parameters.

Table 2 Effects of (1) soil management practices, and (2) fields, on the measured soil characteristics (NSD = no significant difference)

	Management Practice Effect	*Field Effect*
pH (unit)	Significantly higher in conventionally managed soil ($p<0.0001$)	NSD ($p=0.4630$)
Bulk density (g cm^{-3})	NSD ($p=0.1743$)	NSD ($p=0.7032$)
Basal respiration (µg $g^{-1}d^{-1}$ soil)	NSD ($p=0.6433$)	NSD ($p=0.8225$)
Cmik (µg g^{-1} soil)	NSD ($p=0.9956$)	NSD ($p=0.3745$)
Nmik (µg g^{-1} soil)	NSD ($p=0.8946$)	NSD ($p=0.2436$)
Dry matter (% soil weight)	NSD ($p=0.8336$)	NSD ($p=0.7798$)
Ergosterol (µg g^{-1} soil dw)	NSD ($p=0.6539$)	NSD ($p=0.8431$)
Respiratory quotient	NSD ($p=0.2880$)	NSD ($p=0.7564$)
Water-holding capacity (% soil weight)	NSD ($p=0.6382$)	NSD ($p=0.6382$)
Aerobic N-mineralization (µg g^{-1} soil)	NSD ($p = 0.1152$)	NSD ($p=0.3256$)

Source: Akinyemi et al., 2005

It was found that the soil pH was impacted by the soil management practice, with the two conventionally managed soils exhibiting higher pHs when compared to the two organically managed soils ($p < 0.0001$). This difference was approximately one pH unit. In contrast, there was no significant difference ($p = 0.4630$) in soil pH between Field 1 and Field 2 (Fig. 5).

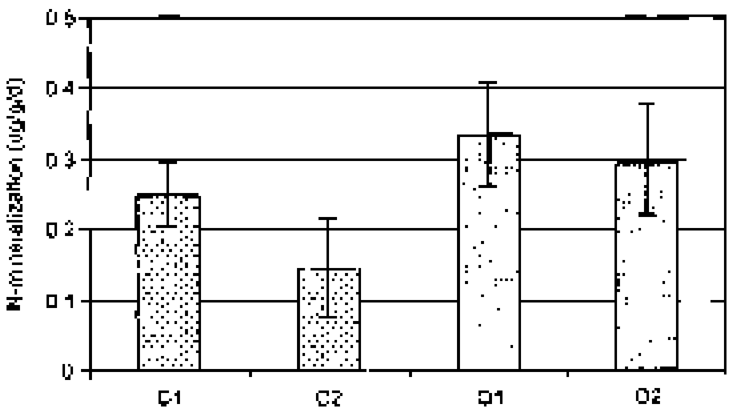


Source: Akinyemi et al., 2005

Fig. 5 Effect of (1) soil management practices and (2) fields on pH of soil

As indicated in the above table, there was no significant effect of soil management practices or fields on the level of N-mineralization in the soil. Figure 6 demonstrates the level of N-mineralization in the soil from Fields 1 and 2 that have been either conventionally or organically managed. Standard error bars displayed on this graph demonstrate highly variable results.

The effect of covariates on N-mineralization was also analyzed. There were no significant relationship between N-mineralization and bulk density ($p = 0.5912$), basal respiration ($p = 0.5956$), Cmik ($p = 0.090$), dry matter ($p = 0.3261$), respiratory quotient ($p = 0.9241$), water-holding capacity ($p = 0.7287$), Nmik ($p = 0.7080$), ergosterol ($p = 0.8662$) or pH levels ($p = 0.7948$). Therefore, there were no significant relationship between any of the measured soil characteristics and the level of N-mineralization in soil.



Source: Akinyemi et al., 2005

Fig. 6 Effect of (1) soil management practices, and (2) fields on N-mineralization in soil

3.12.8 Discussion

(a) Biological Soil Properties

The results indicate that the measured soil biological properties were independent of field and management practice. However, the results may have been undermined by the high degree of variation between the results of others. This variation may have been due to differences in soil sampling and handling techniques. For example, there may have been differences in the sampling depth and the amount of temperature changes and/or organic matter content in the sample. Compaction or incomplete filling of the core during sampling may also have occurred, which would have skewed the bulk density measurements. In addition, lack of adequate replication may have made it difficult to statistically distinguish between real differences and analytical error.

The results were in the range of those previously reported in the literature. The basal respiration, Cmik (Dimatec), ergosterol and N-mineralization values fell within the ranges obtained by Chander et al. (2001), Wichern et al. (2003) and Wichern et al. (2004). The results for Nmik (Dimatec) were a little higher than recorded by Wichern et al. (2004), but are not extreme. This comparison implies that the results from the experiment were realistic and sensible. A direct comparison of the results obtained here and those reported in the literature is shown in Table 3.

In contrast to this findings, Sivapalan et al. (1993) found that there were generally higher quantities of microorganisms in vegetable gardens that were converted to organic, when compared to those that had remained under conventional management. The increased microbial biomass appears

Table 3 Comparison of results of microbial biomass and activity with that of literature

	Basal Respiration (µg CO_2-C h^{-1})	*Cmik (Dimatec) (µg g^{-1} soil)*	*Nmik (Dimatec) (µg g^{-1} soil)*	*Ergosterol (µg g^{-1} soil)*	*N-mineralization (µg g^{-1} d^{-1})*
Akinyemi et al., 2005	0.280 – 2.900	158.400 – 384.000	21.200 – 67.100	0.230 – 0.570	0.200 – 0.310
Chander et al., 2001	0.600 – 3.360	166 – 4498		0.420 – 14.88	
Wichern et al., 2003	0.075 – 0.410	106 – 765		0.700 – 2.890	0.046 – 0.320
Wichern et al., 2004	0.036 – 0.250	65 – 296	10 – 38		0.523 – 0.780

to be due to higher levels of organic matter in the organic system. Sivapalan et al. (1993) also found that vegetable gardens which had previously been used as pastures for 10 years, had higher levels of microbes than those that had been planted with vegetables for the same period. In addition to this, vegetable gardens treated with compost had higher levels of microorganisms than those not treated with compost. This is not surprising considering the importance of organic matter for microbial growth and survival.

Jensen et al. (2000) used a case study to compare ergosterol levels in soil from differing farming systems—organic (plants only), conventional (plants only) and conventional (including animals)—on a sandy loam in New Zealand. They found no significant difference between ergosterol levels in the conventional and organic systems. This supported the results of our findings, as this experiment also did not find significant differences in the ergosterol levels between the conventionally and organically managed soils. However, Jensen et al. (2000) also found that there was significantly less ergosterol in the conventional plant farm soil compared to the soil sampled from conventional plant farms that included animal husbandry. The ergosterol content was correlated with the frequency of grass and legume leys, the input of animal manure, total C and frequency of ploughing. In addition, Jensen et al. (2000) found that ergosterol levels in some soils varied greatly within a few centimeters suggesting that a large numbers of samples are needed to detect differences between paddock management in a case study situation. These results highlight the importance of farming practices on ergosterol levels and suggest that there is more at play than simply the organic/conventional status of the soil.

The hypothesis of this investigation is that N-mineralization would be higher under organic management due to higher microbial biomass and activity, but was not supported by data (Akinyemi et al., 2005). Research from the Iowa State University found 8% increase in potential N-mineralization under organic management compared to conventional management. The results of this experiment did not support or oppose these findings. Although the study indicated that N-mineralization tended to be higher under organic management, this difference was not significant. In addition, this tendency may have been influenced by recent soil disturbances in the conventional systems. It is likely that some N-mineralization had already occurred in these soils due to the disruption of macro-aggregates which protected the SOM. The lack of significance in the results may again be explained by the lack of replication and high variability between authors. In addition, the results may not be statistically significant because of the modified analysis method used. The N-mineralization analysis method normally includes two periods of incubation of 14 days each. However, due to time constraints, a single incubation period of only six days was used. This short incubation period may not have allowed the complete release of nitrogen bound to SOM. This, in turn, may have led to be lower than expected measurements of N-mineralization.

(b) Physical and Chemical Soil Properties

The soils studied had no major restrictions on plant growth or microbial activities. The bulk density values indicated that the soil was not compacted, the water-holding capacity was in a range expected from a sandy clay loam, and the pH values were in the range suitable for healthy plant growth and microbial activity. ***Conventional farming has higher synthetic inputs which leads to soil acidification***. The significant difference in pH between the conventional and organically managed soils is not consistent with this process of acidification. Increased product removal from conventional farms due to the higher yields may also result in acidification of soil. The lower pH in the organically managed soils may be due to increased levels of SOM, which may slightly acidify the soil. The addition of manure fertilizers may also have acidifying effects; however additional information is required about past management practices in the fields before conclusions can be drawn. The results of this experiment differed from those obtained by Brown et al. (2000). Both studies found no significant difference between the pH of soils under organic and conventional management. Ammonia fertilizers could displace exchangeable Ca^{2+} from soil colloids. However, conventional management of soil using ammonia fertilizers could lead to a reduction in soil pH. The results of this studies are incomplete in contrast to these findings.

3.12.9 Conclusion

The experience indicated that the number of people carrying out soil microbial analysis techniques should be minimized to reduce sampling and handling variability. It also suggests that there should be sufficient replication of treatments to ensure optimal validity of results. Increased replication also allows for accurate measurement of significant differences between management practices. When comparing fields in a case study, large numbers of samples may be needed to account for field variability. The lack of significantly different results in this experiment may be due to both experimental/handling error and the lack of replication.

From the results of our experiments, no firm conclusions can be drawn or comparisons made regarding the effects of organic and conventional management practices on soil microbial properties and N-mineralization.

However, the results do suggest that the pH of soil can be reduced slightly under organic situations, perhaps due to manure inputs and SOM build up.

3.13 FACTORS AFFECTING SOIL FERTILITY

(a) Soil Erosion

Soil erosion can be a significant catalyst that aids soil degradation all over the world. The loss of fertile top soil by erosion results in lower crop yield. The comparison made by Reganold et al. (1987) in a long-term experiment showed that there was a 16 cm thicker topsoil depth on the organically managed plot as a result of lower erosion. This was probably due to inclusion of green manure legume crop in the third year of rotation and fewer tillage operations on the organic field (Alfoeldi et al., 2002). In a trial, long-term effects of organic (since 1948) and conventional farming on selected properties of the same soil had been compared in farms near Spokane in Washington, USA. The organically farmed soil did not only have thicker topsoil, but also had significantly higher organic matter content and less soil erosion than the conventionally farmed soil. The authors, therefore, concluded that the organic farming system was more effective than the conventional farming system in reducing soil erosion and in maintaining soil productivity (Alfoeldi et al., 2002).

In general, organic soil management techniques like organic fertilization, mulching and cover cropping improve soil structure and, therefore, increase the water infiltration and retention capacity. It also reduces the risk of erosion on the farm. It is, however, recommended that farmers implement good management techniques in order to have a good quality of porous feralitic soil in the tropics and sub-tropics. The effective management will, no doubt, reduce soil erosion risk as a consequence of frequent heavy rainfall.

Organic farming can successfully counter erosion, while in conventional farming in the tropics, flat soil gets eroded due to the use of herbicides and the lack of soil cover. In organic farming, a permanently covered soil is an intrinsic part of the system (Alfoeldi et al., 2002).

(b) Desertification

Degradation of dry lands is referred to as desertification. Desertification occurs due to over-cultivation, over-grazing and deforestation, and may lead to soil exhaustion and erosion. Desertification diminishes soil productivity, reduces food production, robs the land of its vegetative cover, and leads to negative impacts in the areas not directly affected by its symptoms. For example, floods, soil salinization, deterioration of water quality, and silting of rivers, streams and reservoirs.

Organic farming provides appropriate solutions to the problems associated with desertification. Organic farming techniques bear potentials to improve soil fertility, soil structure and moisture retention capacity. Relevant techniques used in organic farming to protect the soil include composting, mulching, use of cover crops, intercropping, and use of supplemental organic fertilizers (like compost, farmyard manure, green manure and mulch). The use of endemic species that are more adapted to climate stress, as well as water preserving and agro-forestry techniques, will help prevent desertification

Organically managed soils have a high potential to counter soil degradation, as they are more resilient to both water stress and nutrient loss. Organic farmers feed their soils with organic fertilizers, and thus enhance degraded and problematic soils (Alfoeldi et al., 2002).

With a high level of organic matter and a permanent soil cover, water and nutrient retention capacity increases, it provides a good feeding zone for microorganisms, and creates a stable soil structure. Due to the resulting high moisture retention capacity, the amount of water needed for irrigation can be reduced substantially.

So far there is little scientific evidence demonstrating organic farming's potential for combating desertification. Organic farming can help bring degraded lands back to fertility. An organic farmer in Egypt cultivating 70 hectares desert near Cairo was found using organic and biodynamic agricultural methods (composting, mulching and cover cropping), consequently the desert sands were converted into fertile soil, supporting livestock and bees. The method used by the Egyptian farmer motivated Sekem in the early 1990s and he started applying biodynamic methods to cotton. The success in cotton pest control (by pheromones) raised the interest of Egyptian authorities in biological control. Today, nearly 80% of Egypt's cotton cultivators apply biological pest control, and the Ministry of Agriculture has placed a ban on aerial sprays of synthetic pesticides on cotton farms, with a view to promote biological control. The organic cotton producers in Egypt currently use organic fertilization such as compost, wood ash, rock phosphate and clover-onion rotations, to produce crops.

