

TRAINING --- MANUAL

- AGRICULTURAL PRODUCTION AND PROCESSING -

ORGANIC PRODUCTION



COLEACP

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- AGRICULTURAL PRODUCTION AND PROCESSING -

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Chapter 1

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1.1. Organic agriculture origins

1.1.1. The origins of the name organic

Jerome Irving Rodale was the first major international author and publisher of books and magazines on organic farming. His primary magazine was called *Organic Farming and Gardening*. It was based in the USA; however this publication was widely read by many thousands of people around the world. He actively promoted the name 'organic farming' in this and other publications and the name 'organic' quickly dominated over the numerous other names like natural, permanent and ecological that were being used at the time to describe the farming system.

The word organic has several meanings in the dictionary, with many people taking the dictionary definitions of "*Organized or systematic or co-ordinate*" (Oxford Dictionary) as the context for the use of the word in organic farming.

Rodale's use of the term 'organic farming' was specific to the farming system's use of organic matter as the primary source of soil health and plant nutrition in contrast to the use of synthetic chemical fertilizers in conventional farming. Rodale repeatedly stated that the fundamental basis of organic farming was to improve soil health and build up humus through a variety of practices that recycled organic matter (Rodale, 2011).

1.1.2. The origins of the movement

The organic agriculture movement arose over the concern over the loss of quality in crops with an increase in diseases and pest attacks affecting yields in the later part of the 1800s in Europe and the USA, after the introduction of chemical fertilizers.

These chemical fertilizers were based on the published research of Baron Justus Von Liebig, in Germany, in the 1840s.

Liebig was the first modern chemist to look at the plant growth in a laboratory. He determined that **plants needed minerals from the soil and carbon dioxide from the air**. He showed that although plants are surrounded by nitrogen in the air, they needed nitrogen in the form of ammonia that they took up through their roots. Liebig **stated that nitrogen was the most important mineral and proved that synthetic chemical fertilizers could replace natural ones** such as animal manures as the source of nitrogen.

Because his many of the **experiments** were done in a laboratory in **sand and other soil-less potting media** that did not contain humus and organic matter, Liebig **believed that humus did not have a significant role in plant nutrition**. He believed that plants only needed minerals in the certain types of water soluble chemical forms and in the correct ratios.

Liebig's research fundamentally changed the direction of agriculture and became the basis of conventional agriculture that is practiced around the world.

The people involved in the movements that would lead to modern organic agriculture believed that there was direct relationship between the health of the soil, the crops that were grown in it and ultimately with the animals and people who consumed these crops.

Ironically one of the first persons to write about his concerns over the damage that these chemicals were doing to the soil and crop quality was Baron Justus Von Liebig. In the latter part of his life he felt that other researchers were using his research out of context and this was causing problems.

In the midst of this concern by farmers and researchers, several key books were published, giving alternatives to chemical fertilizers. These books are still used as reference texts by the organic movement. Two of the critical texts were *Bread from Stones*, by Julius Hensel that was published in Germany in 1893 and *Farmers of Forty Centuries – Permanent Agriculture in Japan, China and Korea*, by F.H. King that was written around 1900 and published posthumously in the USA in 1911.

The **most significant origins of the formal movement began in Germany in 1924** when the philosopher **Rudolf Steiner** gave a series of eight lectures on agriculture. This was in response to the repeated requests from a group of farmers who were concerned about the declining quality of their soils and crops, since the introduction of synthetic fertilizers and pesticides. The lectures were published later that year in a book titled *Agriculture*.

Steiner tasked Ehrenfried Pfeiffer with developing the specific preparations and farming methods based on the broader, philosophical concepts that he used in his lectures.

Pfeiffer developed the preparations and also the name 'Biodynamic' to describe this new farming concept. He gave numerous lectures throughout Europe and **started the Biodynamic movement.** This is why many European countries **use the words 'bio' or 'biological' to describe organic farming.** Biodynamic practices and preparations have now spread around the world.



Biodynamic preparations

Not long after the beginning of the Biodynamic movement a range of **other organizations concerned about the link between soil health and human health** began to form in the 1930s and 1940s.

These organizations were based around the concept of soil health and were called names such as *The Soil Association*, *Healthy Soil Society*, *Soil and Health* and were formed primarily in the English speaking countries or ex colonies of the United Kingdom (UK) such as Australia, New Zealand, USA, India and South Africa

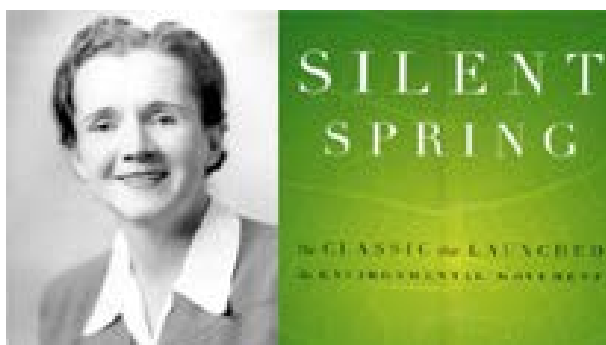
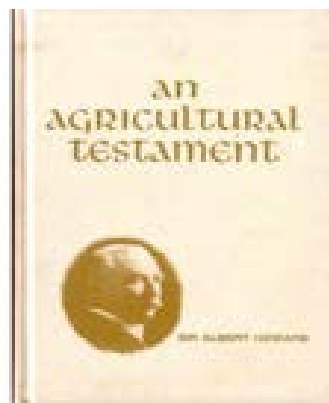
The most significant of these is the **UK Soil Association** which still continues to have a leading role in the organic movement in the UK and internationally. Ehrenfried Pfeiffer

gave several lectures at key conferences and events that were organized by the founding members of the UK Soil Association.

Most of these organizations produced magazines and books that were widely read.

The book from that time that had the most significant influence was ***An Agricultural Testament* by Sir Albert Howard**. Howard had spent much of his time in India and had pioneered efficient forms of composting that achieved high yields of healthy plants.

Howard had an enormous influence on Rodale who widely publicized his methods and disseminated the name "organic farming" based on the widespread use of recycling organic matter through composting that was advocated by Howard.

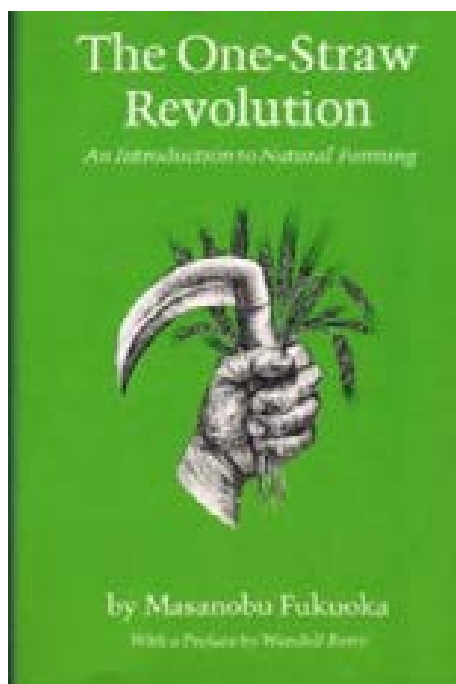


The publication of ***Silent Spring* in 1962 by Rachel Carson** had a significant effect in raising the public awareness about the dangers of the pesticides that were being used in farming at the time. *Silent Spring* created a huge controversy and a **massive concern about the chemical residues in food and in the environment**. The public pressure saw strengthening of pesticide

regulations and most importantly **the beginning of the consumer movement that demanded food that is grown without toxic chemicals**.

It also saw the beginning of **the awareness of how farming** was impacting on the environment and gave rise to a number 'whole of systems' approaches that fit within the broad organic paradigm.

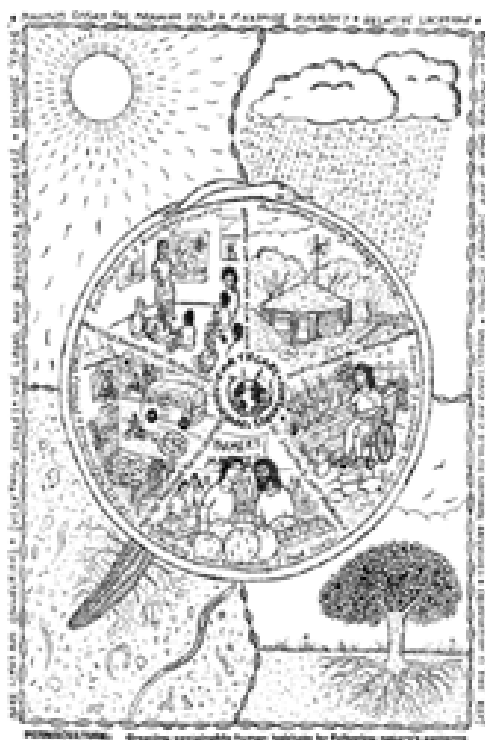




Examples of these are **The One Straw Revolution** by the Japanese farmer **Masanobu Fukuoka**. Fukuoka had published earlier books however *The One Straw Revolution* was published in English in 1978 and quickly became one of the most influential books at the time. His 'natural farming' methods were based on **observing how nature works and then designing the system so that nature did the work for you**. This is why it was sometimes called 'Do-nothing farming'.

Unfortunately some people misunderstood the concept and instead of having carefully planned systems where nature did the work for you, they did nothing and then criticized Fukuoka by saying that it failed.

He was one of the **pioneers of organic no-till grain systems that did not use herbicides**. These systems are easily applied to small-holder farms.



Quite independently of Fukuoka, two Australian researchers, **Bill Mollison and David Holmgren published a book called Permaculture in 1979**. 'Permaculture' was a shortened word for permanent agriculture which was the concept first put forward by FH King in the book *Farmers of Forty Centuries* in 1911.

Permaculture is a comprehensive whole of systems approach with the concept of a designing completely integrated systems that not only included cropping, they also included working with the ecology, horticulture, stacking production systems vertically to maximize solar capture, integrating animals, water systems, architecture, energy use efficiency and numerous other concepts.

The ideal was to start with a vacant block of land and design the new system based on the specifics of that block, its climate, topography and other attributes. Each permaculture farm would be unique because of this.

In 1979 three books on the concept of Agroecology were published. Gliessman published *Agroecosistemas y tecnologia agricola tradicional*, Cox and Atkins published *Agricultural*

Ecology: An Analysis of World Food Production Systems and Hart published 'Agroecosistemas: conceptos básicos.'

This saw the beginning of the **agroecology movement**. The Laboratory of Agroecology at the University of California, Berkeley, offers the following definition: "Agroecology is both a science and a set of practices. As a science, agroecology consists of the application of ecological science to the study, design and management of sustainable agroecosystems" (Altieri, 2002). "This implies the diversification of farms in order to promote beneficial biological interactions and synergies among the components of the agroecosystem so that these may allow for the regeneration of soil fertility, and maintain productivity and crop protection" (Altieri, 2002).

All of **these farming systems fit within the broad paradigm of organic farming** and are seen as part of the continued growth and evolution of organic systems.

1.1.3. The origins if the formal international movement

The formal international movement began in Versailles, France on 5 November **1972** when at the invitation of Roland Chevriot of *Nature et Progrès* in France, Lady Eve Balfour, a founder of the UK Soil Association in the UK, Kjell Arman from the Swedish Biodynamic Association, Pauline Raphaely from the Soil Association of South Africa, and Jerome Goldstein from the Rodale Institute held a meeting and **formed the International Federation of Organic Agricultural Movements (IFOAM)**.



IFOAM is the international umbrella movement that has the role to both lead and unite the organic sector around the world. It is the organization that sets the international standards, policies, definitions and positions around the multi-functionality of organic agriculture through consulting with its members that cover the whole spectrum of the sector in the majority of the countries in the world.

Consequently IFOAM documents are seen as credible source texts for reference material.

1.2. Organic agriculture principles and definitions

1.2.1. The principles of organic agriculture

The major concerns and concepts that were advocated by the founders and key opinion leaders of the organic movement over the last century, such as soil health, ecology, care, and using the precautionary principle with new technologies have been clearly articulated in IFOAMs four principles of organic agriculture.

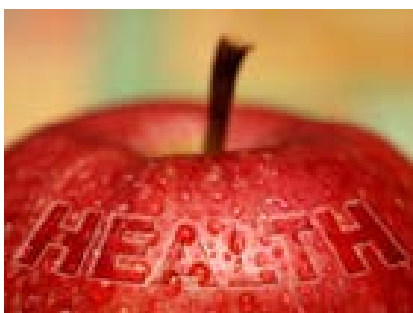
The four Principles of organic agriculture were developed from current organic practices through extensive worldwide consultation by the International Federation of Organic Agricultural Movements (IFOAM). They are the agreed international consensus on the fundamental basis of organic production.

These principles are used by IFOAM and other organic organizations to inform the development of practices, positions, programs and standards.

Organic agriculture is based on:

1. The principle of health
2. The principle of ecology
3. The principle of fairness
4. The principle of care

❑ Principle of health



Organic agriculture should sustain and enhance the **health of soil, plant, animal, human and planet as one and indivisible.**

This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems – healthy soils produce healthy crops that foster the health of animals and people.

Health is the wholeness and integrity of living systems. **It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being.** Immunity, resilience and regeneration are key characteristics of health.

The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from

the smallest in the soil to human beings. In particular, organic agriculture is intended to **produce high quality, nutritious food** that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

❑ Principle of ecology

Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

This principle roots organic agriculture within living ecological systems. It states that **production is to be based on ecological processes, and recycling**. Nourishment and well-being are achieved through the ecology of the specific production environment. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic farming, pastoral and wild harvest systems should fit **the cycles and ecological balances in nature**. These cycles are universal but their operation is site-specific. Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.



Organic agriculture should **attain ecological balance** through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

❑ Principle of fairness

Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.



Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings. This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties – farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a **good quality of life**, and contribute to **food sovereignty and reduction of poverty**. It aims to produce a sufficient supply of good quality food and other products.

This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behavior and well-being.

Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

❑ Principle of care

Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Organic agriculture is a **living and dynamic system** that responds to **internal and external demands and conditions**. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at **the risk of jeopardizing health and well-being**. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken.



This principle states that **precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture**. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate

technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

1.2.2. The definition of organic agriculture

IFOAM has developed a consensus definition on organic agriculture that clearly shows that organic systems are based on environmental and social sustainability by working with the ecological sciences, natural cycles and people.

IFOAM definition:

“Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved”.
(www.ifoam.org)

The United Nations Food and Agriculture Organization (FAO), international standard for the trade in food products, **Codex Alimentarius**, has a section that **covers organic production, the Codex Alimentarius Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods.**



It does not have a simple definition for organic agriculture and instead gives an overview of the types of practices and principles that it considers make an organic system.

Some *Codex Alimentarius* sections on organic agriculture:

Organic agriculture is based on minimizing the use of external inputs, avoiding the use of synthetic fertilizers and pesticides. Organic agriculture practices cannot ensure that products are completely free of residues, due to general environmental pollution. However, methods are used to minimize pollution of air, soil and water. Organic food handlers, processors and retailers adhere to standards to maintain the integrity of organic agriculture products. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people.

Organic agriculture is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system.

An organic production system is designed to:

- a) enhance biological diversity within the whole system;



- b) increase soil biological activity;
- c) maintain long-term soil fertility;
- d) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources;
- e) rely on renewable resources in locally organized agricultural systems;
- f) promote the healthy use of soil, water and air as well as minimize all forms of pollution thereto that may result from agricultural practices;
- g) handle agricultural products with emphasis on careful processing methods in order to maintain the organic integrity and vital qualities of the product at all stages...

1.2.3. Significant differences between conventional and organic systems

Most organic production standards clearly state **that organic production avoids the use of synthetic fertilizers and pesticides.**

This is an important distinction between conventional and organic products. Unfortunately it has also led to the wrong assumption that because organic systems do not use these two key conventional farming inputs, that they do not use any fertilizers to correct nutritional deficiencies or any methods to stop pests and diseases.



Organic farming is not a system of neglect. It negates the need for synthetic pesticides and fertilizers by improving soil fertility by using composts, natural minerals, cover crops and by recycling organic materials. **Cultural and ecological management systems** are used as the **primary control of pests, weeds and disease**, with a limited use of natural biocides of mineral, plant and biological origin as the tools of last resort.

1.2.4. Substitution farming through to whole of systems approach

When products labelled as 'organic' are being sold in the market place, they have to comply with the specific standards and legal requirements of that market.

However on the generic level, organic farming is a very large umbrella that can cover a huge array of different types of agricultural systems. IFOAMs *"... goal is the worldwide adoption of ecologically, socially and economically sound systems that are based on the principles of Organic Agriculture"*.

This means that agricultural systems are organic when they comply with IFOAMs Principles of Organic Agriculture and Definition of Organic Agriculture. The reality of farming around the world is that the **majority of the world's farmers are traditional smallholder farmers who are largely organic by default.**

Significant **increases in yields** can be achieved by teaching these farmers to **add good organic practices to their traditional methods** such as:

- better soil nutrition;
- improved pest and disease control;
- water use efficiency;
- better weed control methods;
- ecological intensification.

Organic agriculture has a proven **track record of improving yields** as well as delivering a range of social and environmental benefits, **particularly with smallholders in the developing world** (Badgley, 2007); (FAO, 2007); (Leu, 2004); (Pimentel, 2005); (Unep-Unctad, 2008).

A report by two UN agencies, UNCTAD and UNEP, found that organic agriculture significantly increases yields in Africa. “[...] the average crop yield was [...] 116 per cent increase for all African projects [...] The evidence presented in this study supports the argument that **organic agriculture can be more conducive to food security in Africa than most conventional production systems**, and that it is more likely to be sustainable in the long term”.

Supachai Panitchpakdi, Secretary general of UNCTAD and Achim Steiner, Executive Director of UNEP stated: “All case studies which focused on food production in this research where data have been reported have shown increases in per hectare productivity of food crops, which challenges the popular myth that organic agriculture cannot increase agricultural productivity” (Unep-Unctad, 2008).

In many cases when farmers are starting out along the organic pathway they usually start as **‘organic by neglect’, ‘organic by default’ or ‘substitution farming’**.

The first two systems are where farmers essentially avoid using synthetic fertilizers and pesticides without taking adequate measures to maintain soil fertility. These are considered as the poorest examples of organic systems and they are the classic low yielding systems that are rightfully criticized by most commentators.

“Substitution farming” is where organic farmers just substitute organically allowed inputs for the chemical fertilizers and chemical pesticides used in conventional farming. These organic systems are essentially conventional farming systems with inputs that are much better for the environment and for human health. Some of these system scan be very high yielding because of the levels of nutrients and the spray management systems.

The organic systems that farmers and land managers should aim for is a whole of systems approach that integrates all the elements of the farm into a low input, highly productive and resilient system. Good managers can learn from agroecology, permaculture, natural farming, modern soil science, microbiology, entomology and numerous other applied science and practices to achieve this outcome.

This manual is based on the “whole of systems approach” model of organic agriculture and will give readers the knowledge to apply this to their farming systems.



1.3. An opportunity of development

1.3.1. Organic – The fastest growing agricultural based industry in the world

“*The World of Organic Agriculture 2011*” is the annual book on organic statistics that is produced by FiBL and IFOAM. It gives an excellent overview of the organic information from around the world in 2009.



The growth in the **markets for organic product sales** continues to **increase** and defy the global market slowdown in many countries. The data shows that nearly every country has an expanding organic sector. The UK was the only country where there was a slight decrease.

The information presented February 2011 showed that 160 countries collected certified organic data in 2009 compared to 86 countries that collected certified organic data in 2000.

The global value of certified organic market sales was US \$54.9 billion in 2009. **The USA became the largest market** with a value of \$26.6 billion **followed by the European Union** with \$26 billion.

The comparison with the global organic sales of \$33.2 billion in 2005 and \$15.2 billion in 1999 shows a consistent trend of a high rate of growth.

Other indicators continue to show the sustained growth in organic production.

In 2009 there were 1.8 million organic producers farming **37.2 million hectares of certified organic agricultural land** compared to 2008 where there were 1.4 million organic producers with 35 million hectares of certified organic agricultural land in 2008. There were **11 million hectares in 1999**.

A rapidly emerging area is certified organic wild collection. There were over 41 million hectares in 2009 compared to 31 million hectares in 2008.

This is a very important activity as it allows the sustainable harvest of wild resources ensuring the conservation of high biodiversity ecosystems and providing an income to people who manage these ecosystems. It is one of the most successful examples of a market based system that rewards landholders for ecosystem services and provides an economic incentive to conserve the ecosystems so that they are sustainable sources of income.

This means that there are over 78 million hectares that are certified for organic production. The true figure for land under organic management would be significantly

more than double this as the majority of farmers are smallholders who use organic methods, however they are not certified.

❑ A snapshot of some countries

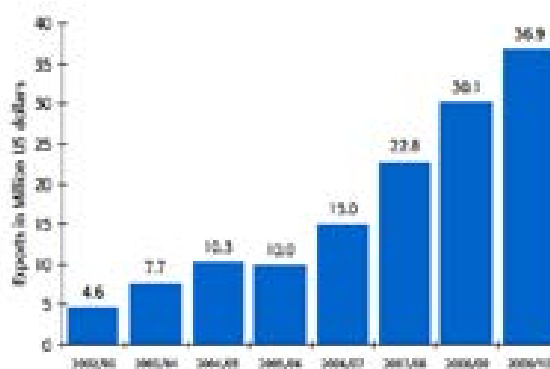
A snapshot of the 2010 data of several key countries shows that the rate of growth continues to increase.

❑ Uganda

Currently **226,954 hectares** are under organic agricultural management in Uganda (up from 210,245 hectares in 2008/2009), with **187,893 farmers** representing 1.3 hectares per farmer on average. Most of these farmers are smallholder farmers.

The main exported products are organic coffee, cocoa, dried fruits; frozen fruit/pulp; fresh products as pineapples, apple bananas, passion fruits, mango, jack fruit, plantain, papaya), ginger; sesame, cotton, vanilla, bird's eye chilies, black pepper, cardamom.

The **Ugandan organic export** sector registered a **double-digit growth in 2009/2010** despite the global economic decline. The survey indicated that organic exports in 2009/2010 totaled 36.9 million US dollars up from 30.1 million US dollars, representing an **overall growth of 22.7%** in value, compared to the previous period.



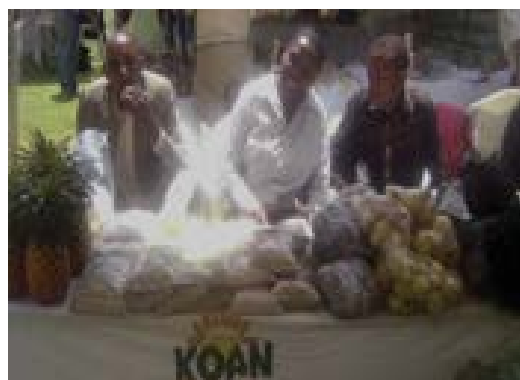
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Value of organic export in million US dollars 2002-2010

❑ Kenya

The Kenya organic domestic market is growing fast (data from 2008).

The number of organic certified enterprises to supply the domestic market has grown to reach 27; nine of whom are smallholder producer groups. An additional nine organic export oriented enterprises also sell a small percentage of their products locally.

The Kenya Organic Agriculture Network KOAN estimates the value to be close to 30 million Kenya shillings (approximately 270,000 €), representing 4.6% of the total turnover of the organic sector.



The **annual growth of organic domestic market** in size is currently estimated to be at **40%**. With a push from the big international community who are working with various United Nations offices, the premiums for organic produce have been ranging from 30 to 40%.

Currently **close to 3,000 farmers are involved in selling organic produce** to different outlets. Out of these, 1,300, representing 7 farmers associations and 17 individuals, have been **certified through a third party verification system** while the rest are trained on organic production technologies and have a verification arrangement with the buyer. The produce marketed by this farmers include vegetables fruits, salads, herbs, spices, pulses, and processed products that includes honey, jams, daily products, dehydrated vegetables, herbal teas and dried fruits.

❑ Germany

The first three quarters of the year were positive for the German wholesale organic food trade, which achieved 6% growth to reach sales of some 628 million EUR. The growth was only slightly less than the figure for the first three quarters of 2008, when it was 7.7%.

The fresh segment grew by 6.2% (395 million EUR), a little stronger than groceries with 5.6% (233 million EUR), according to news from BNN.¹

❑ Italy

The average growth in organic foods has been at 7.5% per year since 2004.

The Ismea/AC Nielsen survey found that there was a 32% increase in the sales of fresh fruit and vegetables, 24.7% for eggs, 7.5% bread and 4.5% increase in beverage sales in 2009.

Italians bought 6.6% more organic packaged foods in 2009 an increase on 5.2% in 2008.

20% of the total amount spent on organic packaged products was spent on dairy products, 19.5% on fruit and vegetables and 14% on breakfast products. The individual products purchased the most were eggs, fresh milk and yogurt, as well as soy drinks, baby food, fruit juices, olive oils and pasta. Purchases at discount stores increased by 45.9%.

❑ USA

The annual survey by the Organic Trade Association found that the US organic industry grew to \$29 billion in 2010 from \$26.6 billion 2009. In 2008 it was worth \$24.6 billion, growing an impressive 17.1% over 2007 sales during the tough economic times.

Despite the nation's worst economic downturn in 80 years, the US organic industry has come out of the recession hiring employees, adding farms, and increasing revenue.

The organic sector grew by 8% in 2010, dramatically outpacing the food industry as a whole, which grew at less than 1% in 2010.

¹ Source: www.n-bnn.de.

❑ China

The official Organic Food Development Center (OFDC) estimates domestic sales of organic products at around \$US 500 million. Organic certification organizations estimate that production will increase by 30 to 50% in the coming years and that the exports of organic products could rise to 5% of total food exports by 2020.²

❑ Peru

Peru's organic food **export trade** has continued to **grow over the past two years** despite the global recession. Peru's Tourism and Export Promotion Board estimated that the value of the **country's exports of organic food rose by 13% in 2009** to US\$ 225 million. Organic coffee is the major revenue earner. Peru is the world's leading exporter of certified organic coffee beans. It also exports organic cocoa and bananas among other products.

The value of Peru's organic exports will continue to rise, bringing valuable extra revenue to the country's small-scale farmers.

1.3.2. Put food on the table first and work from the market backwards

The **most critical issue** for hundreds of millions of smallholder farmers is the **need to feed their families**. They need food security and this is done by Putting Food on the Table First.

However these farmers, just like all other farmers, **need more than just a subsistence diet**. They need to have an income so that they can send their children to school, pay for medicines and health care, veterinary care for their livestock, clothes, a house and the usual basic necessities of life.



They **need have markets** for some of their produce so that they can earn the require money.

The critical issue for the smallholder through to the large broad acre farmer is that they have markets that return viable prices. In many instances farmers grow crops and send the surplus to the markets or to wholesale agents, only to find that they receive very little or nothing for it because of oversupply in that market.

If farmers cannot sell products for profitable financial return, then it usually means that they lose money.

² Source: Organic monitor.



It is critical that farmers work with their markets and make plans to ensure the types, the amounts and the timing of the crops they will supply along with prices they will receive before the first seeds are planted.

The best farmers work with their markets and develop a professional and trusting relationship with their buyers.

1.3.3. Expanding markets from local to export

The **best time to enter** any market is when **they are still small and growing**. This means that it is easier to get market penetration and brand recognition in a sector that is only 2 or 3% of the overall market than to try and do this over a significantly large sector. The brand recognition and sales increase as the market increases.

The organic sector fits these criteria for many products.

The other key issue is that it is usually **best for smaller producers to access high value small volume niche markets rather than** trying to compete with the large multi-national corporations in the **low value high volume commodity markets**.



Many areas of the **organic sector** fit **high value small volume niche markets categories**.

The organic sector offers **numerous markets** that can be utilized to sell produce. These can be short supply change sectors such as **direct farm gate sales**, Consumer Subscription Agriculture (Tei Kei in Japan) and **local farmers markets** through to regional and national wholesalers, **supermarket outlets and exports** around the world.