(e) Environmental Factors

Crops and animal distributions are greatly affected by environmental factors such as climatic conditions. These are natural factors that influence:

- Nature of vegetation
- Soil characteristics
- Type of farming system
- Type of crops and animals raised

The climatic factors influencing agricultural production include:

- Temperature
- Rainfall
- Wind
- Humidity
- Light

(d) Influence of Climatic Change on Agricultural Development

It is recognized worldwide that agriculture is the economic mainstay in most African countries and contributes about 20–30% to the countries GDP, especially in Sub-Saharan Africa, and 55% of the total value is exported. From statistics, 70% of African poor people live in rural areas. The yield of crops and changes in productivity due to climatic change vary considerably across regions of Africa. In the tropics and subtropics, where some crops are tolerant to maximum temperature and where dryland is found, non-irrigated agriculture dominates. In these regions, yields are likely to decrease with even small increases in atmospheric temperature. Overall agricultural productivity in Africa could decrease during the next century leading to hunger and malnutrition in vulnerable areas, especially in drought-prone regions of the continent.

It has also been reviewed by researchers that steady warming of the earth's surface temperature has enormous implications on agriculture, and a small increase in temperature means decrease in agricultural production.

Impact of climatic changes on the availability of water in Sub-Saharan Africa is of major concern to the scientists. It is currently recorded that a population of about about 1.7 billion in developing countries are living in areas where water resources are scarce. This number is expected to increase to about 5.4 billion over the next 25 years. In general, rainfall is projected to increase slightly over much of the continent, but a decline in rainfall is projected for southern Africa, especially in winter. These changes in rainfall and higher temperatures are projected to exacerbate water shortages in southern Africa and in African countries around the Mediterranean Sea. The predominance of rain-fed subsistence agriculture and, across southern Africa, high dependence on water-demanding maize, means that food security for most of the continent is inextricably linked to the amount of rainfall. In dryland regions, crop and livestock production is also extremely susceptible to seasonal rainfall variability. Increased droughts result in climatic change and could seriously impact food availability just like the case of Africa and southern Africa which occurs during the 1980s and 1990s.

Assessing the impacts of climatic change on agriculture is a vital task in both developed and developing countries, the influence of climate on crops and livestock persists despite irrigation, improved plant and animal hybrids and the growing use of chemical fertilizers (Rosenzweig et al., 1992). The continued dependence of agricultural production on light, heat, water and other climatic factors, the dependence of much of the world's population on agricultural activities, and the significant magnitude and rapid rates of possible climatic changes, all combine to create the need for a comprehensive consideration of the potential impacts of climate on global agriculture (Rosenzweig et al., 1992).

The projected climatic changes for the temperate and tropical areas differ in climate models project, there is a greater magnitude of temperature increase in temperate regions than in tropical regions. The projections of changes in the hydrological cycle are almost similar, but rather uncertain, showing a mixed picture of regional precipitation increases and decreases in both areas (Rosenzweig et al., 1992).

(e) Influence of Climatic Change on Crop Production

Climate impacts on agriculture lie on biophysical sciences. The rates of most biophysical processes are highly dependent on climate variables like radiation, temperature, and moisture. The rates of plant photosynthesis depend on the amount of photosynthetic active radiation and the levels of atmospheric carbon dioxide (CO_2). Temperature plays an important role in plant progression through various phenological stages towards maturity. The accumulation of biomass is facilitated by the availability of moisture and nutrients to a growing crop.

Several studies have shown that the impact of climatic changes varies on agriculture (Thompson, 1975; World Meteorological Organization, 1979). The study clearly demonstrates the sensitivity of both temperate and tropical agricultural systems to climatic variations and changes. In temperate regions, the impact of climate variability, particularly drought, on yields of grains, has been the main concern for scientists, as it adversely affects world food security. In the tropics, drought impacts on agriculture and resulting food shortages have been widely studied, especially when associated with the failure of the monsoon in Asia or rains in Sudano-Sahelian Africa. In the temperate regions, climatic variations are associated with economic disruptions; in the tropics, droughts bring famine and widespread social unrest (Pierce, 1990).

(f) Other Factors Affecting Soil Fertility

- **Biotic Factors:** This examines the effects of interaction of other organisms with plants and animals. It overviews the effects of pests and diseases on crops, predators, parasites and other microorganisms.

- Edaphic Factors: This looks at soil conditions and its influence on agricultural production. It overviews the soil pH, soil structure and soil texture

3.14 CARBON SEQUESTRATION IN FARMING SYSTEM

Recently, some world governments promoted the use of soil carbon sequestration (storage) to help mitigate elevated levels of atmospheric CO_2 caused by burning fossil fuels and other sources of industrial pollution in the environment

Application of crop rotation scheme, effective manure management, and green manuring are required for effective and efficient organic farming in all management practices that can enhance carbon storage in the soils though tillage practices help increase CO_2 emissions. Farmers should note this important aspect evaluating the tradeoffs associated with organic systems and carbon sequestration.

3.15 ORGANIC AGRICULTURE/MICROCLIMATES

Organic agriculture can create suitable microclimates in dry areas for the purpose of production. In Kenya, the International Centre for Research in Agroforestry (ICRAF) have established organic farming projects to eradicate drought condition. Agro-forestry is one of the best uses of agro-biodiversity that also generates multiple benefits, including erosion control and moisture retention. In Tanzania, the Chagga home gardens on the slopes of Mount Kilimanjaro, where certified organic coffee is produced, display an excellent example of agroforestry (Alfoeldi et al., 2002). The system used includes a diversity of cash and subsistence crops (e.g., bananas, coffee, yams, and beans) as well as livestock.

Cattle and pigs are kept in stables (zero grazing) while the manure is recycled to provide fertility. The home gardens were designed to maximize diversity.

3.16 GROUND AND SURFACE WATER

It was pointed out by Alfoeldi et al. (2002) that the detrimental effects of intensive agriculture on ground and surface water are largely due to erosion, nitrate and pesticide pollution. Other literature also explained that the most important threats to water quality caused by agriculture are high organic fertilization levels together with high stocking rates. Frequent and excess application of mineral N-fertilizers can contaminate soil water as well. With well tillage practices and the use of cover crops and crop rotation scheme, the effects of soil water contamination can be reduced. In this case, the impact of organic farming on water quality can be evaluated by analyzing the parameters of pesticides and nitrate leaching.

Since organic farming does not involve use of synthetic pesticides and other artificial or synthetic elements, there is no risk of ground and surface water pollution through synthetic elements. There is also a lower rate of nitrate leaching in organic farming due to ban of mineral N-fertilizers and lower livestock density. The constraints set up by the organic farming standards lead to this situation. The opportunity costs (costs to produce nitrogen on-farm) of 1 kg nitrogen on organic farms can amount from seven to sixteen times the costs of mineral N-fertilizers (Stolze et al., 2000). In contrast to conventional farms, where manure and slurry are often a waste problem, organic farmers are forced to develop efficient nitrogen management strategies like intercropping, catch cropping, optimal ploughing of leguminous crops or limiting the use of liquid manure to avoid nitrogen losses (Alfoeldi et al., 2002).

Effects and Consequences of Agricultural Chemicals on Soil

Chapter 4

Currently, governments of different countries fund large numbers of researchers studying the side-effects of toxic and undesirable chemicals, and solutions to the symptoms of problems caused by chemical usage on soil, with a view to improve quality of produce. The essence of scientific studies on chemicals are to:

1. Examine the problem of agricultural chemicals on soil
2. Design ecologically sound management strategies for dealing with non-productive soils, pests and diseases
3. Evaluate crop yield in both chemical farming and non-chemical farming
4. Examine the taste of organically produced products in comparison to conventionally produced products

In a symposium on pesticides in soil, it was stated by Audus (1970) that scientists must realize the fantastic complexity of the physical and biological structure of soil and the dynamic nature of its biological equilibria. Additionally, hundreds of papers and reviews concerning the relationships between chemicals used in agriculture, forestry and soil have publicized comments on the adverse effects of chemicals in agricultural production (Guenzi et al., 1974). Evans (1970) pointed out that "Life is on a Little Known Planet" and that a great deal has been learnt, but humans are still unable to conclude on the right methods for use in production. Needham (1932) once criticized biological scientists for not being able to implement the rightful way to achieve the best in agriculture. Medawar (1969) also mentioned that there are plenty of analysts among modern scientists but few synthesists are known. It is felt that poor understanding of soil is closely related to lack of nutrient synthesis by plants. This has become particularly evident some years ago when a number of colleagues of the author from the University of Kassel attempted to review the effects of chemicals on soil and its inhabitants following the steps taken by Hill, 1972; Weetman et al., 1972; Weetman and Hill, 1973; Hill et al., 1975. It was extremely difficult to compare the results of different works, partly because none of them had measured sufficient variables to draw meaningful conclusions, but more particularly because there is really no established framework for viewing the relationships in soil.

4.1 CONSEQUENCES OF CHEMICAL USAGE

One of the most prolific reviewers of studies, Dr. Clive Edwards, once analyzed the effects of agricultural chemicals on soil organisms. His conclusion was "the most usual effect of agricultural practice is to decrease the number of species of soil organisms and the few species that remain will be able to multiply rapidly until the total numbers are greater than they were originally. This statement is somehow true. However, some organisms reproduced may act as pests to crops. On the other hand, the statement is unacceptable as the reduction of soil organisms will affect nutrient turnover and aeration. Also, the time taken for the multiplication may affect certain activities expected to be carried out by a large number of soil organisms. It was pointed out by Edwards (1965) and Edwards and Thompson (1973), that the main difference from cultivation is the effects of chemicals which are expected to last longer. It was explained that ploughing or rotation of crops can only change the balance of soil fauna or flora within weeks or at most months, whereas persistent chemicals can alter them for months or years. Looking only at the beneficial effects of chemicals and ignoring the disastrous aspects will not promote agriculture in the long run. The adverse effects caused by chemicals used on soil, on both human health and environment, are fully known.

A lot of authors have focused their attention on agricultural insecticides and fertilizers. These are not the only external regulations through chemical inputs. Other chemicals used by farmers also affect and deter the activities of soil organisms directly. In fact, there is a vast array of agricultural chemicals, the effects of which are usually sublethal rather than lethal. Another common misconception is that increases in population density are good whereas decreases are bad. Thus, Harris (1969) pointed out that not all chemicals descrease the rate of soil organisms, but instead increase their activities and multiplication. He cited examples using collembola, a largely beneficial group of soil arthropods. He noted that the application of DDT changes the composition of species. Unfortunately, the role of most organisms in the soil is poorly defined to permit such analysis at the present time.

4.2 EFFECTS OF CHEMICALS ON SOIL

The continuous use of chemical inputs such as pesticides has resulted in damage to the environment causing human ill-health, negative impact on agricultural production and reducing agricultural sustainability (Pimentel et al., 1992; Pimentel and Greiner, 1997). Chemicals affect environment on farms and in neighbouring areas through disruption of beneficial insect populations and through groundwater contamination (Beck and Quigley, 2001). It has also affected the fauna and flora adversely (Pimentel and Greiner, 1997). Numerous short- and long-term human health effects have been recorded. The decimation of beneficial agricultural predators of pests has led to the proliferation of several pests and diseases (Pimentel and Greiner, 1997).

Several studies addressed the possible environmental impacts of agricultural pesticides (Liu et al., 1995; Mostaghimi et al., 1993; Ritter, 1990, Shumway and Chesser, 1994; Skinner et al., 1997). Some have also analyzed the possible reductions of pesticide use for environmental reasons (Beach and Carlson, 1993; Crowe and Mutch, 1994; Whittaker et al., 1995). Much of the concern on environmental impacts of pesticides mainly focused on contamination from the applications (Gunter and Gentner, 2000). Agricultural chemicals affect non-target species such as animals and soil organisms, contaminate drinking water supplies and the atmosphere. Groundwater contamination is caused due to percolation of pesticides through soil, runoff or soil erosion, volatilization of pesticides into the atmosphere, and drift resulting from pesticide spraying. The use of chemicals in plant boosters also results in (1) deterioration of soil friability, creating hardpans soil, (2) destruction of beneficial soil life, including earthworms, (3) altering vitamin and protein content of certain crops, (4) making certain crops more vulnerable to diseases, and (5) preventing plants from absorbing some needed minerals.

Recommendation

Chemical usage on soil as described in some literature is not only detrimental to soil organisms, but also to humans who may consume chemically produced crops and animals. Beside, chemicals have an adverse effect on the environment we live in. Scientific evidence available indicates that in most instances, the use of agricultural chemicals is inadvisable as it affects human health and destroys the natural environment in which we live in. In this case, it is advised that farmers and producers should refrain from chemical usage in crop and animal production.

4.3 DEVELOPING AND MAINTAINING FERTILE SOILS

With respect to soil fertility, it is relevant to review how soil is formed. The formation of soil requires two material inputs, rocks (the earth's crust) and dead organic matters. These are converted into soil largely through the process of decomposition.