Local organic farmers market

All of these outlets are expanding offering a range of choices. Good farmers should do their homework and identify a list of suitable markets. It is **important to have multiple markets** as all markets go up and down in value. If a producer only has one market and there is a problem and they cannot pay or accept the produce, this means that the producer loses income. However when they have multiple markets, if there are problems

with one of the markets, they can spread the produce amongst the other markets and not lose income.

A good example of this is the trend for new market outlets is in Italy. The annual Bio Bank Report, which reveals that various sales figures for organic operators in Italy increased between 2007 and 2009 analyzed the growth in several organic market and found that while sales in the stores grew by 2% the sales in **numerous other areas** increased at significantly higher levels:

- purchasing groups grew by 68%
- farm-gate sales by 32%
- restaurants by 31%
- Internet sales by 25%
- school cafeterias by 23%
- holiday farms by 22%
- farmers' markets by 10%

This shows that there are numerous valuable market outlets that should be utilized by farmers. There is an old farmers saying: “Never put all your eggs in the one basket”.

Organic producers have always had a diverse range of markets and many have a direct relationship with their customers. This is one of the key reasons why the number of organic farms continues to increase while the total number of conventional farms is always decreasing.

Also of great significance is that these local types of markets ensure the viability of small-holder and family farms.

There are **two trends** that are **helping small-holders access viable markets**.

Participatory Guarantee Systems (PGS) are where the famers do peer reviews of each other to ensure that they are fully organic. These systems are mostly used for local and national markets.



Farmer sign for a Participatory Guarantee System

Group Certification Systems are where an accredited Third Party Certification Organization certifies the whole group for various markets including export markets.



Both of these systems significantly reduce the costs for individual farms and enable both the farmer and the customer to have a guarantee that the products have been produced in genuine organic systems.

Organic farmers still work in **cooperatives** and these are some of the most successful ventures in the world.



Huiwani Cooperative Society farmers in New Guinea

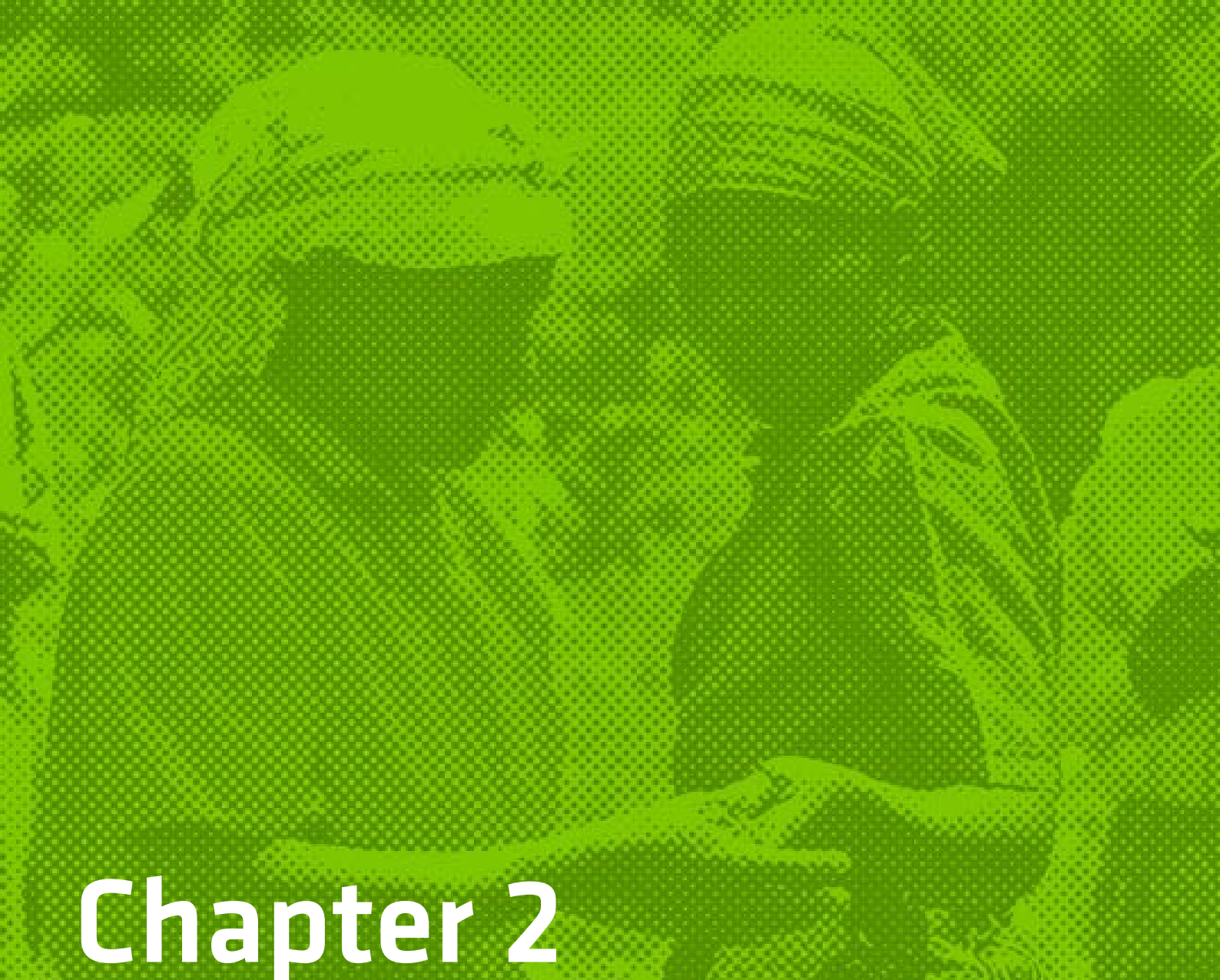
The largest organic business in the world is a coop called Organic Valley, based in the USA. It turns over more than \$200 million every year.

Organic Valley started in January of 1988 at a time when family farms were on the brink of extinction. A handful of farmers in South Western Wisconsin who shared a love of the land formed the Farmer-Owned Cooperative.



The key to their success is their cooperative business model. It keeps on expanding every year and adding new farmer members. **The 1,658 farm families** who produce the premium quality food products share a voice in the future of the business, because they own it.

Farmers working together cooperatively to market their produce is one of the best strategies



Chapter 2

Soil fertility in organic agriculture

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2.1. Soils in organic agriculture

2.1.1. Soil health

Soil health is the key principle to successful sustainable organic farming.



A poor soil results in poor plants, more pests and diseases and poor yield. The key to successful soil health is the **correct management of organic matter**, as this gives the soil an open friable structure to aid both drainage and water retention and buffers the pH in soils that naturally tend to acidity or alkalinity.

It also creates large complex organic molecules that **allow minerals ions to adsorb (stick) to them for later use by the crop**. This is very important in areas that are inundated with periodic heavy rainfall as these organic carbon molecules prevent the mineral ions from leaching, keeping these nutrients on farm for later use by crops and preventing eutrophication of water catchments. The stable forms of organic matter such as humus and charcoal acts as a storage bank and buffer for these minerals. Humic, fulvic, ulmic acids and other organic acids such as carbonic and acetic acids from decay of organic matter help make locked up minerals available for use by plants by changing them into forms that plants can use. The term for this is that **the minerals are bio-available**.

The other important function of organic matter is **to encourage beneficial soil micro-organisms** that make minerals such as nitrogen, phosphorous, potassium and trace elements bio-available. Also they provide a host for beneficial fungi such as *Trichoderma sps.* and *Penicillin sps.* which help control pathogens such as *Rhizoctonia*, *Phytophthora*, *Armillaria*, *Pythium* etc.

A whole of systems approach to soil management is required to achieve high yields including using a complete analysis soil test to assess the mineral balance of soil. It is important that the soil has sufficient plant available nutrients in the correct balance to ensure that the crop is not deficient so that it can achieve its maximum genetic potential. **The correct balance of minerals** is essential to the health of the crops and to the soil micro-organisms that help as part of the soil food web to produce healthy crops.

A benefit of the total nutrition is **that healthy plants are more robust** in adverse conditions such as of drought and heavy rain and are more resistant to pests and diseases.

2.1.2. Soil organic matter – the key to productive farming

Soil organic matter is one of the most neglected yet most important factors in soil fertility, disease control, water efficiency and farm productivity.

It has largely been ignored by most of conventional agriculture as it has preferred a hydroponic model of nutrition of where plants are directly fed from dissolved mineral ions in the water of the soil. This combination of dissolved mineral ions in the soil water is known as the soil solution. The plants absorb these dissolved minerals when they take up the soil solution into their roots to obtain water. In most agronomy texts this is seen as the only model for plants to absorb nutrients so the role of organic matter in the soil was seen as irrelevant.

While absorbing minerals through the soil solution is responsible for a significant amount of the minerals that plants need, it is not the only method. Research shows that plants also obtain **significantly high levels of nutrients from ion exchange, from absorbing larger organic molecules** like chelates and amino acids, **from direct symbiosis** with micro-organisms, **through the action of plant root enzymes and through the stomata in their leaves**. Several of these critical areas of plant nutrition are clearly linked to the organic matter cycles in soils.

The first step is to have an understanding of what constitutes organic matter and in particular soil organic matter (SOM).

2.1.3. Soil organic matter – what is it?

Soil organic matter is derived from the decay of the living and dead parts and excretions of plants, animals, insects, micro-organisms and all biotic forms of life.

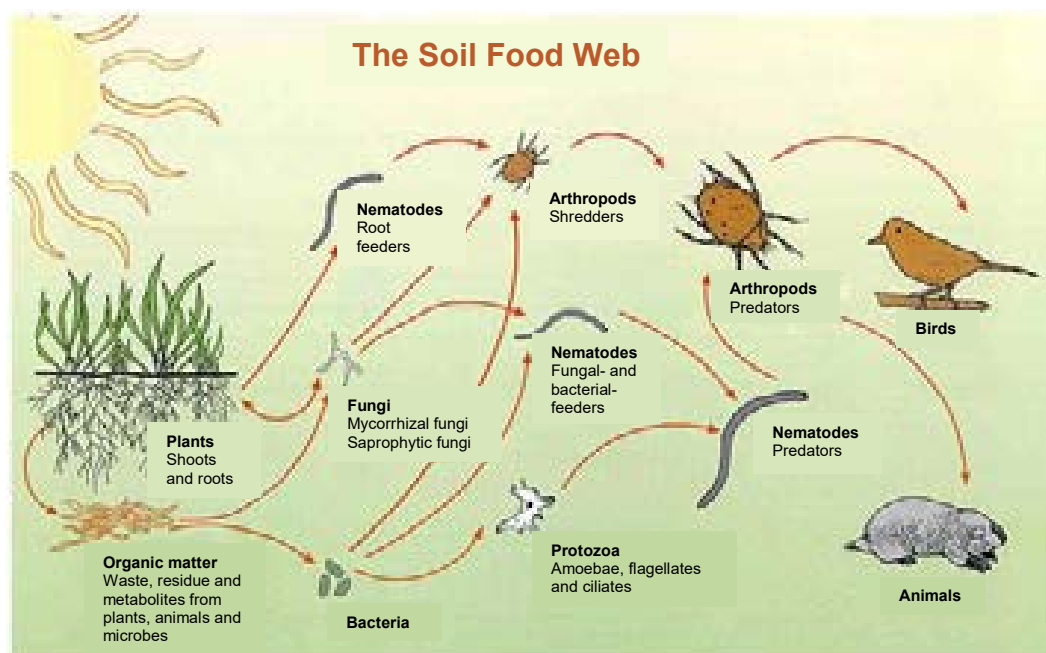
Soil organic matter is very complex and scientists and researchers are only starting to understand small parts of this complexity. Current research shows that it is composed of two main fractions that are part of two cycles that merge and overlap continuously.

These main cycles are **the labile or volatile fraction** and **non-labile or stable fraction**.

❑ Labile or volatile fraction

The labile fraction is composed of decaying organic matter. This is the most crucial part of the soil organic matter cycles. This is where microbes are breaking down residues of crops, leaves, twigs, branches, root excretions, animal manures, animal remains and releasing all the minerals, sugars and other compounds into the soils to feed plants and other micro-organisms. This complex process is known as **the Soil Food Web**.





The key to this cycle is that it needs to be continuously feed with fresh organic matter to ensure that it is active.

Some models just look at this cycle and no deeper into the soil organic matter cycles. These models assume that all the carbon in organic matter has to be completely decayed into carbon dioxide (CO₂) for all the minerals to be released as nutrition to plants.

In natural eco-systems and under good management some parts of the decaying organic matter form stable soil carbon and soil organic matter fractions

❑ Non-labile or stable fraction

The **most stable** organic matter fractions are **humus**, glomalin (from fungi) and **charcoal (char)**. Research shows that humus and char can last for thousands of years in the soil. Other fractions are less stable (labile) and can be easily volatilized into CO₂.

Bio-chars (charcoals from living sources) are now being promoted as the stable form of soil carbon along the benefits that they bring to the soil and to crops.

While bio-chars do have several benefits, the **multiple benefits of soil humus** are significantly greater.

❑ Humus improves nutrient availability

- Stores **90 to 95% of the nitrogen** in the soil, **15 to 80% of phosphorus** and **20 to 50% of sulphur** in the soil.
- Has many sites that hold minerals and consequently dramatically increases the soils Total Extractable Cations (TEC) (The amount of plant available nutrients that the soil can store).
- Stores cations, such as calcium, magnesium, potassium and all trace elements.

- It can store significantly higher amounts of anions (nitrates, sulphur, phosphorous) than clays.
- The complex of humic acids (humic, fulvic, ulmic and others) help make minerals available by dissolving locked up minerals.
- Prevents mineral ions from being locked up.
- Prevents nutrient leaching by holding on to them.
- Encourages a range of microbes that make locked up minerals available to plants.
- Helps to neutralize the pH.
- Buffers the soil from strong changes in pH.

☐ **Humus improves soil structure**

- Promotes good soil structure which creates soil spaces for air and water.
- Assists with good/strong peds formation.
- **Resists soil erosion.**
- Encourages macro organisms (*i.e.* earthworms and beetles etc.) that form pores in the soil.