There is certainly no shortage of rocks and dead organic matters in temperate countries as the optimum temperature for production is nearer to the annual mean temperature than the optimum temperature for decomposition. This, in fact, is the main reason why deep litter layers are found in most forests, whereas there is usually no litter layer in lowland tropical forests. The biological decomposition of organic matters is mainly carried out with the help of bacteria and fungi.

Lack of effectiveness of these organisms is affected by six factors. This is where the soil fauna play an important role because through their feeding and movement, they are continually removing the limiting factors for the microflora, particularly through their ability to distribute the spores of the latter. Thus, if certain members of the fauna are killed or reduced by agricultural chemicals, the activity of the bacteria and fungi species will decline. Increases in the population density of certain groups of soil organisms can also lead to problems through imbalance.

While detailed knowledge of these processes is currently very poor, the basic fact that by taking into account organisms in the soil and catering to their needs will contribute to the maintenance of soil fertility. The primary objective of land management is to ensure the return of organic materials taken from the land.

4.4 PREVENTING OUTBREAKS OF PESTS AND DISEASES

Pests and diseases are symptoms of poor management. Pesticides, antibiotics and drugs have generally been regarded as "magical bullets" that eliminate pests and disease problems. The act of elimination of pests and diseases is the result of trying to create a conducive atmosphere for plant growth and development. However, the use of pesticides and antibiotics to control pests and pathogens leads to the development of a long list of serious secondary problems in agricultural production. The reason is, as most pesticides are synthetic organic compounds that have no counterpart in nature, they are likely to accumulate in the environment, thereby causing serous problems to human health.

Pesticide approach predominates largely because most of the costs (e.g., environmental, human health) are not taken into account in our cost benefit analysis (Moore, 1967).

In order to treat pest problems at the causal level, it is necessary to examine in detail the relationships between agricultural practices and pest damage. This approach has been used to generate the strategies. Basic principles must be designed for each unique situation, consequently the particular strategies employed should ideally be selected by the farmer himself.

4.5 IMPLEMENTING CHANGES IN CHEMICAL APPLICATIONS

Changing from chemical to management strategies will not be easy. Modern agriculture has become dependent on chemicals just as heroin addicts have become dependent on their drugs (neither pesticides nor stimulatory drugs treat problems at the causal level). The irrational outbursts experienced on withdrawal of these two "drugs" share certain features in common; such outbursts are a measure of a loss of true freedom, the kind that is unfortunately not protected by any Bill of Rights.

Due to the addictive nature of the problem, the implementation of alternative ecological strategies will require an enormous cooperative effort involving the general public (consumers), industry and commerce (including producers), researchers (in federal and provincial governments, universities and industry), communicators (media people, educators, and extension agents) and governments (federal, provincial and local). The alternative to cooperation is to respond to the crises that will undoubtedly occur with increasing frequency. If we continue with the kinds of solutions to problems that are exemplified by the use of agricultural chemicals (Whiteside, 1977), agricultural development will improve rapidly.

4.6 ECOLOGICAL STRATEGIES FOR PEST CONTROL

(a) Selection of Plant

1. Stricter limits on plant introduction
2. More thorough quarantine procedures for introduced plant materials
3. Increase genetic diversity
4. Develop and use resistant varieties
5. Only use healthy seeds and plants, e.g., certified disease free, and from reliable dealers
6. Use varieties suited to your soil and climate
7. Use seeds inoculated with beneficial microorganisms
8. Develop and use varieties able to compete with weeds
9. Develop and use varieties able to grow in mixed culture

(b) Selection of Site

Selection of site, particularly the soil, for its ability to satisfy all the needs of plants and to avoid pest damage, requires detailed knowledge of plants, soils, and pests

Consider:

1. Soil type, fertility, structure and drainage
2. Elevation, slope, aspect
3. Location in relation to other features of the landscape
4. Climate
5. Previous history of site, i.e., crop, tillage, chemicals, pests
6. Modify site, if necessary, to meet needs of crop

(c) Planting

1. Crop rotation
2. Mixed or companion planting
3. Management of field borders and other adjacent environments to favour natural controls, e.g., by provision of nursery or trap crops, nesting and overwintering sites
4. Plant at the best time and in the best way for the plant and the worst time and way for the pest
5. Introduce preventative pest control devices, e.g., tree bands, barriers, pheromone or other traps
6. Design size and shape of plots to discourage pests

(d) Maintenance of Site

General:

1. Create and maintain optimum soil conditions for the plant and beneficial soil and aboveground organisms and unfavourable conditions for pests, e.g., through appropriate tillage, irrigation, drainage and application of organic and inorganic amendments and mulches; inoculation of plant and/or soil with beneficial organisms.
2. Avoid damaging the plant or stressing it with growth stimulants or toxins, e.g., unbalanced fertilizers, hormones, herbicides and pesticides
3. Practice good sanitation
4. Prune and thin where and when necessary
5. Monitor pest populations

(e) Harvesting, Distribution, Storage and End-of-Season Chores

1. Time of harvest to avoid late pest attack
2. Store only healthy, pest-free produce in optimal conditions for crops and unfavourable conditions for pests

3. Destroy crop residues and potential overwintering sites of pests
4. Manage soil overwinter to reduce pests and encourage natural controls

(f) Reasons to Opt for Organic Products

1. Organic food has a distinguished natural taste
2. Organic production reduces health risks
3. Organic farms respect water resources
4. Organic farmers build healthy soil
5. Organic farmers work in harmony with nature
6. Organic producers are leaders in innovative research
7. Organic producers strive to preserve diversity
8. Organic farming helps keep rural communities healthy
9. Organic abundance—foods and non-foods alike

(g) Nutrient Usage in Plants

Adequate and balanced supply of nutrients in the soil is very necessary for several reasons in agricultural improvement. Surplus nutrients in the soil might result in nutrient losses which may subsequently lead to water and air contamination and eutrophication of the farming environment. Nutrient deficiency is synonymous with the overexploitation of soil nutrients in the long run, consequently, this may lead to decrease in the performances, yield and quality of crops.

Research conducted by Freyer (1997) in Switzerland explained that 14% of all organic farms have an N-surplus, and only 1.5% have a P-surplus. It was further explained that most of the organic farms have a negative nitrogen and phosphorus balance. Table 4 shows the results of phosphorus

Table 4 Phosphorus and potassium balances (kg/ha) compared with organic and conventional farms

	P Balance (kg/ha)		K Balance (kg/ha)	
	Organic	*Conventional*	*Organic*	*Conventional*
Sweden	–12	+37	–4	+39
Netherlands				
Cash crop farm	+18	+23	+31	+25
Horticulture	+32	+60	+119	+110
Dairy farm	+8	+31	N.A.	N.A.
Germany				
Mixed farm	–4	+13	–27	+31
Dairy farm1	–2	+5	+7	+20

Source: Stolze et al. (2000) N.A. – Not available and potassium balance in some European countries. At the end of the research, it was concluded that the phosphorus and potassium surpluses of organic farms are significantly lower than those of conventional ones (Stolze et al., 2000).

Due to negative nutrient balances as shown in the table, the question raised was that does an organic farming method cause gradual loss of soil minerals? In the first case, the proportion of soluble nutrient fractions is lower on organic managed soils. On the other hand, Mäder et al. (2000) found no decrease in organic yields as an indicator for nutrient deficiency on farms that are managed organically for more than 20 years. Oberson et al. (2000) pointed out that higher biological activity and higher mycorrhizal root colonization counteract nutrient deficiency. He also noted that the aim of organic farmers is to increase the supply of nutrients through increased biological activity.

References

Abushita, A.A., Hebshi, E.A., Daood, H.G. and Biacs, P.A. (1997). Determination of antioxidant vitamins in tomatoes. Food Chemistry. 60.

Adeniji, K.O. (1985). Review of endangered cattle breeds of Africa. In: Animal genetic resources in Africa: high potential and endangered livestock. 2nd OAU Expert Committee Meeting on Animal Genetic Resources in Africa, 24-28 November 1983, Bulawayo, Zimbabwe. Nairobi, Kenya. OAU/STRC/IBAR., 20-32.

Agrawal, A.A. (1998). Induced responses to herbivory and increased plant performance. Science. 279.

Agrios, G.N. (2005). Plant Pathology. 5th edition. Elsevier Academic Press. Burlington, MA. USA.

Akinsanmi, O. (1994). Senior Secondary Schools Agricultural Science. Longman Group. Malaysia.

Akinwumi, J.A. and Ikpi, A.E. (1985). Trypanotolerant cattle production in southern Nigeria. Report to International Livestock Centre for Africa (ILCA) Humid Zone Programme. Ibadan, Nigeria. ILCA.

Akinyemi, O.M. (2005). New Poultry Production: The Case of American, British and German Systems. Masters Thesis. University of Kassel, Germany. Published in Organic Eprints.

Akinyemi, O.M., Blake, F., Hindo, N. and Shulz, K. (2005). The effects of organic and conventional management practices on soil characteristics, in particular aerobic nitrogen mineralization: Working paper in the faculty of soil microbiology (unpublished paper).

Aleman, F. (2001). Common bean response to tillage intensity and weed control strategies. Agronomy Journal. 93(3).

Alföldi, T., Fliessbach, A., Geier, U., Kilcher, L., Niggli, U., Pfiffner, L. Stolze, M. and Willer, H. (2002). Organic agriculture and the environment. In: El-Hage S.N. and Hattam C., eds. *Organic Agriculture, Environment and Food Security*. Chapter 2. Environment and Natural Resources Series 4. Food and Agriculture Organization of the United Nations (FAO).

Altieri, M.A., Letourneau, D.K. and Davis, J.R. (1983). Developing sustainable agroecosystems. BioScience. 33.

Amaral, L.D. (2004). Drinking water as a risk factor to poultry health. Brazilian Journal of Poultry Science. Available at: http://www.scielo.br/pdf/rbca/v6n4/23024.pdf.

Anderson, J.P.E. (1982). Soil respiration. In: Haney R.L. et al. (eds): Soil Carbon and Nitrogen Mineralization: Influence of Drying Temperature. Published in Soil Sci Soc. Am. J. 68.

Anderson, J.P.E. and Domsch, K.H. (1975). Measurement of bacterial and fungal contributions to respiration of selected agriculture and forest soils. Canadian Journal of Microbiology. 21: 314-322.

Anderson, T.H. and Domsch, K.H. (1990). Ratio of microbial biomass carbon to total organic carbon in arable soils. Soil Biology & Biochemistry. 21.

Anonymous (2005). Systemic acquired resistance. Available at: http://www.aber.ac.uk/plantpathol/sar.html

Anonymous (1999). Product and Market Development by International Trade Centre, GENEVA. http://www.intracen.org/mds/sectors/organic/bluebook.pdf.

Anonymous (2000). Hypersensitive response (HR) in tobacco leaf. American Phytopathological Society. http://www.apsnet.org/online/feature/Genomics/Images/hrtobacco.htm

Anonymous (2000). The state of food insecurity in the world. Published in 2000 by the Food and Agriculture Organization of the United Nations. ISBN 92-5-104479-1. Accessed on. 20.07.06 at. http://www.fao.org/FOCUS/E/SOFI00/img/sofirep-e.pdf.

Anonymous (2001). Onion Cultivation. Accessed July 12th 2006. http://www.avrdc.org/LC/onion/practices.html

Anonymous (2001). Organic Consumer Trends. Published by the Natural Marketing Institute and Organic Trade Association (OTA).

Anonymous (2001). World Markets for Organic Fruit and Vegetables - Opportunities for Developing Countries in the Production and Export of Organic Horticultural Products. Published by FAO, Rome. Available at: http://www.fao.org/DOCREP/004/Y1669E/Y1669E00.HTM.

Anonymous (2001). World Markets for Organic Fruit and Vegetables. FAO/ITC/CTA joint publication. Rome. http://www.cta.int/pubs/world markets/summary.pdf.

Anonymous (2002). World Horticultural Trade and US Export Opportunities. January. Available at: http://www.fas.usda.gov/htp/circular/2002/02-01/Stats/organic.pdf.

Anonymous (2002). World summit on sustainable development in Johannesburg 26th August to 4th September 2002.

Anonymous (2003). Current market situation and medium-term prospects by Food and Agriculture Organization of the United Nations. Unpublished Article.

Anonymous (2003). Defence related proteins, division of medical devices. http://dmd.nihs.go.jp/latex/defense-e.html.

Anonymous (2005). First-Year Effect of Organic and Conventional Management Practices on Selected Soil Quality Indicators at the Neely-Kinyon Farm. Greenfield. Iowa. http://www.extension.iastate.edu/Publications/PM1881.pdf.

Anonymous (2005). Soil Formation and Classification. United States Department of Agriculture. National Resources Conservation Services. Available at: http://soils.usda.gov/education/facts/formation.html.

Appleby, M.C. (1991). Do Hens Suffer In Battery Cages? The Athene Trust. Petersfield, UK

Appleby, M.C., Hughes, B.O. (1991). Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. World Poultry Science Journal. 47: 109-128.

Asmal, K. (1995). Forest Policy Discussion, Minister of Water Affairs and Forestry, Republic of South Africa.

Atterholt, C.A., Delwiche M.J., Rice R.E. and Krochta J.M. (1999). Controlled release of insect sex pheromones from paraffin wax and emulsions. Journal of Controlled Release. 57.

Audus, L.J. (1970). Symposium summary. In: Hill, S.B. (ed.) Pesticides in the Soil: Ecology. Degradation and Movement. Michigan State Univ. East Lansing in Agricultural Chemicals and Soil (1977). pp. 142-144.

Babu, S.C. and V.J. Quinn (1994). Food security and nutrition monitoring in Africa. Food Policy. 19 (3)

Baldwin, K. R. (2001). Soil Fertility for Organic Farming. Assessed on the 26th July 2006 at: http://www.ncsu.edu/organic_farming_systems/news/soil fertility.pdf

Bàrberi, P. (2002). Weed management in organic agriculture: are we addressing the right issues? Weed Research. 42(3).

Barnes, J.P. and Putnam, A.R. (1983). Rye residues contribute weed suppression in no tillage cropping systems. J. Chem. Ecol. 9: 1045-1057.

Barret, H.R., Browne, A.W., Harris, P.J.C. and Cadoret, K. (2002). Organic certification and the UK market: organic imports from developing countries. Food Policy. 27.

Bates, T.R., Dunst, R.M., Taft, T. and Vercant, M. (2002). The vegetative response of 'concord' grapevines to soil pH. Horticulture Science. 37(6): 890-893.

Bationo, A. and Mokwunye, A.U. (1991). Role of manures and crop residue in alleviating soil fertility constraints to crop production: With special reference to the Sahelian and Sudanian zones of West Africa. Nutrient Cycling in Agroecosystems. 13 (1).

Beach, E.D. and Carlson, G.A. (1993). A hedonic analysis of herbicides: do user safety and water quality matter? American Journal of Agricultural Economics. 75: 612.

Beck, B. and Quigley, M.F. (2001). Intensive Organic Gardening. Department of Horticulture and Crop Science, Ohio State University Extension. Accessed on the 24th of May 2006 (http://ohioline.osu.edu/hyg-fact/1000/1257.html).

Besong, J.B. (2005). Best options for securing the future of African rainforest: Theme 2: Participatory approaches to forest management. Published by Earth Watch Institute, Europe. Available at http://www.earthwatch.org/site/pp.asp?c=crLQK3PHLsF&b=479765

Besong, J.B. and Ngwasiri, C.N. (1995). The 1994 Forestry Law and National Natural Resources Management in Cameroon". A PVO-NGO/NRMS Cameroon Publication.

Bjerklie, S. (1995). On the horns of a dilemma: The US meat and poultry industry. In: Stull D.D., Broadway D.J. and Griffith D. eds. Any Way You Cut It: Meat Processing and Small-Town America. University Press of Kansas, Lawrence, USA.

Blench, R.M. (1994). The Expansion and Adaptation of Fulbe Pastoralism to Subhumid and Humid Conditions in Nigeria. Cahiers d'études africaines. 133-135.

Blokhuis, H.J. and Wiepkema P. R. (1998). Case Studies of feather pecking in poultry. Vet Quart. 20: 6-9.

Blowfield, M. (1999). Ethical Trade: A Review of Developments and Issues. Unpublished Report for NRI, University of Greenwich, UK.

Boom, R. (2002). Healthy soil, healthy grass, healthy stock—the balance approach. First Virtual Global Conference on Organic Beef Cattle Production, organized by University of Contestado—Concordia Campus, Brazil.

Bowden, R.L. (2000). Effects of Reduced Tillage on Wheat Management. Department of Plant Pathology, Kansas State University, Kansas, USA.

Bramwell, K.R. (2005). Basic Concepts and Current Challenges in Managing the Modern Broiler Breeder. Published by the Department of Poultry Science, University of Arkansas, Fayetteville, Arkansas 72701, USA.

Broady, P. A. (1981). The ecology of chasmolithic algae at coastal locations of Antarctica. Phycologia, 20, p. 259.

Brookes, P.C., Landman, A., Pruden, G. and Jenkinson, D.S. (1985). Chloroform fumigation and the release of soil nitrogen: a rapid direct extraction method for measuring microbial biomass nitrogen in soil. Soil Biol Biochem. 17: 837-842.

Brouwer, J., Fussell, L.K. and Herrmann, L. (1993). Soil and crop growth micro-variability in the West African semi-arid tropics: a possible risk-reducing factor for subsistence farmers. Agric. Ecosyst. Environ. 45.

Brouwer, J., Powell, J.M., (1998). Increasing nutrient use efficiency in West-African agriculture: the impact of micro-topography on nutrient leaching from cattle and sheep manure. Agric. Ecosyst. Environ. 71: 229-239.

Brown, A.S.M. Cook, H.F. and Lee, H.C. (2000). Topsoil characteristics from a paired farm survey of organic versus conventional farming in southern England. Biological Agriculture and Horticulture. 18: 37-54.

Buerkert, A., Mahler, F. and Marschner, H. (1996). Soil productivity management and plant growth in the Sahel: Potential of an aerial monitoring technique. Plant and Soil. 180: 29-38.

Buol, S.W. (1995). Sustainability of Soil Use. Annual Review of Ecology and Systematics. Vol. 26. Soil Science Department, North Carolina State University.

Cabrera, M.L. and Kissel, D.E. (1988). Potentially mineralisable N in disturbed and undisturbed soil samples. Soil Sci. Soc. Am. J. 52.

Carter, M.R. and Rennie, R.A. (1982). Changes in soil quality under zero tillage farming systems: distribution of microbial biomass and mineralizable C and N potentials. Canadian Journal of Soil Science. 62.

CGIAR (2001). South Africa Host Mid-term meeting. Available at: http://www.worldbank.org/html/cgiar/newsletter/jul01/cgnews0107.pdf

Chander, K., Dyckmans, J., Hoeper, H., Joergensen, R.G. and Raubuch, M. (2001). Long-term effects on soil microbial properties of heavy metals from industrial exhaust deposition. Journal of Plant Nutrition and Soil Science. 164: 657-663.

Clark, L.R., Geier, P.W., Hughes, R.D and Morris, R.F. (1974). The Ecology of Insect Populations in Theory and Practice. Methuen, Lond. Kluwer Academic Press.

Clark, S., Klonsky, K., Livingston, P. and Temple, S. (1999). Crop-yield and economic comparisons of organic, low-input, and conventional farming systems in California's Sacramento Valley. American Journal of Alternative Agriculture. 14(3).

Clarke, A.C. and Hodges, R.D. (1987). The environmental effects of conventional and organic/biological farming systems. Biological Agriculture and Horticulture. 4: 309-357.

Cockcroft, F.L. (1977). Agricultural Development Planning Project: Ghana Meat Development Project. A UNDP FAO Consultancy Report. Rome, Italy.

Collier, T. and Van Steenwyk, R.A. (2004). Critical Evaluation of Augmentative Biological Control: Department of Environmental Science, Policy and Management. University of California, Berkeley, CA, USA Department of Renewable Resources, University of Wyoming, Laramie, WY, USA, Biological Control. 31.

Conroy, D.W. (1945). Legal Aspects of Land Holding Among the Tonga. In: Allan, W. et al., Land Holding and Land Usage Among the Plateau Tonga of Mazabuka District: A Reconnaissance Survey, Manchester University Press.

Cordier, C., Pozo, M.J., Barea, J.M., Gianinazzi, S. and Gianinazzi-Pearson, V. (1998). Cell defense responses associated with localized and systemic resistance to phytophthora parasitica induced in tomato by an arbuscular mycorrhizal fungus. MPMI 11.1017-1028 http://www.apsnet.org/mpmi/PDFS/1998/0730-02R.pdf.

Creamer, N.G. and Baldwin, K.R. (1999). Summer Cover Crops. HIL-37. Department of Horticultural Science, North Carolina State University, Raleigh, NC, http://www.ces.ncsu.edu/depts/hort/hil/pdf/hil-37.pdf

Creamer, N.G., and Baldwin, K.R. (1999). Summer Cover Crops. HIL-37. Department of Horticultural Science, North Carolina State University, Raleigh, NC, http://www.ces.ncsu.edu/depts/hort/hil/pdf/hil-37.pdf.

Crowe, A.S. and Mutch, J.P. (1994). An expert systems approach for assessing the potential for pesticide contamination of ground water. Ground Water. 32: p. 487.

Cruse, R.M. (2001). Strip Tillage Effects on Crop Production. Department of Agronomy, Iowa State University. USA.

Davis, K. (2004). The Need for Federal Legislation Prohibiting the Inhumane Practice. http://www.all-creatures.org/articles/egg-debeaking.html.

Dawkins, M.S. (1989). Time budgets in red junglefowl as a baseline for the assessment of welfare in domestic fowl. Appl. Anim. Behav. Sci. 24: 77-79.

Dean, M., Motes, J. and Schatzer, R.J. (1987a). Commercial Production of Fresh Market Tomatoes. OSU Extension Facts No. 6019. Cooperative Extension Service, Oklahoma State University, USA.

Dean, M., Motes, J. and Schatzer, R.J. (1987b). Commercial Production of Fresh Market Tomatoes. OSU Extension Facts No. 6019. Cooperative Extension Service, Oklahoma State University, USA.

DeBach, P. (1964). Biological Control of Insect Pests and Weeds. Chapman and Hall, London.

Delate, K. (2002). Soil Quality in Organic Agricultural Systems: Series 5 at physiologic maturity and the USDA-ARS Sustainable Agriculture Initiative, Iowa State University, USA.

Delate, K. (2005). Organic Agriculture. Iowa State University, USA.

Delate, K., Cambardella, C., Taylor, K. and Burcham, B. (1999). Comparison of organic and conventional rotations at the Neely-Kinyon Long-Term Agroecological Research (LTAR) site: First year results. Leopold Center for Sustainable Agriculture Annual Report, Iowa State University, Ames. IA.

Dick, W.A. and Tabatabai, M.A., (1992). Potential uses of soil enzymes. In: Metting, B. ed. Soil Microbial Ecology, Marcel Dekker, New York.

Diver, S. (1999). Biodynamic Farming and Compost Preparation. Published by ATTRA—National Sustainable Agriculture Information Service.

Djajakirana, G., Joergensen, R.G. and Meyer B. (1996). Ergosterol and microbial biomass relationship in soil. Biol Fertil Soils. 22: 299-304.

Domingo, P.M. (1976). Contribution à l'étude de la population bovine des Etats du golfe du Bénin. Ecole inter-Etats des sciences et de médecine vétérinaires de Dakar: p. 148.

Doutt, R.L. and Hagen, K.S. (1949). Periodic colonization of *Chrysoperla californica* as a possible control of mealybugs. Journal of Economic Entomology. 42

Dumas M. (1997). Weathering of Rocks and Minerals. http://www.usoe.k12.ut.us/curr/science/core/plans/int/rocks.html.

Durrant, W.E. and Dong, X. (2004). Systemic acquired resistance. Annual review of phytopathology 42: 185-209. http://www.arjournals.annualreviews.org/doi/full/10.1146/annurev.phyto.42.040803.140421

Edwards, C.A. (1965). Some side-effects resulting from the use of persistent insecticides. In: Hill, S.B., ed. Agricultural Chemicals and the Soil. EAP Publication-1.

Edwards, C.A. and Thompson, A.R. (1973). Pesticides and the soil fauna. In: Hill, S.B. ed., Agricultural Chemicals and the Soil. EAP Publication-1

Ellis, R.H., Roberts, E.H. and Summerfield, R.J. (1988). Variation in the optimum temperature for rates of seedling emergence and progress towards flowering amongst six genotypes of faba bean (*Vicia faba* (L.)). Annals of Botany 62: 119-126.

Emmert, J.L. (2005). Modern Poultry Production. Arkansas State University, USA.

Epstein, H. (1971). The Origin of the Domestic Animals of Africa. Africana, Vol I. New York, NY, USA.

Evan, E., (2000). Botanical insecticides. NC State University. Available at: **http://www.ces.ncsu.edu/depts/hort/consumer/quickref/pest%20management/botanical_insecticides.html**

Evans, H.E. (1978). Life on a little known planet . In: Hill, S.B. ed., Agricultural Chemicals and the Soil. EAP Publication-1.

Evans, L.T. (1993). Crop Evolution, Adaptation and Yield. Cambridge University Press, Cambridge, UK.

Expert Consultation. (1999). Soil and Nutrient Management in Sub-Saharan Africa in Support of the Soil Fertility Initiative (SFI). Lusaka. 6-9 December 1999 conference.

Fanatico, A. (2002). Sustainable Poultry Overview. Published by ATTRA. USA.

FAO. (1992). Food Balance Sheets. FAO Data Service. Rome.

FAO (2002a). Land Tenure and Rural Development. ISBN 92-5-104846-0 (ftp://ftp.fao.org/docrep/fao/005/y4307E/y4307E00.pdf

FAO (1994). Production Yearbooks. Rome.

FAO (1994a). New Directions for Agriculture, Forestry and Fisheries, Strategies for Sustainable Agriculture and Rural Development. Rome.

FAO (2002). Organic Agriculture, Environment and Food Security. SDRN. Rome. Published article 2002 by FAO.

FAO (2002). Water Source of Food Security. World Food Day: October 16th 2002.

FAO (2000). Assessing of Soil Nutrient Balance: FAO fertilizer and plant nutrient bulletin ISBN:0532-0488.

Farrell, K., Flint, M., Lyons, J., Madden, J., Schroth, M., Weinhold, A., White, J., Zalom, F. and Jaley M. (1992). Beyond Pesticides, Biological Approaches to Pest Management in California. ANR Publications. University of California, Oakland. CA, USA.