☐ **Humus directly assists plants**

- The spaces allow micro-organisms to turn the nitrogen in the air into nitrate and ammonia.
- Soil carbon dioxide contained in these air spaces increases plant growth.
- **Helps plant and microbial growth** through growth stimulating compounds.
- Helps root growth, by making it easy for roots to travel through the soil.

☐ **Humus improves soil water relationships**

- The open structure **increases rain absorption.**
- Decreases water loss from runoff.
- Humus molecules soak up to 30 times their weight in water.
- It is **stored** in the soil **for later use by the plants.**
- Improved peds formation helps the soil stay well drained.

☐ **Humus and soil nutrients – ion exchange**

Ions are charged atoms or molecules of minerals. Positively charged ions are called cations and negatively charged ions are called anions.

In standard agronomy texts the ions are dissolved in the soil solution and when plants absorb water through their roots, they absorb the dissolved ions as nutrients.

Many of these ions also adsorb to the charged sites on humus and will not be dissolved in the soil solution. This prevents the ions from leaching out and causing environmental problems especially in rivers and seas.



Plants use a process called ion exchange where they can separate water into the required charged ions. These are the positively charged hydrogen ion and the negatively charged hydroxyl ion.

The charges on these ions will displace the ions adsorbed on humus to allow them to be absorbed by the plant roots (Handrek).

Humus can store significantly higher amounts of both cations and anions than clays due to more sites for ions to adsorb (stick) to. These sites have positive and negatively charged electrostatic sites that work like magnets to attract the ions.

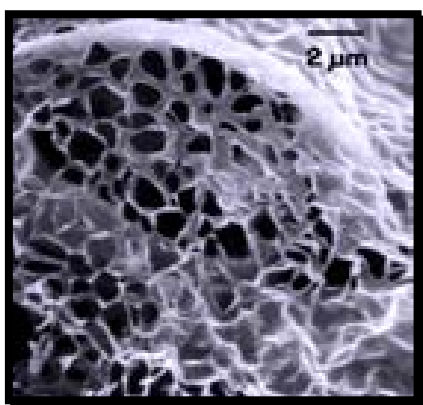
Ion exchange is a significant process in the nutrition of plants in organic systems with high levels of humus in the soil organic matter.

❑ Building long lasting soil organic matter

Humus is the longest lasting component of soil organic matter. It can last for several thousand years. Over time bio-chars will be turned into humus and/or CO₂ depending on the soil management systems. Humus is generally very resistant to microbial breakdown; however a combination of synthetic nitrogenous fertilizers and oxidation through poor tillage practices causes it to decline rapidly. Soil erosion is the other major cause of humus loss, due to the top layers of the soil having the highest percentages of humus.

The exact nature of humus is still being researched. It is a complex of substances that have been formed from the lignins, oils and waxes in the plants rather than from the other main organic compounds, cellulose, sugars and starches.

Under an electron microscope **humus looks like a sponge** – it is a sticky substance with numerous porous holes. This is why it can store up to 30 times its own weight in water and why it holds on to the soil nutrients and prevents them from being leached away.



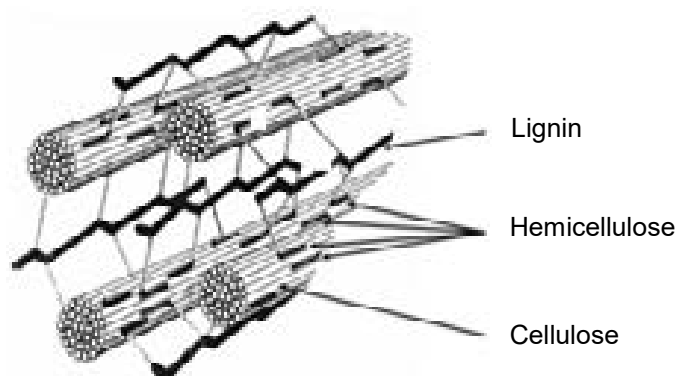
Humus under an electron microscope (source: Rodale Institute)

The critical issue **when building up humus** is to allow **the ground covers, green manure crops, stubble etc. to mature to the point where they have formed lignins.** The structures of most plants are composed of cellulose and lignin. Cellulose is the part

that makes wood and paper. The lignins are like strong flexible fibers that glue the plant structures together to give them both flexibility and strength.

Young fresh plants tend to have few lignins as they are mostly cellulose, sugars and starches. These are readily consumed by the micro-organisms as food sources – feeding the labile cycle of the soil food web.

Cellulose takes longer to break down. Cellulose is formed in plants through building chains of glucose. It is very stable, not water soluble and resistant to being degraded. Various micro-organisms, especially fungi can digest it. They use enzymes such as cellulase that breaks it into glucose and water. Ruminants and termites have symbiotic micro-organisms in their digestive tracts that break down cellulose. This is why termites can thrive in arid areas because they get their water and glucose from breaking down the cellulose in wood or grasses.



Lignins tend to be the **last parts of the plants to be consumed by micro-organisms**. They can be converted into humus and humic acids, provided that the correct species of micro-organisms are available and that the negative farming practices are avoided.

The best way to ensure that **plants are rich in lignins** is to **let them mature** and become coarse and woody. It is the lignins that turn tender plants into tough plants. Where possible let green manures reach full maturity before recycling them into the soil.

Young fresh green manures are great to feed the soil micro-organisms with sugars and the cash crop with nutrients such as nitrogen, however they will not produce as much humus as mature lignified organic matter.

Without regular inputs of organic matter, soil organic matter levels can fall over time as the sugars and starches are consumed as the food sources for the soil food web.

Soil organic matter tends to volatilize into CO₂ in most conventional farming systems. However, the correct management systems can continuously increase both the non-labile and labile fractions. The research conducted by Dr Christine Jones showed that the majority of the newly increased soil carbon was in the stable fractions. *“78% of the newly sequestered carbon is in the non-labile (humic) fraction of the soil – rendering it highly stable”* (Jones, 2011).



Long term research conducted for more than 100 years at the Rothamsted Research Station in the UK and the University of Illinois Morrow Plots in the USA showed that the total soil carbon levels can steadily increase and then reach a new stable equilibrium in farming systems that use organic matter inputs. This means that good organic management systems can increase and maintain the labile fractions as well as the stable fractions.

2.1.4. Water management

One consistent piece of information coming from many studies is that organic agriculture performs better than conventional agriculture in adverse weather events, such as droughts and intense rains.

❑ Organic systems use water more efficiently

Research shows that organic systems use water more efficiently due to better soil structure and higher levels of organic matter particularly humus. The open structure allows rain water to quickly penetrate the soil, resulting in less water loss from runoff.

Humus is one of the most important components of organic matter. It stores up to 30 times its weight in water so that rain and irrigation water is not lost through leaching or evaporation. It is stored in the soil for later use by the plants (Handrek, 1990; Stevenson, 1998; Zimmer, 2000; Handrek and Black, 2002).

The scientific Review by Cornell University into 22 year – long Rodale field study found:

- The conventional crops collapsed during drought years.
- The organic crops fluctuated only slightly during drought years, due to greater water holding capacity in the enriched soil.
- When these fluctuations in yields were averaged out the organic crop had yields equal to greater than the conventional crop (Pimentel, D. et al., 2005).

The Rodale Farm Systems Trial showed that the organic systems produced more corn than the conventional system in drought years. “Average corn yields in those 5 dry years were significantly higher (28% to 34%) in the two organic systems: 6938 and 7235 kg per ha in the organic animal and the organic legume systems, respectively, compared with 5333 kg per ha in the conventional system” (Pimentel, D., 2005).

The researchers attributed the higher yields in dry years to the ability of soils on organic farms to better absorb rainfall. This is due to the higher levels of organic carbon, making the soils more friable and better able to store and capture rain. According to the authors, “This yield advantage in drought years is due to the fact that soils higher in carbon can capture more water and keep it available to crop plants” (La Salle and Hepperly, 2008).

❑ The importance of organic matter for water retention

There is a strong relationship between the levels of soil organic matter and the amount of water that can be stored in the root zone of a soil. The table below should be taken as a

rule of thumb, rather than as a precise set of measurements. Different soil types will hold different volumes of water when they have the same levels of organic matter. Sandy soils as a rule hold less water than clay soils.

The table gives an understanding of the potential amount of water that can be captured from rain and stored at the root zone in relation to the percentage of soil organic matter.

Volume of water retained /ha (to 30 cm) in relation to soil organic matter (SOM):

0.5% OM	80,000 liters
1% OM	160,000 liters
2% OM	320,000 liters
3% OM	480,000 liters
4% OM	640,000 liters
5% OM	800,000 liters

This table is designed to be a rule of thumb guide. The precise amount of water stored is dependent on soil type, specific soil density and a range of other variables and consequently the amount could be higher or lower. This table is sufficient to allow an understanding of the concept.

There is a large difference in the amount of rainfall that can be captured and stored between the current SOM level in most conventional farms and a good organic farm with reasonable levels of SOM. This is one of the reasons why organic farms do better in times of low rainfall and drought

The **soil** can be the **largest reservoir of water if it has good levels of SOM**. This water is stored at the cash crop root zone to be used as needed.

1,000 hectares of farmlands with just over 3% SOM would be storing 500 megaliters of water in the soil. This is an enormous saving if the water had to be purchased or the farms have to pay for building a dedicated 500 megaliters dam and irrigation system.

□ How organic matter improves water use efficiency

Soil organic matter increases water retention in several ways. As stated before, humus, one of the major components of organic matter stores up to 30 times its own weight in water. The other very significant role is through building a soil with an open sponge like structure that efficiently captures the water and stores it in the numerous pores.

A good soil needs to be able to hold lots of water, air and nutrients. Air is essential for the roots to breathe. Plants like animals need oxygen. In most cases the roots have to get the oxygen directly from contact with the air. Some wetland plants such as waterlilies, reeds and mangroves have special tubes that can conduct air from the surface to the roots.

However the majority of plants need to have their roots in direct contact with air. Too much water replaces the air and the roots suffocate, killing the plant. Air is essential for



soil microbial activity. Too much water also creates anaerobic (no air) conditions that kill the beneficial micro-organisms and can favor the micro-organisms that cause diseases.

The soil should be **like a sponge with lots spaces (pores)** that will hold **both water and air**. Organic matter is the key to this.

The soil should be composed of crumbs. These crumbs are called peds. When good quality peds are gently squeezed between the thumb and fingers they should crumble away to smaller peds.

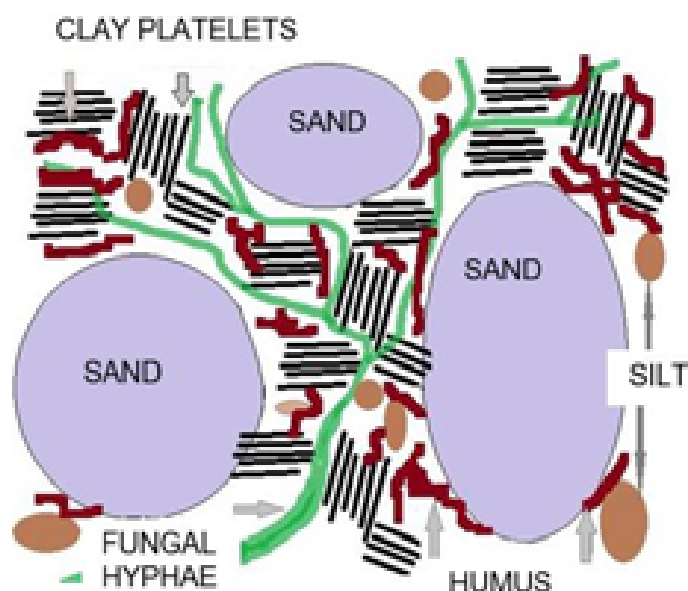
This gives a soil **numerous pores of different sizes**. **Some sizes are better for air and others are better for holding water**. Very importantly the open structure of the soil ensures good capture of rain and irrigation water.

Compacted soils and those with crusts on the surface have very few spaces for water to infiltrate, so much of the water from rain or irrigation either runs off the surface or is evaporated.

❑ Building good quality peds

Organic matter, calcium, clay, micro-organisms, air, moisture and plant roots are needed to build peds. They have interrelated roles and it is difficult to build good soils without them.

Soil diagram



Clays are needed as **the binding agents**. Nearly all soils have some clay component including most sandy soils.

The regular addition of small amounts of clay will improve sandy soils. However without organic matter these clays can be dispersed through the pores in the sand, stopping

infiltration and tightly binding to water. Pure clays hold more water than sands however they hold onto it very strongly making it difficult for plants to access.

Micro-organisms are the key to building peds. They have numerous roles. They turn organic matter into humus. Humus is made from **phenolic polymers**. They are very **sticky** and this is one of the reasons why they are good at **holding soil nutrients and stopping them from leaching out of the soil**. They act as the soil glue. The various particles of clay, silt and sand stick to it.

Calcium also has a **key role**. It helps the aggregation of the various components that make up the soil to form into peds. The best analogy is the mortar between bricks.

Over time the micro-organisms assemble the various soil particles into peds using humus as the glue and calcium as the mortar. This gives the soil the combination of strength and flexibility. Soil fungi further hold it together with their hyphae (fungal filaments) and by secreting substances like glomalin.

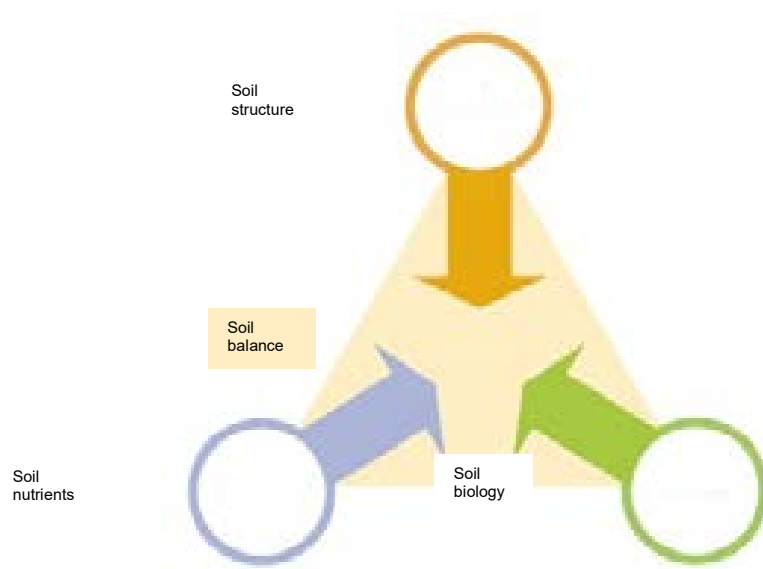
Glomalin is a stable carbon polymer that forms long strings that work like reinforcing rods in the soil. Research is showing that they form a significant role in building a good soil structure that is resistant to erosion and compaction. The structure facilitates good aeration and water infiltration.