Firman, J.D. (1993). Nutrient Requirements of Chickens and Turkeys. A publication of the University of Missouri Extension. Accessed 17th July 2006 at: http://muextension.missouri.edu/xplor/agguides/poultry/g08352.htm.

Foodnews (2003). Time to give your brand a health check. Leatherhead Food International. 37 (8).

Frankenberger, W.T. and Dick, W.A. (1983). Relationship between enzyme activities and microbial growth and activity indices in soil. Soil Science Society of American Journal. 47.

Franzluebbers, A.J., Hons, F.M. and Zuberer, Z.A. (1994). Long-term changes in soil carbon and nitrogen pools in wheat management systems. Soil Sci. Soc. Am. J. 58: 1639-1645.

Freyer, B. (1997). Kennziffern der Nachhaltigkeit von 317 ackerbaubetonten Betrieben des biologischen Landbaus in der Schweiz, ausgewertet auf der Basis von Betriebskontrolldaten. In: Köpke, U. and Eisele, J.A. eds. Beiträge zur 4. Wissenschaftstagung zum ökologischen Landbau, Berlin. 103-106.

Fricke, W. (1979). Cattle husbandry in Nigeria: a study of its ecological conditions and social-geographical differentiations. Heidelberger Geographischen Arbeiten. Geographisches Institut der Universität Heidelberg. 330.

Friedmann, E. I. (1971). Light and scanning electron microscopy of the endolithic desert algal habitat. In: Halt and Otte, (Ed.). Biological Weathering on Nunataks of the Juneau Icefield, Alaska. Periglacial Processes, Vol 1: p 190.

Friedmann, E. I. and Galun, M. (1974). Desert algae, lichens and fungi. In Halt and Otte (Ed), Biological Weathering on Nunataks of the Juneau Icefield, Alaska. Permafrost and Periglacial Processes, Vol 1: p 190.

Friedmann, E. I. and Weed, R. (1987). Microbial tracefossil formation, biogenous, and abiotic weathering in the Antarctic cold desert. Science, N. Y., 236, pp. 703-705.

Friend, D.H. and Helson, V.A. (1986). Thermo periodic effects on the growth bud photosynthesis of wheat and other crop plant. Bot. Gaz. 137: pp. 75-84.

Garci Gil, J.C., Plaza, C., Soler-Rovira, P. and Polo, A. (2000). Long-term effects of municipal solid waste compost application on soil enzyme activities and microbial biomass. Soil Biology and Biochemistry. 32.

Gary, D. and Butcher, D.V.M. (2003). Ph D., Professor and Poultry Veterinarian and Richard Miles, Ph D. Poultry Nutritionist, College of Veterinary Medicine, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, USA.

Geenzi, W.D. et al., eds. (1974). Pesticides in Soil and Water. Soil. Sci. Soc. Am., Madison, Wi. In: Hill, S.B (ed.). Agricultural Chemicals and the Soil. Ecological Agricultural Project

George, J., Nuttall, S.L. and Kendall, M.J. (2001). Prostate cancer and antioxidants. Journal of Clinical Pharmacy and Therapeutics. 26.

Gerster, H. (1997). The potential role of lycopene for human health. Journal of the American College of Nutrition. 16.

Ghani, A., Shah, M. and Khan, D.R. (1990). Response of rice to elevated rates of Zn in mountainous areas of Swat. Sarhad J. Agric. 6.

Gilks, P. (1975). The Dying Lion: Feudalism and Modernization in Ethiopia. Julian Friedmann Publishing Ltd. London.

Gold, M.V. (1999). Sustainable Agriculture: Definitions and Terms. Special Reference Briefs Series no. SRB 99-02. ISSN 1052-5368.

Gorlach, J., Volrath, S., Knauf-Beiter, G., Hengy, G., Beckhove, U., Kogel, K.H., Oostendorp, M., Staub, T., Ward, E., Kessmann, H. and Ryals, J. (1996). Benzothiadiazole, a novel class of inducers of systemic acquired resistance, activates gene expression and disease resistance in wheat. Plant cell. 8: (4): pp. 629-643. http://www.plantcell.org/cgi/content/abstract/8/4/629.

Gorlach, J., Volrath, S., Knauf-Belter, G., Hengy, G., Beckhove, U., Kogel, K.H., Oostendorp, M., Staub, T., Ward, E., Kessmann, H. and Ryals, J. (1996). Benzothiadiazole, a novel class of inducers of systemic acquired resistance, activates gene expression and disease resistance in wheat. Plant Cell. 8.

Gozzo, F. (2004). Systemic acquired resistance in crop protection. Outlook on pest management. DOI: 10.1564/15feb10. http://www.researchinformation.co.uk/pest/sample/15-1/11-Gozzo.pdf

Graziano, M. and Lamattina, L. (2005). Nitric oxide and iron in plants: an emerging and converging story: TRENDS in Plant Science. 10 (1). Available online at http://www.sciencedirect.com.

Grigg, D.B. (1993). The World Food Problem. 2nd edition. Published by Blackwell Publishing Press. ISBN: 0631176330.

Grimble, R. and Calder, P.C. (2002). Immunonutrition. CABI Publishing Press, British Journal of Nutrition. 87 S1.

Gueye, E.F. (1998). Village egg and fowl meat production in Africa. World's Poultry Science Journal. 54 pp. 73-86.

Guenter, L.F. and Centner, T.J. (2000). Characteristics of state agricultural pesticide collection programs. Journal of Environmental Management. 58: 61.

Hamm, U. and Gronefeld, F. (2004). The European Market for Organic Food: Revised and Updated Analysis. Organic Marketing Initiatives and Rural Development. School of Management and Business, University of Wales Aberystwyth. United Kingdom. 5.

Hamm, U., Gronefeld, F. and Halpin, D. (2002). Analysis of the European Market for Organic Food. Organic Marketing Initiatives and Rural Development. I. School of Management and Business, University of Wales, Aberystwyth, UK.

Hanson, P., Chen, J.T., Kuo, C.G., Morris, R. and Opena, R.T. (2001). Tomato Production. Prepared by T. Kalb. Published by AVRDC. Assessed on the 27th July 2006 at. http://www.avrdc.org/LC/tomato/production/01title.html.

Harris, C.R. (1969). Insecticide pollution and soil organisms. Proc. Entomol. Soc. Ont. 100: pp. 14-29.

Hawkins, B.A. and Cornell, H.V. (2000). Theoretical Approaches to Biological Control, edited by Cambridge University Press. http://www.elsevierhebis.de/pdflinks/06011614022528437.pdf (accessed on February 16th 2006).

Hayashi, S., Ganno, K., Ishii, Y. and Tanaka, I. (2002). Robotic Harvesting System for Eggplants. Published by Japanese International Research Centre for Agricultural Sciences. 39(3).

Herdt, R.W. and Steiner, R.A. (1995). Agricultural sustainability, concepts and conundrums. In: Vic Barnett. Rodger Payne and Roy Steiner, eds. Agricultural Sustainability. Economic, Environmental and Statistical Considerations, Teachester, New York, Brisbane. Toronto, Singapore. John Wiley, S. 3-13.

Hermansen, J.E. and Horsted. K. (2004). Organic poultry farming. Paper presented at 1st international congress on Organic Animal Production and Food Safety, Kusadasi– Turkiye, 28 April-1 May 2004; Published in Incuglu, Serife, eds. Tebligler, Izmir Regional Chamber of Veterinary Medicine. pp. 271-284.

Hickey, S. (2005). Understanding the politics of challenging chronic poverty: some conceptual approaches. Presentation at Policy Influence and Media Engagement, a joint ODI-CPRC workshop, at ODI on 17-16 January 2005.

Hiernaux, P. (1983). Les ressources végétales et leur productivité. In: Wilson, R.T., de Leeuw, P.N., De Haan, C. eds. Recherches sur les systèmes des zones arides du Mali: résultats préliminaires. Research Report No. 5. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

Hill, S.B. (1972). Effects of agriculture on soil mites. Unpublished paper presented to joint meeting of Entomol. Soc. Am., Entomol. Soc. Que., and Entomol. Soc. Can., Montreal, 26th November 1972.

Hill, S.B., Metz, L.J. and Farrier, M.H. (1975). Soil mesofauna and silvicultural practices. In: Bernier, B. and Winget, C.H. eds. Forest Soils and Forest Land Management. Pr. Univ. Laval, Quebec. pp. 119-135.

Hinrichs, C.C. and Welsh, R. (2003). The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Kluwer Academic, The Netherlands.

Hochmuth, G. J., Maynard, D. N., Vavrina, C. S., Stall, W. M., Kucharek, T.A., Stansly, P.A., Smith, T.S.A., and Smajstrla, A.G. (1999). Tomato Production in Florida. Published online by the University of Florida. Accessed on the 26th January, 2007 at http://www.uog.edu/cals/PEOPLE/PUBS/Tomatoes/CV13700.pdf

Hocombe, S.D. (1968). Herbicides in soil. In: Fryer, J.D and Evans, S.A. eds. Weed Control Handbook. Blackwell, Oxford. 1: pp. 152-158.

Hoitink, H.A.J. and Fahy, P.C. (1986). Basis for the control of soil-borne plant pathogens with compost. Annual Review of Phytopathology. 24: pp. 93-144.

Houot, S., Chaussod, R. (1995). Impact of agricultural practices on the size and activity of the soil microbial biomass in a long-term field experiment. Biology and Fertility of Soils. 19.

Hovi, M., Sundrum, A., and Baars, T., eds. (2001b). Feeding for Health and Welfare. Proceedings of the 4th NAHWOA-Workshop, 24-27.03.2001, Wageningen, NL. NAHWOA—Network of Animal Health and Welfare in Organic Agriculture. 198-202.

Hovi, M., Sundrum, A., Hovi, M. and Baars, T., eds. (2001a). Network of Animal Health and Welfare in Organic Agriculture. Wageningen, NL. http://www.orgprints.org/00000953

Huber, H.U. (1987). Untersuchungen zum Einfluss von Tages- und Kunstlicht auf das Verhalten von Hühnern. Ph.D. Thesis, ETH Zurich. In: Zeltner, E., Hirt, H. and Hauser, J. eds. How to Motivate Laying Hens to Use the Hen Run. Proceedings of the 2nd SAFO Workshop, Witzenhausen, Germany.

Huber-Eicher, B. and Wechsler B. (1998). The effect of foraging material and perch height on feather pecking and feather damage in laying hens. Applied Animal Behaviour Science. 58: pp. 131-141.

Huber-Eicher, B. and Wechsler, B. (1997). Feather pecking domestic chicks: Its relation to dustbathing and foraging. Animal Behaviour. 54: pp. 757-767.

Hughes, B.O. and Duncan, I.J.H. (1972). The influence of strain and environmental factors upon feather pecking and cannibalism in fowls. British Poultry Science, 13.

Idris, A.B. and Grafius, E. (1995). Wildflowers as nectar sources for *Diadegma insulare* (Hymenoptera: Ichneumonidae), parasitoid of diamondback moth (Lepidoptera: Yponomeutidae). Environmental Entomology. 24: pp. 1726-1735.

IFOAM (2000). Basic Standard for Organic Production and Processing. Decided by the IFOAM General Assembly in Basel, Switzerland. September 2000, Tholey-Theley. Available at: http://www.ifoam.org/standard/index_neu.html.

IIED (1997). Changing Consumption and Production Patterns: Unlocking Trade Opportunities. (International Institute for Environment and Development). In: Nick Robins and Sarah Roberts eds. United Nations Department of Policy Co-ordination and Sustainable Development. United Nations, New York, USA.

ILCA (1979b). Trypanotolerant livestock in West and Central Africa Vol. 2: Country Studies. International Livestock Centre for Africa (ILCA) Mono. No 2. Addis Ababa, Ethiopia. ILCA.

ILCA/FAO/UNEP (1979). Trypanotolerant livestock in West and Central Africa. Volume 1. General Study, Volume 2: Country Studies. ILCA Monograph 2, CA, Addis Ababa, Ethiopia

Ingham, R. (1993). Report to the Oregon Potato Commission. Dept. of Botany and Plant Pathology, Oregon State Univ., Corvallis, OR

Ivey P.W. and Johnson S.J. (1998). Integrating control tactics for managing cabbage looper (Lepidoptera: Noctuidae) and diamondback moth (Lepidoptera: Yponomeutidae) on cabbage. Tropical Agriculture. 75: pp. 369-374.

Jensen, U.B., Elmholt, S. and Labouriau, R. (2000). Distribution of Ergosterol in organically and conventionally cultivated agricultural soils. Biological Agriculture and Horticulture. 18: pp. 113-125.

Jersey, R.L.M. (1992). U.K. Resource Inventory and Management: Nigerian livestock resources. 1-4.

Jeune Afrique (1973). The atlas of Africa. In: J.E.O. Rege, G.S. Aboagye and C.L. Tawah eds. Shorthorn Cattle of West and Central Africa IV. Production Characteristics. Published by FAO, Rome.

Joergensen, R.G. (1995). The fumigation extraction method. In: Alef, K. and Nannipieri, P. eds. Methods in Applied Soil Microbiology and Biochemistry. Academic Press, London.

Joergensen, R.G. (1996a). The fumigation-extraction method to estimate soil microbial biomass: calibration of the KEC factor. Soil Biol Biochem. 28: 25-31.

Joergensen, R.G. and Mueller, T. (1996). The fumigation-extraction method to estimate soil microbial biomass: calibration of the KEN value. Soil Biol. Biochem. 28: pp. 33-37.

Jones, L.H.P. and Jarvis, S.C. (1981). The fate of heavy metals. In: D.J. Greenland and M.H.B. Hayes, eds. The Chemistry of Soil Processes, Chichester, New York, USA.

July, R. (1975). Pre-Colonial Africa. In: Kajoba, G.M. Land Use and Land Tenure in Africa: towards an evolutionary conceptual framework. Assessed on the 4th August 2006 at: http://www.codesria.org/Links/conferences/ifs/Kajoba.pdf.

Kappen, L., Friedmann, E. I. and Garty, J. (1981). Ecophysiology of lichens in the dry valleys of southern Victoria Land, Antarctica. In: Hall and Otte, (Ed.). Biological Weathering on Nunataks of the Juneau Icefield, Alaska. Microclimate of the cryptoendolithic lichen habitat. Flora, 171, pp. 216-235.

Karaban, R. and Kuc', J. (1999). Induced resistance against pathogens and herbivores: an overview. In: Agrawal, A.A., Tuzun, S. and Bent, E. eds. Induced Plant Defences Against Pathogens and Herbivores; Biochemistry, Ecology, and Agriculture. The American Phytopathological Society Press, St. Paul., USA.

Kawerau, J.G. (2005). Aubergine Eggplant Cultivation and Growing. Accessed on the 11th July 2006 on: http://www.turkishlanguage.co.uk/aub.htm

Kennedy, G.G. and Storer, N.P. (2000). Life systems of polyphagous arthropod pest in temporally unstable cropping systems. Annual Review of Entomology 45: pp. 467-493.

Kent, R., Johnson, D.E. and Becker, M. (2001). The influences of cropping system on weed communities of rice in Côte d'Ivoire, West Africa: Agriculture, Ecosystems and Environment. 87.

Khan, M.U., Qasim, M., Jamil, M. and Pakistan, I.K. (2002). Effects of Different Levels of Zinc on the Extractable Zinc Content of Soil and Chemical Composition of Rice, Faculty of Agriculture, Gomal University, Pakistan.

Kim, C.K. and Curry, J. (1993). Paradigm, flexible specialization and agricultural industrial restructuring: The case of the US broiler industry. Sociologia Ruralis 33(1): pp. 61.

King, E.G., Hopper, K.R. and Powell, J.E. (1985). Analysis of systems for biological control of crop arthropod pests in the U.S. by augmentation of predators and parasites. In: Hoy, M.A. and Herzog, D.C. eds. Biological Control in Agricultural IPM Systems. Academic Press, London. pp. 201-227.

Klasing, K.C. (1998). Nutritional modulation of resistance to infectious diseases. Poultry Science. 77.

Koning, R.E. (1994). Flower Structure. Plant Physiology Information Website. http://www.plantphys.info/plants_human/flowerstructure.html

Köpke, U. (1999). Review of crop production and weed control: state of the arts and outlook. In: Isart, J and Llerena, J.J., eds. Organic Farming Research in the EU, Towards 21st Century. ENOF White Book. European Network for Scientific Research Co-ordination in Organic Farming (ENOF), Barcelona.

Kortbech-Olesen, R. (2001). World Markets for Organic Fruit and Vegetables: opportunities for developing countries in the production and export of organic horticultural products. FAO, Rome.

Kortbech-Olesen, R. (2002). Market opportunities for organic products in Europe and North America. United Nations Conference on Trade and Development, Italy 2002. Accessed on the 11th July 2006. (http://www.intracen.org/mds/sectors/organic/sana.htm)

Kotschi, J. (1985). Möglichkeiten für eine ökologische Agrarproduktion in der Dritten Welt. In: Vogtmann, H. ed. Oekologischer Landbau – Landwirtschaft mit Zukunft. Stuttgart.

Kotschi, J. ed. (1986). Control of desertification in African drylands problems, experiences, guidelines. Sonderpublikation der GTZ 168, published jointly by the Commission of the European Communities (CEC) and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) Eschborn 1986.

Kristiansen, P.E. (2003). Sustainable Weed Management in Organic Herb and Vegetable Production: PhD thesis, University of New England. Deposited in organic eprints. Can be accessed at. http://www.orgprints.org/4829/01/4829.pdf.

Krul, J.M., Penning de Vries, F.W.T. and Traoré, F. (1982). Le processus du bilan d'azote. In: Penning de Vries, F.W.T., Djitèye, M.A. (eds.), La productivité des pâturages sahéliens. Une etude des sols, des végétations et de l'exploitation de cette ressource naturelle. Pudoc, Wageningen, The Netherlands.

Kuepper, G. and Born, H. (1999). Organic Tomato Production. NCAT Agriculture Specialists. Online publication by ATTRA–National Sustainable Agriculture Information Service. http://www.attra.org/attra-pub/tomato.html#4.

Kurklü, A. (1990) Greenhouse heating systems and comparison with the ones used in greenhouses in Antalya. MSc Thesis. University of Çukurova, Adana, Turkey, p. 74.

Kurklu, A. (1995) Effects of Temperature and Time of Harvest on the Growth and Yield of Aubergine (*Solanum melongena* L.). Tr. J. of Agriculture and Forestry 22

Ladd, J.N., Amato, M., Zhou, L.K. and Schultz J.E. (1994). Differential effects of rotation, plant residue and nitrogen fertilizer on microbial biomass and organic matter in an Australian Alfisol. Soil Biology and Biochemistry. 26: 821-831.

Lampkin, N. (1997). Organic Poultry Production. Welsh Institute of Rural Studies. The University of Wales, Aberystwyth, UK.

Landis, D.A., Wratten S.D. and Gurr, G.M. (2000). Habitat management to conserve natural enemies of arthropod pests in agriculture. Annual Review of Entomology. 45: 175-201.

Lardner, K.S. (2004). Doing things right-Bird Welfare. University of Saskatchewa. Accessed on the 17th July 2006 at: http://www.poultryworkshop.com/Presentations/Karen%20Schwean%20Lardner/Bird%20Welfare.pdf.

Lawton, K., Friedrich, L., Hunt, M., Weymann K., Delaney, T., Kessmann, H., Staub, T. and Ryals, J. (1996). Benzothiadiazole induces disease resistance in Arabidopsis by activation of the systemic acquired resistance signal transduction pathway. Plant J. 10.

Lee, L-W. and Shin, J-H.(1998). Optimal Irrigation Management System of Greenhouse Tomato based on Stem Diameter and Transpiration Monitoring. Available at http://www.jsai.or.jp/afita/afita-conf/1998/P29.pdf

Leeson, S. (2001). Feeding Programmes for Laying Hens. Published American Soybean Association Bulletin PO49. Available at: http://www.asasea.com/graphics/pdfs/PO49 Leeson.pdf.

Lim, G.S. (1986). Biological control of diamondback moth. In: Talekar, N.S. and Griggs, T.D. eds. Diamondback Moth Management. Proceedings 1st International Workshop, Shanhua, Taiwan. Asian Vegetable Research and Development Center. pp. 159-171.

Liu, S., Carlson, G.A. and Hoag, D.L. (1995). Trade-off analysis of herbicide withdrawals on agricultural production and groundwater quality. Journal of Agricultural and Applied Economics. 27: 283.

Livingstone. D.A. (1975). Late Quaternary Climatic Change in Africa: Department of Zoology, Duke University. Durham, North Carolina 27706.

Lockeretz, W. and Lund, V. (2003). Socio-economic aspects of animal health and food safety in organic farming. Proceedings of the 1st SAFO Workshop. 5-7 September 2003, Florence. Italy. pp. 201-210. Online publication by the organic eprints.

Loomis, R.S. and Connor, D.J. (1992). Crop Ecology. Productivity and Management in Agricultural Systems. Cambridge Univ. Press, Cambridge, UK

Lopez-Bote, C.J., Sanz, A.R., Castano, A., Isabel, B. and Thos, J. (1998). Effect of free-range feeding on n-3 fatty acid and δ-tocopherol content and oxidative stability of eggs. In: Zeltner, E., Hirt, H. and Hauser, J. How to motivate laying hens to use the hen run. Proceedings of the 2nd SAFO Workshop, Witzenhausen, Germany. Animal Feed Science and Technology 72: pp. 33-40.

Lovins, A. (1976). Exploring energy-efficient futures for Canada. Conserver Soc. Notes. 1 (4): pp. 5-16.

Lyman and Herdt (1989). Concepts and Issues of Sustainability in Countries in Transition – An Institutional Concept of Sustainability as a Basis for the Network (quoted by Lutteken, A. and Hagedorn, K.). Humboldt University of Berlin, Germany

Lyon, G.D. and Newton, A.C. (2005). Induced plant disease resistance. Available at: http://www.scri.sari.ac.uk/SCRI/web/site/home/ResearchAreas/TopicsinPlantPathology/ResistanceElicitors/elicitors.asp accessed on 10.06.2005.

M.H.B., eds. The Chemistry of Soil Processes. Chichester, New York.

Mäder, P., Edenhofer, S., Boller, T., Wiemken, A. and Niggli, U. (2000). Arbuscular mycorrhizae in a long-term field trial comparing low-input (organic, biological) and high-input (conventional) farming systems in a crop rotation. Biol. Fertil. Soils. 31: 150-156

Mangan, F.X., Herbert, S.J. and Litchfield, G.L. (1991). Cover crop management systems for broccoli. In: W.L. Hargrove, ed. Cover Crops for Clean Water. Soil and Water Conservation Society, Ankeny, IA. 178-179.

Maqsood, M., Irshad, M., Wajid, S.A. and Hussain, A. (1999). Growth and yield response of Basmati-385 to $ZnSO_4$ application. Pak. J. Bio. Sci., 2.

Marsh, J.S. (1997). The policy approach to sustainable farming systems in the EU: Centre for Agricultural Strategy, The University of Reading, Reading, UK.

Martin, J.H. et al. (1994). Testing the iron hypothesis in ecosystems of the equatorial Pacific Ocean. Nature. 371.

Martinez, G.M. and Banados, F. (2004). Impact of EU organic product certification legislation on Chile organic exports: Department of Agricultural Sciences, Centre for Food Chain Research. Imperial College London. Wye, Ashford, Kent TN25 5AH, UK. Food Policy. 29.

Matthews, B. (2003). USDA ARS, SGIL. http://www.bldg6.arsusda.gov/benlab/Soybean%20Defense%20Response/oxidative_burst1.htm accessed on 14.06.2005.

Maule, J.P. (1990). The cattle of the tropics. Centre for Tropical Vet. Med., University of Edinburgh, Edinburgh, UK.

May, R.M. (1977). Food lost to pests. In: Hill S.B., ed. Agricultural Chemicals and the Soil. Ecological Agriculture Project. Nature. 267 (5613): 669-670

McCauley, A., Jones, C. and Jacobson, J. (2003). Soil pH and organic matter. Sourced from www.agronomy.org/cca/exam_pdf/ss01260.pdf (on 12/03/04).

Medawar, P. (1969). Induction and Intuition in Scientific Thought. Methuen, Lond. 62.

Medina, E. and Cuevas, E. (1989). Patterns of nutrient accumulation and release in Amazonian forests of the upper Rio Negro Basin. In: Matson, P.A., McDowell, W.H., Townsend, A.R. and Vitousek, P.M. eds. The globalization of N deposition: ecosystem consequences in tropical environments. Kluwer Academic Publishers. Netherlands. Biogeochemistry 46.

Melander, B. (1998). Economic aspects of physical intra-row weed control in seeded onions. In: Foguelman, D. and Lockeretz, W., eds. Organic Agriculture - the Credible Solution for the 21st Century. Proceedings of the 12th International IFOAM Scientific Conference. International Federation of Organic Agriculture Movements, Mar del Plata, Argentina.

Melander, B. (1998). Interactions between soil cultivation in darkness, flaming and brush weeding when used for in-row weed control in vegetables. Biological Agriculture and Horticulture. 16 (1): 1-14.

Mellor, E. (1922). Vitricolous lichens and the deterioration of church windows. In Hall and Otte (Ed.). Biological Weathering on Nunataks of the Juneau Icefield, Alaska. Permafrost and Periglacial Processes, Vol 1: p 190

Michelsen, J., Hamm, U., Wynen, E. and Roth, E. (1999). The European market for organic products: growth and development. Organic farming in Europe: Universitat Hohenheim, Germany. Economics and Policy. 7

Mkize, N. and Villet, M.H. (2001). Seasonal rates of parasitism of diamondback moth (*Plutella xylostella*) in subsistence cabbage crops in the Eastern Cape, South Africa. Department of Zoology and Entomology. Rhodes University, Grahamstown.

Mohr, E.C.J., van Baren, F.A. and van Schuylenborgh, J. (1972). Tropical Soils: Comprehensive Study of Their Genesis. 3rd ed. 481.

Montsma, G. (1960). Observations of milk yield and calf growth and conversion rate on three types of cattle in Ghana. Trop. Agric. (Trinidad). 37.

Moore, N. (1967). A synopsis of the pesticide problem. Adv. Ecol. Res. 4: 75-129.