Plants are the other important key. The **carbon gifted by the roots** feeds the microorganisms that produce the bulk of the organic matter used for humus and building soil. The roots also work as **reinforcing rods and deepen the soil over time**.

As a result a good living soil will recover from compaction from moderate vehicle use.

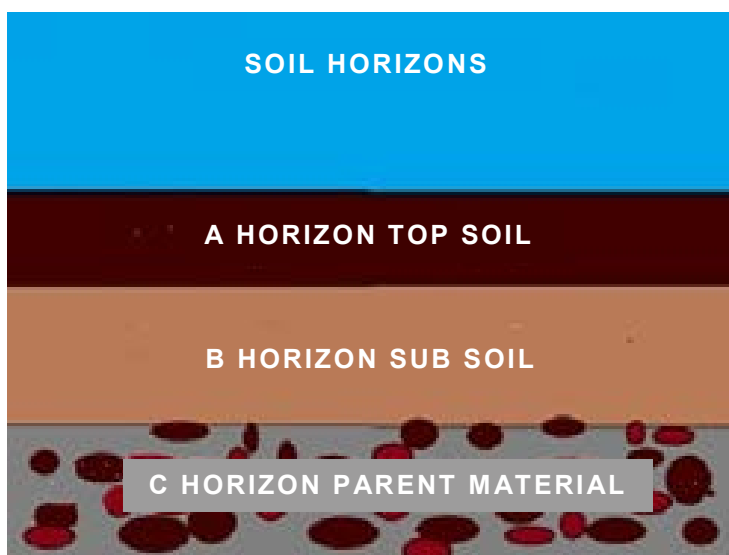


2.2. Soil fertility components



2.2.1. Physical fertility

Soils generally have **3 layers or horizons**. These are called the **Topsoil or A horizon**, the **Subsoil or B horizon** and the **Parent Material or C horizon**.



The most important area is the topsoil as this is the most fertile zone. It is the area where most of the nutrients and where the majority of the crops feeding roots will be found. The top soil is formed from the sub soil by the action of crop roots and other parts of plants depositing the organic matter that feeds the soil biology that forms soil.

The subsoil or B horizon is usually a lighter color as it does not contain the same levels of organic carbon as the topsoil and because of this does not have the same level of fertility.

In many soils due to poor management there is either no top soil or a very little marked difference. These are usually soils of very poor structure and fertility except for some soils of recent volcanic and glacial origin.

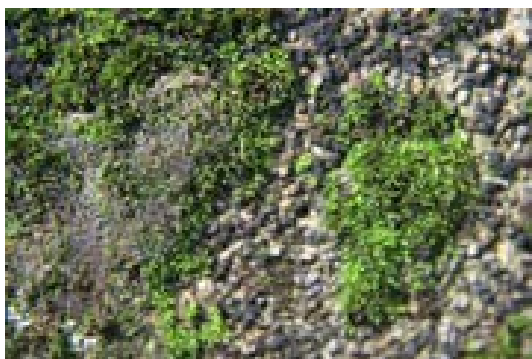
The **Parent material or C horizon** is composed of the '**decomposing**' or '**weathering**' **rock material** that forms the basis of the soils above. In some cases this parent material has been deposited by volcanic eruptions as lava or ash, as ground rocks and rock dust from retreating glaciers or by recent sedimentary events such as flooding rivers, lakes and sea sands.

Other soils have come from the 'weathering' of harder rocks of igneous, metamorphic or sedimentary origin over longer geological periods. The standard geological and soil books state that these rocks were weathered down by the normal physical weathering events such as extremes of heat and cold, wind and running water or by chemical weathering such as weak acids to produce their respective soils. Chemical weathering can be applied to limestone and dolomite, however most acids and alkalis have little effect on the silicates that form most rocks, especially the very dilute organic acids that are formed in normal soil processes. Strong acids and alkalis are usually stored in glass containers because they resist these. Glass is very pure silica.

Similarly the extremes of atmospheric weather such as abrasive winds, very hot or freezing cold temperatures and fast flowing water rarely reach the C horizon of the soil and do not have enough effect to cause major weathering at this depth in the soil.

These types of weathering are now being seriously questioned as the most significant parts of the weathering process that forms soils.

❑ **Biological weathering**



Moss builds soil from rock

A large body of scientific research is showing that a major part of the rock decomposition process that forms soils is biological, rather than mechanical or chemical.

Scientists studying these rocks have **found a wide range of micro-organisms, higher animals such as worms and plant roots** that mine them for specific minerals.



These micro-organisms produce various enzymes that will **extract their desired mineral or minerals from the parent rock**. Three very important outcomes happen in these complex biological processes of mining rocks for minerals.

The process of the soil biology mining the parent material for new minerals is the key to maintaining a fertile and productive soil. This can be achieved if there is an active and healthy soil biology and the key to a healthy soil biology is to feed it with organic matter

➤ **Orphaning of other minerals**

When the biological agents extract the mineral that they want (for instance potassium), they will 'orphan' release the other mineral or minerals that it was attached to (for instance silica). These orphaned minerals can be taken up by other organisms or combined with other minerals to form new compounds outside of the parent rock.

➤ **Cause rock to decomposed**

The gradual loss of the minerals that are holding the parents rocks together cause them to crumble into smaller particles and start the process of forming the physical basis of the soil type.

➤ **Feed the soil food web**

The initial micro-organisms that mine the minerals continuously die and are consumed by other micro-organisms to form a food chain through the soil food web. This results in some of the newly mined minerals being taken up by plant roots.

Von Liebig showed that plant roots could extract the minerals directly from rocks in 1840 and Charles Darwin conducted similar experiments later that century that showed the ability of plant roots to extract significant amounts of minerals and weather rocks.

Darwin also showed how smaller rock particles were weathered when they went through the digestive tracks of worms and how these minerals were bio-accumulated in the worm casts in the top soil or A horizon.

At this stage there is limited scientifically verified data on specific micro-organisms that can be used in farming to improve the availability of soil mineral for crops. There are many companies and organizations making claims about their proprietary micro-organisms, however few have had these claims verified in the scientific literature.

The ability of microbes to extract significant amounts of minerals from the parent rock has been successfully used for commercially viable mining operations to collect minerals such as copper and gold. Mining companies have isolated specific microbes that they can use to inoculate the rocks to extract the required minerals in commercially viable quantities.

The other critical element is deep rooted plants. The cropping system needs to include species of plants that can send their roots down to the parent material in the C horizon

and extract the minerals. These plants also have another critical role of deepening the soil by their roots opening up the subsoils to allow the infiltration of air and water as well as the deposition of organic carbon that is shed by roots.

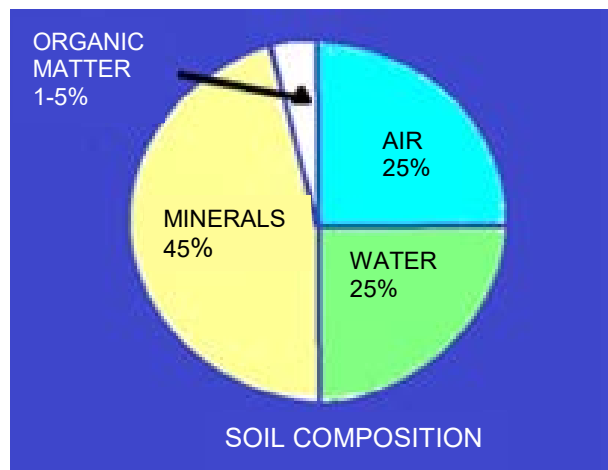
Ideally a farming system should not be exporting more nutrients from the soil through the sending crops off farm, than can be replenished from the parent rock by the farming system. Where more nutrients are exported than can be naturally replenished it is critical to look at two key areas.

Firstly to improve the soil biology so that it can replenish minerals at the same rate as they are exported and/or secondly to bring these required minerals to the farm where the natural system is not replenishing it. If either of these is not done then the land management system is unsustainably degrading the soil.

❑ Soil composition

Soils are made up of more than minerals. Soils also **contain air, water, organic matter and most importantly soil biology**. Soils are very different from inert mineral dusts such as ground basalt or sands. Most of the parent rocks of soil if they are finely ground into a powder will barely support plant growth if they are used as potting media. When organic matter with living biology such as fresh compost added, they support good plant growth. Organic matter and its biology is the key to turn dirt into soil.

The typical textbook soil contains around 45% minerals, 25% air, 25% water and around 1 to 5% organic matter. The soil biology is found throughout however it is concentrated in the organic matter and particularly in the zone around the roots.



❑ Soil color

Soil color can be **one of the indicators of soil quality** and it is used as **one of the classifiers of soil type**.

The parent material is one of the determinants of soil color however other factors such as organic matter levels and drainage can change this.





Munsell Book of Soil Color Charts

Black and dark/chocolate brown colors are caused by the organic matter levels. The blackness comes from high levels of organic carbon that occurs in organic matter.

The red colors come from the two most common elements in soils, iron and aluminum oxides. Oxides form due to presence of the oxygen in the air and reddish subsoils are usually a sign of well aerated subsoils – which usually indicate good drainage.

White soil can come from silicates such as sand, pure kaolin clays and from excess salt. High levels of salt indicate levels of sodium and chlorine that are toxic for plants.

Very white sands or clay soils indicate soils that are critically low in nutrients will need a lot of building up with organic matter and other amendments to be able to grow viable crops.

Soils with grey to blue subsoils show poor drainage or regular waterlogging in the wet seasons of the year. These soils generally need a range of works to remediate them. This type of soil or farm remediation is not in the scope of this manual.

□ Texture

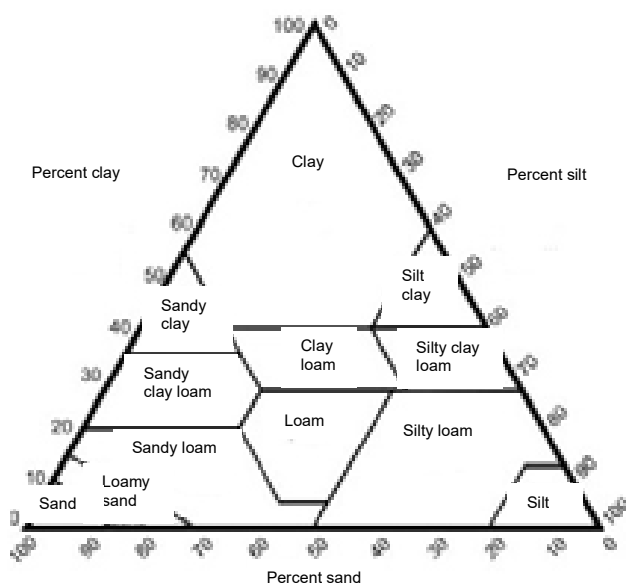
In classical soil manuals the texture of the soil is determined by the **proportions of three distinct particle elements**. These are sand, silt and clay.

Sand is defined as particles of silica from 2.0 to 0.02 millimeters. **Silt** are defined as particles of various sources from 0.02 to 0.002 millimeters. **Clay** are defined as platelets of aluminum silicate of less than 0.002 millimeters.

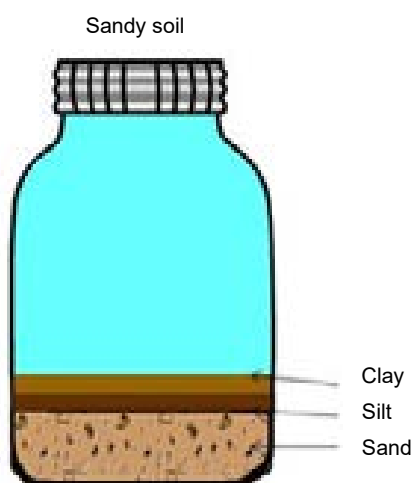
The critical areas for clays are the **colloidal clays** in the range from **0.0005 millimeters to less than 0.00002 millimeters**. Humus is also in colloidal form.

Colloidal particles such as clay and humus are very important as they **have the most sites for exchanging nutrients to plants via ion exchange**. This means that soils with high levels of these types of colloids can store more nutrients that can be made available for plants.





The texture of a soil is classified by the percentage of each of these particle elements that is found in the soil.



This can easily be done by finely crushing the soil, mixing it with water and letting it settle out until clear. It should be done in a clear glass container with straight sides. The largest and first particles to settle are the sand particles, followed by the silt and finally the clay will settle on the top. The colloidal particles of clay and humus will be the last to settle.

Some of the organic matter will float to the top and other bits will settle on top of the clay and some of it will disperse through all the layers.

Once all the layers have settled it is quite easy then to measure each of these with a ruler and work out their relative percentages. This is then used to work out the type of soil.

Standard texts will state that the soil on a farm cannot be changed and this it will always stay that way. If the farm has a heavy clay soil it will always have a heavy clay soil and if it has a light sandy soil it will have that type of soil.



However when organic matter is combined with either clay or fine sand particles that can give soils the same loam textures that silt produces.

The fact is that the regular addition of organic matter will move a sandy soil towards a sandy loam and a clay soil towards a clay loam. Loams are regarded as amongst the best of soils. This is yet another reason why building up soil organic matter is so important.

2.2.2. Mineral fertility

Professor Von Liebig's research and a substantial amount of further scientific research have determined that plants need a range of minerals. Several of these are needed in major quantities and are called macro nutrients and the others although still essential to growth and yield are need in trace amounts. Consequently **minerals are divided into macro nutrients and micro nutrients** (or trace elements).

The science behind multiple roles that minerals have in the numerous biochemical functions, as well as in the soil to assist these functions, continues to expand annually and shows that there is far greater complexity than we fully understand.

New minerals are being added to the list all the time and some of them that were previously ignored such as silica clearly show the faults in the original scientific methodologies that were used to determine which minerals are essential to crop yield. Other minerals are not essential, in that crops will grow without them however they will not reach their full genetic potential of high yields or will be more prone to damage from pests, diseases and weed competition in the mineral's absence.

A number of nutrients such as cobalt may not be directly needed by the plant however they are essential for symbiotic micro-organisms such as Rhizobium bacteria that fix nitrogen in the root nodules of legumes.

The critical issue is that plants need the complete range of them to function well. As Von Liebig's law of minimums show, maximum crop yield will be determined by the level of mineral/minerals that is/are deficient.

Organic matter is one of the best sources of all these minerals because it is usually made up from the residues of a mixture plants that will contain all the required minerals for plant growth. The critical issue that needs to be determined is if there are deficiencies in any of the levels of specific minerals.

□ The three major nutrients

Three of the macro nutrients, **carbon, hydrogen and oxygen account for between 95 to 98% of the biomass of most plants**. These elements are sourced from the air and water and are combined through photosynthesis into glucose and then through other biochemical processes to form cellulose, lignins and most of the other numerous compounds that make up plants.

➤ **Carbon**

Carbon is the fundamental building block of all plants.

It is mostly sourced from the carbon dioxide in the air and combined with the hydrogen and oxygen from water through photosynthesis to make simple sugars - glucose and/or fructose.

Glucose is the basic molecule of life. It is the energy source of the cells of plants and animals. Glucose molecules can be combined together and slightly modified to build many other sugars such as sucrose (cane sugar), dextrose (fruit sugar), lactose (milk sugar) etc.

Glucose molecules can be **combined together in long chains to form cellulose.** These are the basis of paper and wood. Glucose molecules can be also combined together in a different type of long chain to form carbohydrates – starch which is the basis of flour, bread and staples such as rice, wheat, potatoes, cassava etc.

The carbohydrates can be modified to form hydrocarbons – oils and fats. Glucose molecules can be modified again with the addition of nitrogen and sometimes sulphur to form amino acids – the basis of proteins, DNA, hormones etc.

Nearly all life on earth is dependent of the products of photosynthesis either directly or indirectly as in the case of micro-organisms and animals. We get our sugars, starches and oils from plants or from animals that have fed on plants.

Carbon is the major component of soil organic matter. The vast majority of this carbon has come from the CO₂ in the air that has been captured through photosynthesis.

➤ **Hydrogen**

As stated in the section above, hydrogen is an essential component in the sugars and all the other organic molecules in plants. Its primary source is from water. Hydrogen ions also have a key role in the electron transport chain in photosynthesis, respiration and other functions in the plant.

➤ **Oxygen**

Oxygen is the key element for life in most living organism as it is necessary for the respiration of cells. It is also one of the building blocks in most of the organic compounds that are synthesized by plants.

Plants get most of their oxygen from both water and air. It is critical for most plants that their roots get oxygen from the air in the soil. If not the plants roots tend to die very quickly affecting both the water and nutrient uptake if the soil. Plants can quickly wilt in waterlogged soils from the lack of water due to root death from lack of oxygen.

The remaining 5% or less comes from the soil.



While the following list of nutrients usually account for between 2 to 5% of the total biomass of a plant; a deficiency in one of them will limit the yield of the crop. All of these nutrients are important and need to be supplied in the correct proportions.

☐ Primary macro nutrients

➤ Nitrogen

Plants need nitrogen to **build amino acids from glucose**. Amino acids are the **basis of DNA, RNA, proteins, hormones and numerous other essential compounds in plants**. These are some of the most important molecules of life and clearly define the living biota of the planet from non-living structures. This is why nitrogen is regarded as the most important of the soil based macro nutrients.

Standard agronomy texts state that the majority **of nitrogen used by plants** is in **nitrate form** with a smaller percentage in the **form of ammonium**. However an increasingly growing body of scientific evidence is showing that most plants absorb nitrogen **in amino acid form** and in some instances that can be the main form of nitrogen that they use.

➤ Phosphorus

Phosphorus is essential and fundamental to the cellular energy function in plants and animals. It **forms a key part of Adenosine-5'-triphosphate (ATP)**. ATP's main role is to **transport chemical energy** obtained from glucose within cells so that they can function. ATP is also involved in the synthesis of many other compounds within plants. As a result every cell in a plant needs good amounts of phosphorus. Phosphorus also has several other key roles that involve enzymes and other compounds within the plants.

➤ Potassium

Potassium regulates the **opening and closing of the breathing holes** on the plant leaves (**stomata**). Stomata absorb oxygen and carbon dioxide that are essential for plant life as well as a significant amount of other nutrients that are carried in the air. Stomata also have a major role in water transpiration to stop water loss in the heat of the day.

One of potassium's most important roles is in the **building of cellulose, the protective outer covering of plant cell walls**. When the nitrogen to potassium relationship is out of balance with too much nitrogen, thinner longer cell wall structures are built. This can predisposed some plants to easier attacks from pests and diseases and also make crops more susceptible to falling over (lodging).

These types of potassium deficiencies can be easily overlooked as the excess nitrogen initially gives the impression of tall fast growing crops. Many farmers will blame the pest, disease or weather for the crop losses rather than the poor cell structure caused by the imbalance.

☐ Secondary macro nutrients

➤ Calcium

Calcium is regarded a secondary macro nutrient in most agronomy texts, while others will rank it higher. It is required by every cell in the plant **to assist in movement of many other nutrients throughout the plant**. Therefore it has a key role and not enough

calcium will result in reducing many of the essential biochemical processes, leading to stunting and reduced yields.

Calcium has a key role in building healthy soils with good structure. This is critically important to achieving high yields of good quality crops.

➤ **Magnesium**

Magnesium is a **key element of chlorophyll molecules** and gives the green color to plants. It also has many other important roles.

➤ **Sulphur**

Sulphur is used as the **part of several major amino acids**, vitamins and has several key roles in the processes involved in photosynthesis.

☐ **Micro nutrients**

➤ **Iron**

Iron is used for photosynthesis.

➤ **Molybdenum**

Molybdenum has a **critical role in the enzyme that plants use to add nitrogen to glucose** to form amino acids. Without it plants cannot use nitrogen to build the amino acids that form the DNA in every plant cell, hormones and the proteins needed to form seeds such as grain crops or fruit crops. The amount of nitrogen a plant can use is determined by the amount of molybdenum.

➤ **Boron**

Boron is used by plants **to transport calcium around all of the tissues**. The amount of calcium a plant can use is limited by the amount of boron. As calcium is essential for the transport of many other minerals throughout a plant, a boron deficiency results in multiple deficiencies and severely reduces crop yield.

It also has several other key roles.

➤ **Copper**

Copper has an important **role in the bio-synthesis of lignins**, the compounds that glue the plants walls together and give plants strength and flexibility. Lignins are the primary compounds used to build humus; the most important and stable form of soil organic matter. Copper is also necessary for photosynthesis.

➤ **Manganese**

Manganese is necessary **for plant cells to make chloroplasts**, the mini engines in plants that perform the task of photosynthesis.



➤ **Sodium**

Sodium has numerous roles in plants, however sodium deficiencies are very rare.

➤ **Chlorine**

Chlorine is needed for plants to **transmit the nutrients between the cells** and ensuring that their balance is correct.

➤ **Zinc**

Zinc has numerous roles in many key enzymes and hormones as well as the building of DNA within plant cells.

☐ **New minerals**

The following are examples of new minerals that rarely if ever can be found in older texts on agronomy.

➤ **Silicon**

Most of the earlier agronomy texts do have any references to silica despite the fact that is a major element in many species of the grass family especially species such as rice, sugar cane and bamboo. The hard protective outer coatings of bamboos are made of silica. The itchy hairs of sugar cane and many tall tropical grass species such as guinea grass come from sharp hairs made of silica.

Scientific research is discovering a diverse range of roles that silica has in building healthy plants and crops. One of the most important is that silica has a **role in strengthening the defenses of plants to stop disease and pest attacks.**

➤ **Nickel**

Some plants can use Nickel to produce an enzyme that allows them to **directly use the urea form of nitrogen**, rather than the normal route where it is transformed into nitrate by a series of soil micro-organisms.

➤ **Cobalt**

Cobalt can be indirectly useful for some plants. It is **essential for the Rhizobium bacteria** that synthesize nitrates that are used by legumes. These bacteria need cobalt to make vitamin B12.

➤ **Selenium**

Research has found that good levels of selenium in the soil **increase the protein and amino acids levels in crops**, especially grains. It has been found to increase the sulphur based amino acids such as methionine that are regarded as essential to many species of animals.



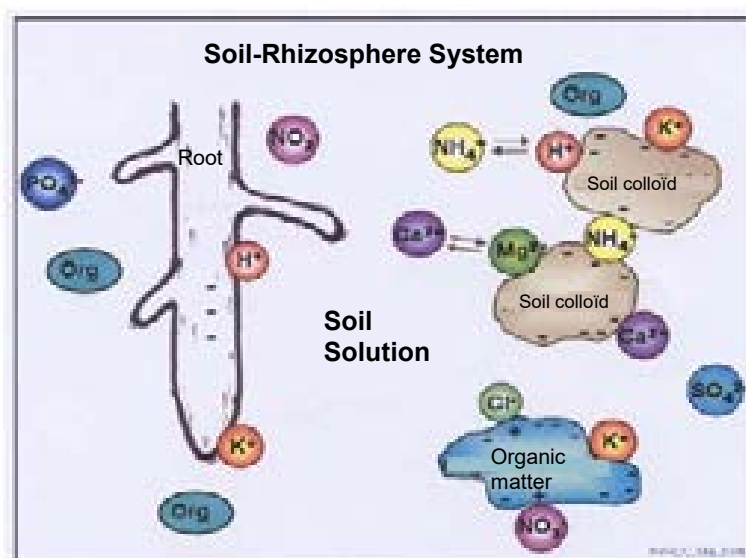
➤ **Vanadium**

Some plants may require vanadium in low concentrations and **in some cases it can be a substitute for molybdenum.**

2.2.3. Biological fertility

Von Liebig downplayed the role of humus in plant nutrition and consequently ignored the critical multifunctional roles of organic matter and soil biology in helping plants obtain good levels of minerals. This has had an unfortunate effect for agriculture for around 150 years as most conventional agriculture systems ignored the key multifunctional roles of the soil biology. This is starting to change as a range of scientists and agronomists are researching it and beginning to apply it to crop production.

❑ The rhizosphere



The term and the concept of the Rhizosphere were proposed by the German scientist Lorenz Hiltner in 1904. Hiltner observed that the **greatest concentration of soil micro-organism** could be found in a **narrow zone surrounding the roots of plants**. He also observed that they were feeding on the sheaths that roots shed as they grow as well as a number of other exudates such as sugars and amino acids.

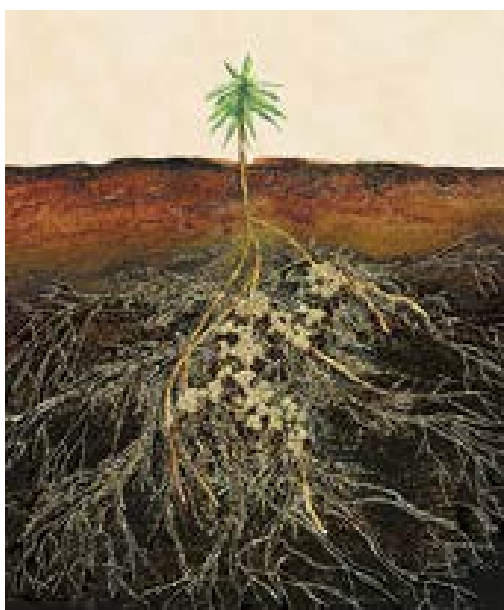
He proposed that the **overall health of plants depended on the health of these diverse colonies of microbes** in that they helped to prevent pathogens and also assisted with the uptake of minerals.

“Based on his observations he hypothesized that ‘the resistance of plants towards pathogenesis is dependent on the composition of the rhizosphere microflora’. He even had the idea, that the quality of plant products may be dependent on the composition of the root microflora” (Hartmann et al., 2008).

Numerous studies show that these microbes produce a range of compounds that plants use for nutrition. The best known are the Rhizobium bacteria that live in the roots of legumes. These organisms convert nitrogen into forms that plants can use.

Hiltner actively worked on applying his observations to improve the productivity of crops and as a result was involved in the first patent on Rhizobium inoculants and developed other microbial inoculants for seed dressings to protect the emerging seedlings (Hartmann *et al.*, 2008).

Other examples of groups of **beneficial micro-organisms are the VAM (Vesicular Arbuscular Mycorrhizal)** and related fungi. These fungi live in the roots of plants and extend their threads of mycelium into the soil to mine minerals. They exchange these minerals for glucose. They are particularly **important with the uptake of phosphorous in many plant species** as they have enzymes that can split phosphorous off rocks and locked up molecules such as iron phosphides and tri-calcium phosphates and feed them into plant roots.

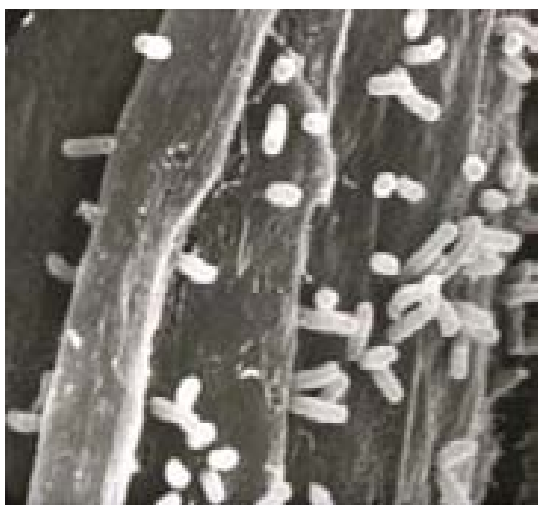


Many of these fungi also protect their hosts from diseases as well as helping them with nutrition.