Moroney, M. (2003). Farm mechanisation strategies change more machine challenges. http://www.farmersjournal.ie/indsup2003/machinery.pdf.

Moroney, M. (2003). Farm mechanisation strategies change more machine challenges: Agriculture New challenges, new opportunities, Ireland

Mostaghimi, S., McClellan, P.W. and Cooke, R.A. (1993). Pesticide contamination of groundwater in Virginia: BMP impact assessment. Water Science Technology 28: 79.

Mueller-Harvey, I., Juo, A.S.R. and Wild, A. (1985). Soil organic carbon, nitrogen, sulphur and phosphorus after forest clearance in Nigeria: mineralization rates and spatial variability. Journal of Soil Science.36(4). ISSN: 0022-4588.

Murwira, K.H., Swift, M.J. and Frost, P.G.H. (1995). Manure as a key resource in sustainable agriculture. In: Powell, J.M., Fernandez-Rivera, S., Williams, T.O. and Renard, C. eds. Livestock and Sustainable Nutrient Cycling. 211-226.

Narendra, P.S., Reitbergen, S., Heimo, R.C. and Patel, J. (1994). A Strategy for the Forest Sector in Sub-Saharan Africa. Technical Paper No. 251. Africa Technical Department Series, Washington, D.C. World Bank.

Naylor, R.L. (1996). Energy and resource constraints on intensive agricultural production. Annu. Rev. Energy Environment. 21.

Naylor, R.L. and Ehrlich, P.R. (1997). The value of natural pest control services in agriculture. In: Daily, G. ed. The Value of Ecosystem Services, Island. New York.

Needham, J. (1932). Thoughts on the problem of biological organization. Scientia (Milan). 52: 84-92.

Ngere, L.O. (1974). Crossbreeding for beef in Ghana and Nigeria. In: Proc. First World Congress on Genetics and Applied Livestock Production. Madrid, Spain.

Ngere, L.O., Hagan, R., Oppong, E.N.W. and Lossli, J.K. (1975). Milking potential of the West African Shorthorn cow. J. Agric. Sci. (Ghana) 8: 31-35.

Nilsson, U., Lundqvist, P. and Martensson, L. (2000). Organic farming and working conditions. In: Alföldi, T., Lockeretz, W. and Niggli, U., eds. IFOAM 2000—The World Grows Organic. Proceedings of the 13th International IFOAM Scientific Conference. Convention Centre Basel, Switzerland 28 to 31 August 2000. pdf Hochschulverlag AG an der ETH Zurich, Basel.

Oberson, A., Oehl, F., Langmeier, M., Fliessbach, A., Dubois, D., Mader, P., Besson, J.M. and Frossard, E. (2000). Can increased microbial activity help to sustain phosphorous availability? In: Alföldi, T., Lockeretz, W. and Niggli, U. eds. Proceedings of 13th International IFOAM Scientific Conference. pdf Hochschulverlag, Zürich. 27.

Olutogun, S. (1976). Reproductive performance and growth of N'Dama and Keteku cattle under ranching conditions in the Guinea savanna of Nigeria. Dept. Anim. Sci., Univ. of Ibadan, Nigeria. (Ph.D. thesis).

Omay, A.B., Rice C., W., Maddox L.D. and Gordon W.B. (1997). Changes in soil microbial and chemical properties under long term crop rotation and fertilisation. Soil Sci. Soc. Am. J., 61. 1672-1678.

Palm, C.A., Gachengo, C.N., Delve, R.J., Cadisch G. and Giller, K.E. (2001). Organic inputs for soil fertility management in tropical agroecosystems: application of an organic resource database. Agriculture, Ecosystems and Environment. 83.

Palmer, R.J. (1989). Microbial weathering of building stone. Abstracts; Biological Conference, Moscow, 152.

Parella, M.P., Heinz, K.M. and Nunney, L. (1992). Biological control through augmentative releases of natural enemies: a strategy whose time has come. American Entomologist. 38.

Patriquin, D.G., Blaikie, H., Patriquin, M.J. and Yang C. (1993). Farm measurements of pH, electrical conductivity and nitrate in soil extracts for monitoring coupling and decoupling of nutrient cycles. Biological Agriculture and Horticulture. 9: 231-272.

Pearce, D.W., Atkinson, G.D. and Dubourg, W.R. (1994). The Economics of Sustainable Development. Centre for Social and Economic Research on the Global Environment (CSERGE), University College, London, Gower Street, London WC1E 6BT, UK.

Pierce, J.T. (1990). The Food Ressource. Longman Publishing, New York.

Pieterse, C.M.J., van Wees, S.C.M., Johan A. van Pelt, J.A., Marga Knoester, M., Laan, R., Gerrits, H., Weisbeek, P.J. and van Loon L.C. (1998). A novel signaling pathway controlling induced systemic resistance in Arabidopsis. Plant Cell. 10: 1571-1580.

Pimentel, D. and Greiner, A. (1997). Environmental and socioeconomic costs of pesticide use. In: Pimentel, D. ed. Techniques for Reducing Pesticide Use: Economic and Environmental Benefits. John Wiley and Sons, Chichester. 51–78.

Pimentel, D., Acquay, H., Biltonen, M., Rice, P., Silva, M., Nelson, J., Lipner, V., Giordano, S., Horowitz, A. and D'Amore, M. (1992). Environmental and human costs of pesticide use. Bioscience. 42: 750-760.

Plucknett, D.L. (1994). Sources of the next century's new technology. In: Anderson, J.R. ed. Agricultural Technology: Policy Issues for the International Community. CAB Int. Wallingford, UK.

Plunknett, D.L. (1995). Prospects of meeting future food needs through new technology. In: Naylor, R.L. (1996). Energy and Resource Constraints on Intensive Agricultural Production. Annual Review of Energy and the Environment. 21

Porter, P.M., Huggins, D.R., Perillo, C.A., Quiring, S.R. and Crookston, R.K. (2003). Organic and other management strategies with two- and four-year crop rotations in Minnesota. Agronomy Journal. 95(2).

Powell, J.M. and Williams, T.O. (1993). Livestock, nutrient cycling and sustainable agriculture in the West African Sahel. Gatekeeper Series SA37. International Institute for Environment and Development (IIED), London. 15

Powell, W., (1986). Enhancing parasitoid activity in crops. In: Waage, J., Greathead, D. (Eds.), Proceedings of the 13th Symposium of the Royal Entomological Society of London on Insect Parasitoids. Academic Press, London. Pp. 319-339.

Pritchard, J.M. (1979). Africa: A Study Geography for Advanced Students. Longman Group. Revised 3rd. edn, UK.

Rao, N. (2003). Economic Efficiency and Farm Mechanisation. New Delhi, Serials Pub.ISBN 81-86771-25-5.

Redclift, M. (1987). Sustainable Development: Exploring the Contradictions. Published by Routledge, London: ISBN: 0415050855

Redclift, M. (1994). Reflections on the 'sustainable development' debate. Int. J. Sustainable Dev. World Ecology.

Rees, R.M. (1989). Measurement of nitrogen mineralisation in soil incubations. In. Hansen, J.A. and Henriksen, K., eds. Nitrogen in Organic Wastes Applied to Soils. Academic Press, London. 11-24.

Reganold, J., Elliott, L. and Unger, Y. (1987). Long-term effects of organic and conventional farming on soil erosion. Nature. 330: 370-372.

Ridgway, R.L. and Vinson, S.B. (1977). Biological Control by Augmentation of Natural Enemies. Plenum Press, New York.

Ritter, M. (2003). Factors Affecting Soil Development. http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/soil_systems/soil_development_soil_forming_factors.html - 15k.

Ritter, W.F. (1990). Pesticide contamination of ground water in the United States: a review. Journal of Environmental Science and Health. 25.

Robins, N., Roberts, S. and Abbot, J. (2000). Who Benefits? A Social Assessment of Environmentally Driven Trade. IIED, London.

Roland, D.A. Sr. (1988). Eggshell problems. Estimates of incidence and economic impact. Poultry Science. 67: 1801-1803.

Romheld, V. and Marschner, H. (1991). Genotypical differences among Gramineae species in release of phytosiderophores and uptake of iron phytosiderophores. J. Plant and Soil. 123.

Rosenzweig, C. and Liverman, D. (1992). Predicted effects of climate change on agriculture: A comparison of temperate and tropical regions. In. Majumdar, S.K. ed. Global Climate Change: Implications, challenges, and mitigation measures. The Pennsylvania Academy of Sciences. 342-61.

Ross, D.J.K., Tate, R., Cairns, A., Mayrhofer, K.F., and Pursie, E.A. (1982). Restoration of pasture after topsoil removal: effect of soil carbon and nitrogen mineralization, microbial biomass and enzyme activities. Soil Biology & Biochemistry. 14.

Ross, S.D. (1944). Nigerian cattle types. In. Rege, J.E.O., Aboagye G.S. and Tawah, C.L., eds. Shorthorn Cattle of West and Central Africa IV. Production Characteristics. Farm Forest (Nigeria). FOA.

Rothrock, C.S. and Kendig, S.R. (1991). Suppression of black root rot on cotton by winter legume cover crops. In: Hargrove, W.L. ed. Cover crops for clean water. Soil and Water Conservation Society. Ankeny, Iowa. 155-156.

Rouse, J.E. (1970). World Cattle. II: Cattle of Africa and Asia. University of Oklahoma Press. Oklahoma City, OK, USA.

Roy, R.N., Misra, R.V., Lesschen, J.P. and Smaling, E.M. (2003). Assessment of soil nutrient balance: FAO Land and Water Development, Division Rome. FAO Consultant, Wageningen University, The Netherland: FAO bulletin 14 (2003).

Ruttan, V.W. (1992). Sustainable growth in agricultural production: into the 21st century, Choices. 7.

Ryan, M. (1999). Is an enhanced soil biological community, relative to conventional neighbours, a consistent feature of alternative (organic or biodynamic) agricultural systems. Biological Agriculture and Horticulture. 17: 131-144.

Sanders, D.C. (1999). North Carolina Commercial Vegetable Recommendations. North Carolina Cooperative Extension Service. Raleigh, NC. 5-6

Sanders, D.C. (2001). Fresh Market Tomato Production. Extension Horticultural Specialist Department of Horticultural Science College of Agriculture and Life Sciences North Carolina State University

Sangakkara, U.R. (1996). Management of organic matter and nutrient turnover for increased sustainable tropical agricultural production and environmental preservation. Second Research Co-ordination Meeting of the FAO/IAEA Cordinated Research Project.

Schlosser, E. (2001). Fast Food Nation. Houghton Mifflin. Boston

Schmidt, H.R. and Becker, S.J.A. (1999). The role of salicylic acid in disease resistance. In: Agrawal, A.A., Tuzun, A. and Bent, E., eds. Induced Plant Defences against Pathogens and Herbivores: Biochemistry, Ecology, and Agriculture. The American Phytopathological Society Press, St. Paul. MN. USA.

Schonbeck, M.W. and Evanylo, G.K. (1998). Effects of mulches on soil properties and tomato production. I. Soil temperature, soil moisture and marketable yield. Journal of Sustainable Agriculture. 13(1): 55-81.

Scialabba, N. (2000). Opportunities and constraints of organic agriculture. A socio-ecological analysis. FAO/World Agricultural Information Centre. Accessed on July 12th 2006 at: http://www.fao.org/organicag/doc/SOCRATES1999.htm.

Scoones, I. and Toulmin, C. (1998). Soil nutrient balances: what use for policy? Ag. Ecosys. Env. 71: 255-267.

Sequeira, L. (1983). Mechanism of induced resistance in plants. Annual Review Microbiology. 37: 51-79.

Sharma, K. (2005). Induced plant disease resistance: An alternative method of controlling plant diseases. Working paper, Department of Plant Protection, University of Kassel, Witzenhausen (unpublished article).

Shelton, A.M., Perez, C.J., Tang, J.D. and Vandenberg, J.D. (1996). Prospects for novel approaches towards management of the diamondback moth. In: Sivapragasam, A., Loke, W.H., Husson, A.K. and Lim, G.S. eds. The management of diamondback moth and other crucifer pests. Proceedings 3rd International Workshop. Malaysian Agricultural Research and Development Institute. Kuala Lumpur, Malaysia. 17-19.

Shumway, C.R. and Chesser, R.R. (1994). Pesticide tax, cropping patterns, and water quality in south central Texas. Journal of Agricultural and Applied Economics. 26: 224.

Sikora, L.J. and Yakovchenko, V. (1996). Soil organic matter mineralization after compost amendment. Soil Science Society of America journal.

Sivapalan, A., Morgan, W.C. and Franz, P.R. (1993). Monitoring populations of soil microorganisms during a conversion from a conventional to an organic system of vegetable growing. Biological Agriculture and Horticulture. 10: 9-27

Skinner, E.P. (1964). The Mossi of Upper Volta: The Political Development of a Sudanese People. Stanford University Press.

Skinner, J.A., Lewis, K.A., Bardon, K.S., Tucker, P., Catt, J.A. and Chambers, B.J. (1997). An overview of the environmental impact of agriculture in the UK. Journal of Environmental Management. 50.

Smil, V. (1994). How many people can the earth feed? Population Development, Rev. 20.