The science around the Rhizosphere has now increased significantly, however the complexity of the interactions of the massive biodiversity in the soils around the roots means that it is still not well understood and as a result it is not being widely applied in most of agriculture.

One of the critical issues that is emerging is that high soil microbe biodiversity is essential and that these micro-organisms work in symbiosis to fight off pathogens. The most recent study into disease suppressing soils found that more than 33,000 species worked together to suppress diseases.

*“Disease-suppressive soils are exceptional ecosystems in which crop plants suffer less from specific soil-borne pathogens than expected owing to the activities of other soil micro-organisms. For most disease-suppressive soils, the microbes and mechanisms involved in pathogen control are unknown. By coupling PhyloChip-based metagenomics of the rhizosphere microbiome with culture-dependent functional analyses, we identified key bacterial taxa and genes involved in suppression of a fungal root pathogen. More than 33,000 bacterial and archaeal species were detected, with Proteobacteria, Firmicutes, and Actinobacteria consistently associated with disease suppression. Members of the γ -Proteobacteria were shown to have disease-suppressive activity governed by nonribosomal peptide synthetases. Our data indicate that upon attack by a fungal root pathogen, plants can exploit microbial consortia from soil for protection against infections” (Mendes *et al.*, 2011).*



Nitrogen-fixing Rhizobium bacteria colonized on the root hairs of clover plants

Similarly the number and types of free living micro-organism species that fix nitrogen continues to increase as researchers find more. Most texts will only mention **Rhizobium bacteria that live in symbiosis in the nodules of legumes**. A few more will mention the free living nitrogen fixing organisms such as azotobacter, cyanobacteria, nitrosomas and nitrobacter.

However there are many more that live in the rhizosphere and help plants take up nitrogen from the soil. Researchers are just starting to discover them. Once again they are finding that there are multiple species that work in symbiosis to achieve this.

Researchers are also finding new nitrogen fixing species in the rhizospheres associated with most species including hostile environments like mangroves growing in sea water.

“These findings indicate that (i) other species of rhizosphere bacteria, apart from the common diazotrophic species, should be evaluated for their contribution to the nitrogen-fixation process in mangrove communities; and (ii) the nitrogen-fixing activity detected in the rhizosphere of mangrove plants is probably not the result of individual nitrogen-fixing strains, but the sum of interactions between members of the rhizosphere community” (Holguin et al., 1992).

❑ **Soil biology is multifunctional**

Soil biology has numerous functions in ensuring optimal crop production. The list below is a summary of some of them.

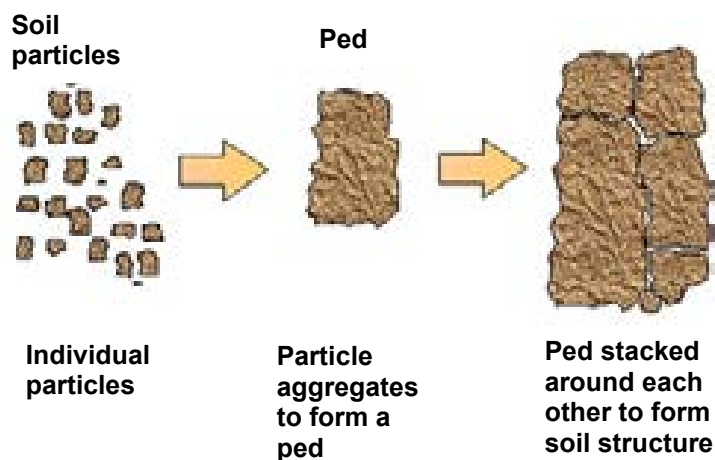
1 Make nutrients available

- Decomposing organic matter and releasing nutrients.
- Dissolving minerals from rock.
- Chelating and complexing nutrients.

2 Improve soil structure

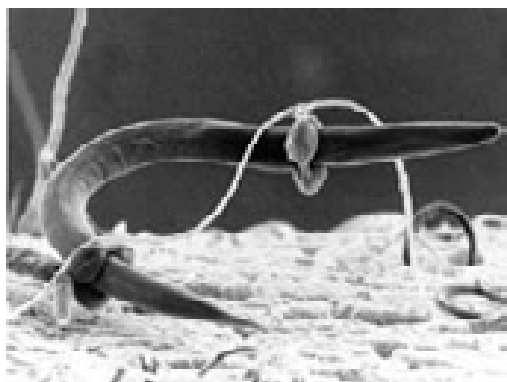
- Building peds by disturbing and stirring clay and other particles into open random forms and gluing them together with humus, organic polymers and fungi hyphae.





- Macro-organism (earth worms and beetles etc.) making large pores for drainage.
- ‘Cultivating’ the soil, breaking into hard pans and moving soil particles around and making pores.

3 Interact with the plants



A fungus traps a nematode in the soil

➤ Indirectly:

- Predating pathogens e.g. eating pests and diseases.
- Protozoa eating bacteria wilt.
- Fungi eating nematodes.
- Nematodes eating nematodes.
- Producing antibiotics killing pathogens.
- Suppressing pathogens through outnumbering them.
- Detoxifying synthetic chemicals and poisons.
- Free living organisms such as Azobacteria and Cyanobacteria, fixing nutrients like nitrogen from the soil air into plant available forms.

☐ **Directly:**

- Plant Health:
 - Creating enzymes, vitamins, amino acids, and plant growth factors.
 - Stimulating plant immune systems.
- ☐ Nutrition:
 - Rhizobia - Fixing soil nitrogen into plant usable forms.
 - VAM fungi - Directly feeding nutrients into plants.

Soil organic matter is the key to a healthy soil biology. The amount of biological activity in a soil is directly related to levels of soil organic matter.



2.3. Soil fertility management in organic agriculture

2.3.1. Soil fertility management principles

□ Mineral balance

A critical area of soil health is **to have adequate levels of all minerals**. It is important to ensure that there are no mineral deficiencies or large excesses of minerals. Deficiencies in macro and trace elements will limit yield and also predispose plants to disease and pest attacks. Large excess of nutrients can cause other minerals to be locked up. In effect they create an artificial deficiency of these locked up minerals.

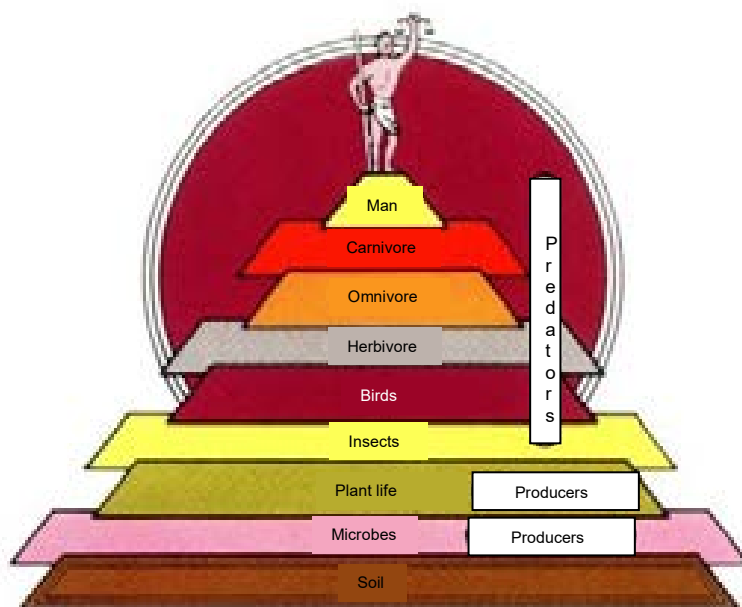
Von Liebig was the first scientist to show that plant growth is dependent on adequate levels of nutrients in the form of ions – cations and anions and this formed the basis of modern agronomy with water soluble synthetic fertilizers.

Emeritus Professor of Soils at the University of Missouri, **Dr William Albrecht** was the first soil scientist to show **the importance of having all the soil minerals in a balanced ratio along with adequate levels of organic matter**.

Whereas Professor Von Liebig felt that organic matter was not important and all necessary plant minerals could be supplied by soluble chemical fertilizers, Professor Albrecht wrote extensively on the importance of organic matter in acting as the primary source for plant nitrogen and as the buffer and storehouse of all the minerals that plants needed along with the importance of the correct soil biology to do this.

Albrecht reintroduced the concept of the soil as living and the fundamental importance of organic matter and soil biology in this process.

“Decomposition by micro-organisms within the soil is the reverse of the process represented by plant growth above the soil. Growing plants, using the energy of the sun, synthesize carbon, nitrogen, and all other elements into complex compounds. The energy stored up in these compounds is then used more or less completely by the microorganisms whose activity within the soil makes nutrients available for a new generation of plants. Organic matter thus supplies the ‘life of the Soil’ in the strictest sense. When measured in terms of carbon dioxide output, the soil is a live, active body.” (Albrecht, 1938).



Albrecht also firmly established **the link to between plant health, particularly the role of soil mineral deficiencies and the health of the animals and ultimately the humans** who fed on the plants and animals.

He showed the direct link between poor quality forage crops and the health of the stock that fed on it. For Albrecht soil health was the fundamental basis of crop health, good yields and animal and human health.

This clearly fits within the organic paradigm of building a healthy soil to grow a healthy plant, rather than the conventional farming paradigm of just adding the soluble nutrients for the plant to take up from the soil solution.

The **two critical issues** that Albrecht wrote about was to have **soils** that had **adequate amounts of all the minerals** that plants need and that these should be the **correct balance or ratios** to achieve the highest yields. These ratios are guidelines meaning that they can and should be modified depending on the environment.

For Albrecht, **soil nutrition** was not about directly feeding the plant, it was about **building a healthy soil** that would produce high yields of healthy plants and animals.

Albrecht found that high levels of calcium will form soils with good ped structures whereas as high levels of magnesium will tighten soils.

This can be applied appropriately to different soil types. Clay soils need high levels of calcium to open them up and these is research that increasing magnesium on sandy soils will tighten them up and give better water and nutrient holding capacity.

While Albrecht wrote about calcium being the most important cation, his papers on organic matter clearly state that nitrogen in the form of nitrate (an anion) is the nutrient that plants needed in the largest quantities and insufficient nitrogen was the one of the major limitations in yield.

Decades of research shows that soil with low levels of organic matter do not have many spaces in the soil where nitrate anions along, with other anions, can adsorb (stick) to be stored for later used by plants. Most of the electrostatic charges on the clay colloids are negatively charged. This means that that they will attract and store cations, however they will repel the negatively charged anions. This is one of the reasons why anions like nitrate are readily leached from the soils with low levels of organic matter. The humus in organic matter has charged sites that will attract and store anions like nitrate.

Albrecht's research showed that for plants to obtain sufficient nitrate that the nitrogen produced in the cation form of ammonium had to be turned into nitrate by the soil biology.

"Soil organic matter is the source of nitrogen. In the later stages of decay of most kinds of organic matter, nitrogen is liberated as ammonia and subsequently converted into the soluble or nitrate form. The level of crop production is often dependent on the capacity of the soil to produce and accumulate this form of readily usable nitrogen. We can thus measure the activity that goes on in changing organic matter by measuring the nitrates. It is extremely desirable that this change be active and that high levels of nitrate be provided in the soil during the growing season" (Albrecht, 1938).

The other key issue he wrote about was **the stable carbon to nitrogen ratios in soil organic matter**. This was the primary source of most plant nitrogen.

Albrecht was the first soil scientist to write widely on the relationship between nitrogen and soil organic matter and showing that the correct way to maintain sustainable fertility was to have farming systems that recycled enough organic matter to have the quantities of nitrogen that are needed by the crop.

The other very important role for organic matter that Albrecht wrote about was **the buffering role for organic matter**. While Albrecht wrote widely about the need for the correct percentages and ratio of available cations in soils, he also showed that **adequate levels of organic matter would act as a buffer where the ratios were not exact and ensure that plants would receive the correct amounts of nutrients**. The key was that there were no deficiencies and that there were adequate levels of all the nutrients that plants needed.

Equally important Albrecht showed that **adequate levels of nitrogen, calcium and other minerals were essential to building soil organic matter**. *"Bacterial activity does not occur in the absence of the mineral elements, such as calcium, magnesium, potassium, phosphorus, and others. These, as well as the nitrogen, are important: Recent studies show that the rate of decomposition is reduced when the soil is deficient in these elements. In virgin soils high in organic matter, these elements also are at a high level, and are reduced in available forms as the organic matter is exhausted. A decline in one is accompanied by a decline in the other"*.

*“ [...] It has recently been discovered that the **fixation of nitrogen** from the atmosphere by legumes is more **effective where high levels of calcium** are present in available form. Thus, if in calcium-laden soils, excellent legume growth results and correspondingly large nitrogen additions are made, such soils may be expected to contain much organic matter. **Liberal calcium supplies and liberal stocks of organic matter are inseparable.** The restoration of the exhausted lime supply exerts an influence on building up the supply of organic matter in ways other than those commonly attributed to liming” (Albrecht, 1938).*

2.3.2. Composting

Adding organic matter to the soil is the most **effective way to increase soil quality**. This can be done in a variety of ways including using composts, mulches, both living and dead as well as green manure cover crops.

Compost is the ideal way to improve soil quality, build up soil organic matter levels and to correct mineral balances. The best way to balance the soil minerals is to work out the amounts needed through a soil test and adding these as ground minerals such as rock phosphate, ground basalt, potassium sulphate, gypsum etc. into the compost material when starting a compost pile. The biological processes that form compost will make these minerals readily available to plants in both quick release and slow release forms.

The resulting mineral rich compost is spread around the crops. Periodically trace elements can be applied. The trace elements can be mixed with molasses and/or compost tea and brewed for several days to make them bio available. These can be sprayed out over the field. The sprayer ensures an even spread throughout the field. It is the intention that most of the nutrients go into the soil.

This system ensures that the soil's biological activity releases a steady flow of all the nutrients needed by the crop to produce a good yield. The complete nature of the nutrition program ensures that there are no deficiencies.

❑ Composting methods

There are many methods that can be used to make compost.

➤ *Sheet composting*

Fresh manure is spread over a cover crop or crop residue and the composting process occurs in soil. It is usually a requirement of this system that a green manure crop is grown afterwards, which is either slashed or ploughed into the soil. One advantage is very little nutrients are lost through leaching or volatilization.