Smith, J.L., Papendick, R.I., Bezdicek, D.F. and Lynch, J.M. (1993). Soil organic matter dynamics and crop residue management. In: Metting, B. ed. Soil Microbial Ecology. Marcel Dekker, New York.

Smith, L.C. (1998). Can FAO measure of Chronic Undernourishment be Strengthened? Food Consumption and Nutrition Divison. FCND Discussion paper No. 44.

Smith, S. and Read, D. (1997). Mycorrhizal Symbiosis. 2nd edn., London. Soil Science Department, North Carolina State University.

Sparling, G.P., Ord, B.G. and Vaughan, D. (1981). Microbial biomass and activity in soils amended with glucose. Soil Biology & Biochemistry. 16.

Stanford, G. and Smith, S.J. (1972). Nitrogen mineralisation potentials of soils. Soil Sci. Soc. Amer. Proc. sourced in March 2005 from http://www.iaea.org/programmes/nafa/d1/crp/isotope-crp-second.pdf. 36: 465-72.

Staswick, P.E. and Lehman, C.C. (1999). Jasmonic acid signalled responses in plant. In: Agrawal, A.A., Tuzun, S. and Bent, E. eds. Induced Plant Defenses against Pathogens and Herbivores: Biochemistry, Ecology, and Agriculture. The American Phytopathological Society Press. 117-131.

Stevenson, F.J. (1986). Cycles of Soil. Wiley J. and Sons. New York. 380.

Stinner, R.E. (1977). Efficacy of inundative releases. Annual Review of Entomology. 22.

Stolze, M., Piorr, A., Haring, A. and Dabbert, S. (2000). The environmental impacts of organic farming in Europe. Organic farming in Europe, University of Stuttgart-Hohenheim, Germany. 6.

Stonehouse, D.P., Weise, S.F., Sheardown, T., Gill, R.S. and Swanton, C.J. (1996). A case study approach to comparing weed management strategies under alternative farming systems in Ontario. Canadian Journal of Agricultural Economics 44(1): 81-99.

Stoorvogel, J.J. and Smaling, E.M.A. (1990). Assessment of soil nutrient depletion in sub-Saharan Africa: 1983-2000. Main Report. DLO-Winand Staring Centre, Wageningen, The Netherlands. 1: 137.

Suchner, U., Kuhn, K.S. and Furst, P. (2000). Clinical Nutrition and Metabolism Group Symposium on Nutrition in the severely-injured patient. Proceedings of the Nutrition Society (2000). 59: 553-563.

Sullivan, P. (2003). Overview of Cover Crops and Green Manures—Fundamentals of Sustainable Agriculture. ATTRA Publication with ref. No. #IP024.

Sullivan, P.G., Parrish, D.J. and Luna, J.M. (1991). Cover crop contributions to N supply and water conservation in corn production. Amer. J. Alternative Agriculture. 6: 106-115.

Tabler, G.T. (2005). Broiler Production Management. Department of Poultry Science, University of Arkansas, Fayetteville, Arkansas 72701, USA.

Tadelle, D. (1996). Studies on village poultry production systems in the central Highlands of Ethiopia. MSc. Thesis, Swedish University of Agricultural Sciences.

Talekar, N.S. (1996). Biological control of diamondback moth in Taiwan - a review. Plant Protection Bulletin 38: 167-189.

Talekar, N.S. and Shelton, A.M. (1993). Biology, ecology and management of the diamondback moth. Annual Review of Entomology. 38: 275-301.

Thaler, S. J. (1999). Jasmonic acid mediated interactions between plants, herbivores, parasitoids, and pathogens: A review of field experiments in tomato. In: Agrawal, A.A., Karban, R. and Colfer, G.R., eds. How Leaf Domatia and Induced Plant Resistance Affect Herbivores, Natural Enemies and Plant Performance. OIKOS 89: 70–80. Copenhagen 2000. 319-331.

Thompson, L.M. (1975). Weather variability, climate change and food production. In: Rosenzweig, C. and Liverman, D., eds. Predicted Effects of Climate Change on Agriculture: A Comparison of Temperate and Tropical Regions.

Thompson, L.M. (1975). Weather variability, climatic change and grain production. In: Rosenzweig, C. and D. Liverman. 1992. Predicted Effects of Climate Change on Agriculture: A comparison of temperate and tropical regions. In: Global climate change: Implications, challenges, and mitigation measures.

Thornbury, W.D. (1969) Weathering, Erosion, and Mass Movement. Available at: http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/mass_movement_weathering/chemical_weathering.html.

Thorup-Kristensen, K. (2002). Utilising Differences in Rooting Depth to Design Vegetable Crop Rotations with High Nitrogen Use Efficiency. Proceedings of the Workshop Eco. Fertilization Veg. Booij R. and Neeteson J., eds. Acta Hort. 571, ISHS 2002.

Tiessen, H., Salcedo, L. H. and Sampaio, E.V.S.B. (1992). Nutrient and soil organic matter dynamics under shifting cultivation in semi-arid northeastern Brazil. Agriculture, Ecosystems and Environment. 38(3).

Tisdale, S.L., Nelson, W.L., Beaton, D.L. and Havlin, J.L. (1993). Soil Fertility and Fertilizers. 5th ed. Macmillan Pub. Company, New York, USA.

Toor, R.K. and Savage, G.P. (2006). Effect of semi-drying on the antioxidant components of tomatoes: Food Chemistry. 94.

Toulmin, C. and Pepper, S. (2000). Land Reform North and South. Assessed July 5th 2006 (http://www.caledonia.org.uk/land/n&s.htm).

Turenne, J.T. (2001) Factors of soil formation. http://www.nesoil.com/plymouth/formation.html.

Twance, C. (1985). A Guide to Poultry Management. The Crowood Press Limited, Ramsbury, Marlborough, Wiltshire UK.

Ulrich, H. and Friederike, G. (2004). Analysis of the European Market for Organic Food 2008. Published by School of Management and Business, Cledwyn Building, University of Wales, UK.

USDA Forest Service (1999). Propagation Techniques: Agriculture Handbook. 674.

Vaarst, M. and Hovi, M. (2004). Organic livestock production and food quality: a review of current status and future challenges. Proceedings of the 2nd SAFO Workshop, Witzenhausen, Germany. Online publication by the organic prints.

Van Engelen, V. (1993). Global and national soils and terrain digital databases (SOTER). Procedures manual. ISRIC. Wageningen

Van Loon, L.C., Bakker, P.A.H.M. and Pieterse, C.M.J. (1998). Systemic resistance induced by rhizosphere bacteria. Annual Review of Phytopathology. 36: 453-483.

Vance, E.D., Brookes, P.C., and Jenkinson, D.S. (1987). An extraction method for measuring soil microbial biomass C. Soil Biol. Biochem. 19: 703-707.

Varvel, G.E. (1994). Rotation and nitrogen fertilisation effects on changes in soil carbon and nitrogen. Agronomy Journal. 86: 319-325.

Viandes, M.H.R. (1999). History of organic farming. In. Stoll. G., ed. The Role of Agriculture and Rural Development in Asia. Regional Overview. Asia and the International Context Available at: http://www.unescap.org/rural/doc/OA/Asia.PDF

Vinten, A.J., Whitmore, A., Bloem, J., Howard, R. and Wright F. (2002). Factors affecting N mobilisation/mineralisation kinetics for cellulose-glucose and straw amended sandy soil. ISBN 0178-2762. Biol. Fertil. Soil. 36: 190

Waterer, D. (2005). Carrots production. University of Saskatchewan – Plant Science Department. http://www.agr.gov.sk.ca/docs/crops/horticulture/carrots01.asp - 33k.

Weetman, G. and Hill, S.B. (1973). General environmental and biological concerns in relation to forest fertilization. Pp. 19-35. Leaflet in Forest Fertilization, Symposium Proceedings. USDA. For. Serv. Gen. Tech. Rep. NE-3. Accessible at: http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/scanned/gtr3.pdf

Weetman, G., Knowles, R. and Hill, S.B. (1972). Effects of different forms of nitrogen fertilizer on nutrient uptake by Black spruce and its humus and humus mesofauna. Pulp. Pap. Res. Inst. Can. Woodl. Rep. 39.

Went, F.W. and Sheps, L.O. (1969). Environmental factors in regulation of growth and development: ecological factors. In: F.C. Steward, ed. Plant Physiology: A Treatise. Academic Press, New York. (5A): 299-419.

West, A.W., Grant, W.D. and Sparling, G.P. (1967). Use of ergosterol, diaminopimelic acid and glucosamine contents of soil to monitor changes in microbial populations. Soil Biology and Biochemistry. 19: 607-612

Whiteside, T. (1977). The pendulum and the toxic cloud. The New Yorker. July 25. 30-55

Whittaker, G., Lin, B. and Vasavada, U. (1995). Restricting pesticide use: the impact on profitability by farm size. Journal of Agricultural and Applied Economics. 27: 352-362

Wichern, F., Lobe, I., Amelung, W., Muller, T., Joergensen, R.G. and Buerkert, A. (2004). Changes in amino acid enantiomers and microbial performance in soils from subtropical mountain in Oman abandoned for different periods. Biology and Fertility of Soils. 39: 398-406.

Wichern, F., Richter, C. and Joergensen, R.G. (2003). Soil fertility breakdown in a subtropical South African vertisol site used as a home garden. Biology and Fertility of Soils. 37: 288-294

Willer, H. and Yussefi, M. (2000). Organic Agriculture Worldwide. Stiftung Okologie and Landbau, Bad Durkheim, Germany.

Williams, R.J.P. and Frausto da Silva, J.J.R. (2002). The Involvement of Molybdenum in Life, Inorganic Chemistry Laboratory, University of Oxford, Oxford, UK; and Department of Chemistry, Instituto Superior Técnico, Lisbon, Portugal.

World Meteorological Organization. 1979. Proceedings of the World Climate Conference. WMO, Geneva. In: Rosenzweig, C. and D. Liverman, eds. Predicted effects of climate change on agriculture: A comparison of temperate and tropical regions. In. Global climate change. Implications, challenges, and mitigation measures.

Wu, J., Joergensen, R.G., Pommerening, B., Chaussod, R. and Brookes, P.C. (1990). Measurement of soil microbial biomass C by fumigation-extraction—an automated procedure. Soil Biol. Biochem. 22: 1167–1169.

Wynen, E. (1992). Conversion to Organic Agriculture in Australia: Problems and Possibilities in the Cereal-Livestock Industry. National Association for Sustainable Agriculture, Sydney, Australia.

Wynen, E. (1997). Research on biological farming methods in Europe: perspectives, status and requirements. In: Krell, R., ed. Biological Farming Research in Europe. Food and Agriculture Organization of the United Nations, Rome. 6-48.

Yuanzhi Li, Guangfu Luo, Yining Fan and Yi Chen (2004). A novel route to the synthesis of nanosized metallic molybdenum at moderate temperature and its catalytic properties, Materials Research Bulletin 39. Available online at http://www.sciencedirect.com.

Yudelman, M. (1964). Africans on the Land. Harvard University Press, Cambridge, USA.

Zehnder, G.W., Yao, C., Murphy, J.F., Edward J., Sikora, E.J., Joseph, W., Kloepper, J.W., Schuster, D.J., and Polston, J.E. (1998). Microbe-induced resistance: A novel strategy for control of insect-transmitted diseases in vegetables. Accessed on April 10th 2006 at http://ipmworld.umn.edu/chapters/zehnder.htm

ZMP, Ökomarktforum (2001). Organic farming in Germany. In: http://www.fao.org/DOCREP/004/Y1669E/y1669e09.htm#TopOfPage

Zorpas, A.A., Dimitris, A.P. and Giovannis H.M.Z. (2002). Compost Quality and use from Sewage Sludge, Organic Fraction of Municipal Solid Waste and Natural Zeolite—Clinoptilolite. Proceedings of the 10th International Conference of the RAMIRAN Network 2002—Published by FAO.

INTERNET SITES

Economic Research Services, United States Department of Agriculture (Organic Farming and Marketing). http://www.ers.usda.gov/briefing/Organic/

Organic Consumers' Association, http://organicconsumers.org/organic/survey072604.cfm

Seminars on Production and Export of Organic Fruits and Vegetables in Asia, Bangkok — Thailand 3-5 November (2003), ftp://ftp.fao.org/docrep/fao/006/ad429E/ad429E00.pdf

World Market For Organic Fruits and Vegetables. Institute of Food and Agricultural Sciences, University of Florida, United States. http://edis.ifas.ufl.edu/pdffiles/HS/HS21300.pdf

The Role and Importance of Nitrogen in Your Soil. http://www.cpit.ac.nz/subjects/horticulture/documents/nitrogen.pdf

Particle sizes—USDA and International Classification Systems. http://www.krishiworld.com/html/soils3.html.

Organic Fruits Production in Austria. http://www.fao.org/DOCREP/004/Y1669E/y1669e05.htm#bm05

European Commission Directorate-General for Agriculture. http://europa.eu.int/comm/agriculture/publi/fact/horti/2003_en.pdf

http://bldg6.arsusda.gov/benlab/Soybean%20Defense%20Response/salicylic_acid_synthesis.htm accessed on 14.06.2005.

United States Department of Agriculture, Natural Resources Conservation Services. (What is Soil?). Available at: http://www.soils.usda.gov/education/facts/soil.html.