The risk is residual chemicals in manure such as, drenches, pesticides, atrazine,



antibiotics etc. that can interfere with the microbial breakdown of the raw organic matter and of weed seeds germinating.

➤ **Aerobic compost**



The advantage of this method is that it is **the fastest way to make compost**. The disadvantages are that more labor is required to do the regular turnings and each turning results in the loss of volatile nitrogen and other compounds.

Some requirements are:

- Ideal carbon to nitrogen (C:N) ratio of 25 – 35 : 1.
- Moisture 60% at point of making (when squeezed hard moisture appears on outside of the bolus).
- Temperatures that reach up to 70 degrees C.
- Constant supply of oxygen by turning at least weekly.
- Well mixed.
- Piles up to 2mtrs high with 45 – 60 degrees slump angle.
- Addition of high pH rock dusts such as lime and dolomite will cause nitrogen losses so need to be carefully managed.

➤ **Anaerobic compost**

- As above for aerobic compost.
- Less oxygen means that it takes more than twice as long before it is ready to use.
- Less nitrogen loss.
- Anaerobic bacteria create a range of low pH organic acids and enzymes that are useful in making mineral rock dusts (lime, rock phosphate, crushed basalt, dolomite, gypsum etc.) bio available.
- Cheaper to make due to less costs for turning to oxygenate.

The permanent compost pile

The pile is started with a combination of fresh and dried organic matter and a mixture of local worms are added at this point. All the sources of organic matter from the farm and around the farm are continuously added to the pile so that it is fed at least every week. The sources can include old palm fronds, branches, leaves, food scraps, weeds, animal carcasses, manure and any other form of organic matter.

Over time this heap will behave multiple species of worms, fungi, bacteria and other beneficial micro-organisms that will break down the organic matter into humus rich compost.

The heap is periodically opened up and the humus rich compost can be collected to be used on the fields. The semi decayed and undecayed organic separated from the compost and left on the same site to ensure that the heap is still continuously making compost. This heap continues to be fed.

❑ Sourcing compost ingredients



Compost can be made from any organic matter sources. This includes animal manures, grass, bushes, branches, leaves and particularly from weeds and overgrown vegetation.

Most farmers become good harvesters of organic materials from diverse sources. Letting the vegetation regenerate around the farm on hillsides, gullies, creeks and along the field borders is the best ways to ensure a constant supply of organic matter for compost making. This can be regularly managed to prevent it from getting out of control and the harvested cuttings can be used for making compost.

➤ *Brown and green sources*

Many compost books will talk about having the materials **in an ideal carbon to nitrogen (C:N) ratio of 25 – 35 : 1.**

They will also have table of the carbon to nitrogen ratios of many ingredients and examples of how to do the mathematics that are need to work out the percentages of each of these to make the ideal ration when using multiple sources.

Most farmers find this too complicated to use. A more practical way is to think of **using a mixture of brown and green organic matter sources.** Brown or dried organic matter sources are usually high in carbon and low in nitrogen. Green or fresh organic matter sources such as freshly cut grasses usually have high levels of nitrogen in relation to carbon.

Mixing the brown and the green will give a good ration of carbon to nitrogen. Experience will be the best guide to getting a good result.

Time is the important factor. Lower levels of nitrogen will mean that it will take longer to break down into humus rich compost. This means that farmers should start making compost **at least 6 months to a year before they need to use it.**

❑ Composts benefits

Research shows that good quality compost is one of the most important ways to improve soil. It is very important to understand that compost is a lot more than a fertilizer.

Compost contains humus, humic acids and most importantly a large number of beneficial microorganisms that have a major role in the process of building healthy soils – especially humus.



Farm compost heap in Kenya

➤ **Humus**

- Adds humus and organic matter to the soil.
- Inoculates soil with humus building microorganisms.
- Improves soil structure to allow better infiltration of air and water.
- Humus stores between 20 to 30 times its weight in water and significantly increases the capacity of soil to store water.
- Humus stores nitrogen and other nutrients for later use by plants.

➤ **Nutrients**

- Mineral nutrients.
- Organic based nutrients.
- Contains a complete range of nutrients.
- Slow release.
- Does not leach into aquatic environment.

➤ **Beneficial micro-organisms**

- Supplies a large range of beneficial fungi, bacteria and other useful species.
- Suppresses soil pathogens.
- Fixes nitrogen.
- Increases soil carbon.
- Release of locked up soil minerals.
- Detoxifies poisons.
- Feeds plants and soil life.
- Builds soil structure.

➤ **Lowering greenhouse gases from compost**

In some parts of Europe and North America up to 10% subsoil clay is added to improve the texture. An acidic clay will stop the volatilization of nitrogen as ammonia. Ammonium

ions will stick to the clay. This lowers the amount of nitrogen based greenhouse gases escaping from the compost.

Similarly it has been shown that potassium tends to leach out of compost heaps. Clay platelets tend to strongly attract potassium ions and will prevent leaching.

Anaerobic composts can have a carbon nitrogen ratio of more than 30/1 as the longer time favors more fungi than bacteria. Fungi need less nitrogen to do the job of breaking down the raw materials. A higher carbon ratio means that it will take longer for the micro-organisms to breakdown the organic matter and turn it into humus, however it will lessen the nitrogen loss and result in a compost with more useable nitrogen for the crop.

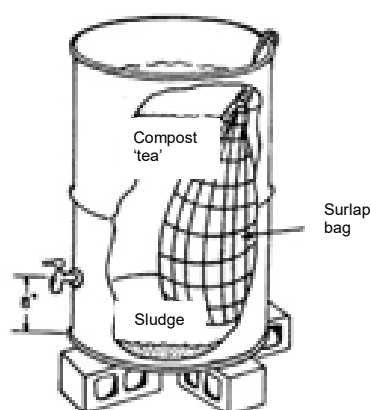
This also lowers the amount of nitrogen based greenhouse gases escaping from the heap.

Covering the compost pile with black plastic or fresh subsoil clay helps keep the moisture level stable. The black plastic will solarize the weed seeds on the surface of the pile while the compost heat will destroy most of the internal weed seeds. Please note that some seeds, especially those with hard coats can survive and germinate later.

Recent research from the USA has found that covering composts with a deep layer of wood chips stops all emissions of volatile organic compounds (VOCs) including greenhouse gases (B. Schafer, pers. com.).

Worms can be added to composts when the compost heap starts cooling down. They are particularly beneficial to anaerobic composts because over time they will turn over and aerate the whole heap. For farm scale compost piles this saves hours of work and many liters of diesel.

❑ Compost teas



Compost teas have been successfully used to inoculate soils with beneficial micro-organisms that will increase soil carbon, improve soil quality and in many cases suppress soil and plant diseases.

Compost teas are made by adding small amounts of compost to water and brewing for a while to ensure that the micro-organisms are active. There are many ways to make compost teas and some very good websites such as the Soil Food Web that give high quality information on how to do it.

It is best to spray out the teas in the late afternoon so that the micro-organisms are not killed by ultraviolet light.

❑ **Biodynamic preparations**

Biodynamic preparations such as *Preparation 500* (horn manure) can work in a similar manner to compost teas and have been very successful in building soil organic matter, especially humus.

2.3.3. Green manure

Green manures are crops that are grown purely to improve soil health and fertility by adding in fresh organic matter and nutrients such as nitrogen when they are incorporated in the soil.



Mucuna Pruriens used as green manure in Kenya

Green manures are generally a **part of a crop rotation** that is used to break the weed and disease cycles. These multifunctional benefits are explained in greater detail in the chapters on weed and pest managements. The other main reason for green manure is to plant and then incorporate them into the soil just before the cash crops to provide a release of nutrients for the cash crop.

Virtually all plants that are grown can be used as green manures, **however legumes are the preferred plants** as they can provide **significant amounts of both organic matter and nitrogen**.

The use of green manures is one of the oldest and proven methods to improve nitrogen and organic matter levels in the soil.

“The restoration of soil organic matter, then, is a problem of increasing the nitrogen level or of using nitrogen as a means of holding the carbon and other materials. This is the basic principle behind the use of legumes as green manures. In building up the organic content of the soil itself, it will often be desirable to use legumes and grasses rather than to add organic matter, such as straw and compost, directly. If legumes and grasses are to be successfully grown on many of the soils of the humid regions of this country it will be necessary, first, to properly fertilize and lime the soil. Legumes use nitrogen from the air instead of the soil, and thus serve to increase the amount in the soil when their own remains are added to it” (Albrecht, 1938).

2.3.4. Mineral fertilizer

This is the area of the greatest misunderstanding between the organic and conventional industries. It is also an area where most farming systems seriously mismanage their growing systems.

The standard for most conventional farming systems has been just to supply three major minerals – nitrogen, phosphorous and potassium (NPK). Consequently a large proportion of farming just uses NPK without testing for the other needed nutrients.

The best illustration of this is Von Liebig's Barrel. The amount of water it can hold is limited by the lowest stave. The highest staves do not help to hold more water.



It is the same with soil nutrients. High levels of NPK will not increase yields if other minerals are deficient.

Examples

Plants have a high need of nitrogen as it is needed to be combined with glucose to make amino acids. Amino acids are critical keys to life as they make DNA, proteins, hormones and other essential components of cells and bodies.

The process of building amino acids from glucose and nitrogen requires a few steps within the plant. One of these steps needs just a few molecules of molybdenum to act as a catalyst for the process. Without it the plant can't use the nitrogen to make the



amino acids. It does not matter how much nitrogen the plant takes up from the soil, it can only use it in the proportion to the amount of molybdenum that it has to produce the amino acids it needs for growth and to produce seeds etc.

Plants need calcium in every cell as it is essential for the transport of many other minerals throughout the plant. Calcium, unlike many other nutrients such as sulphur, potassium and nitrogen is not readily moveable in the cell.

As a plant grows it can transfer many nutrients from the old leaves, before shedding them and use them in the new leaves. Most plants cannot do this with calcium so they need get new supplies from the soil. This means that it is critical to have good levels of available calcium in the soil.

Plants need boron to transport calcium around their structures and into the cells. Without adequate boron plants can end up with inadequate levels of calcium. It is important to ensure that soil boron levels are ok otherwise plants will end up with multiple mineral deficiencies.

❑ Organic systems use complete fertility

Organic farms on the whole have **avoided many of the deficiencies** due to always using fertilizing systems that have come from the decay of plant and animal materials. These generally contain all the minerals that plants need and generally in the good proportions as this how they naturally occur in the proportion needed by plants.

However there is a critical issue where organic systems can end up with mineral deficiencies.

❑ Organic as closed systems

Most texts on organic farming will talk about organic farming systems as being closed systems that should have minimal reliance on external inputs.

However organic farms are not closed when they are selling crops off the farm. They are exporting the soil nutrients in the crops that are taken off the farm.

The minerals that are not being replenished naturally need to be replaced by being brought onto the farm. If more minerals are exported than are naturally replenished by the biology, the system is not sustainable and is degrading the soil. The farming system is being run down. This goes against the Principles of Care, Ecology and Health.



The only way a land manager can tell if the soil needs to be replenished is **to use regular soil tests to measure the levels of the minerals.**

It is critical to establish an agreed baseline for a healthy soil. If any minerals have levels that are below the baseline, they need to be supplied to the soil to ensure that their available levels are equal or slightly more than the baseline.

Many farms have been running down their nutrient levels for decades, possibly for centuries and will have multiple mineral deficiencies. It is usually impractical and too costly to fix this in one go and land managers should look at 3 to five year programs to bring up the levels of all the nutrients. Once that has been achieved it usually only requires small amounts to adjust the soil. This is normally only kilos per hectare rather than tons per hectare.

The critical concept is to think of the soil as a shop that stores essential nutrients for the crop. If the shelves are full of the essential nutrients, the plants can and do select what they need. If the shelves are empty or almost empty, it means that the plants will be hungry because of the deficiency and this will stunt the performance of the crop.

Most of the required nutrients in organic farming can easily be obtained as ground minerals such as lime, dolomite, gypsum, rock phosphate, basalt quarry dust, granite dust and naturally mined potassium sulphate. These will supply virtually every major element, except for nitrogen and most of the trace elements. Trace element deficiencies can be corrected in certified organic systems by using water soluble salts – *i.e.* zinc sulphate, sodium borate, copper sulphate etc.

Fish emulsions and seaweed are an excellent way to correct trace element deficiencies and build healthy plants.

Legumes, green manures, composts and naturally occurring free bacteria are used to provide nitrogen, as well many other nutrients.

A short term strategy can be foliar applications of the locked up minerals to immediately correct the deficiencies. The longer term strategies are to increase the levels of humus to help buffer the excesses and to increase the levels of the other mineral minerals to ensure balanced proportions. It is important not to increase the levels of the excess minerals.

2.3.5. Nutrient level recommendations

❑ Soil test nutrient levels

The **benchmark figures** (see below) are **an indication only**. Albrecht stated that these ratios were guidelines. “*While the above ratios are guide lines [...]*” (Albrecht, 1967). They are based on a modified Albrecht system but have not been proven for most regions so are to be used as a guide and not as an absolute. This means that **they can and should be modified in other environments** and that there needs to be far more research to establish the best baselines for the various regions of the world.

However until this research has been completed the recommendation below can be used as a useful guideline.

Please note that the levels in this list are not based on the levels needed by plants as organic agriculture is not based on the model of feeding plants directly with water soluble nutrients. **The levels in the list are based on research about the levels needed to build soils that produce good yields of healthy crops.**



Suggested minimum baseline recommended nutrient levels	
pH	6.0 - 6.8
Organic matter	3 - 6%
Major nutrient	
Calcium	1,800 ppm
Phosphorous P1	100 ppm
Phosphorous P2	200 ppm
Nitrogen	60 ppm
Magnesium	300 ppm
Potassium	175 ppm
Sulphur	75 ppm
Trace elements	
Zinc	12 ppm
Manganese	20 ppm
Iron	20 ppm
Sodium	20 ppm
Copper	5 ppm
Boron	3 ppm
Chlorine	3 ppm
Molybdenum	1 ppm
Cobalt	0.5 ppm
P1 = water soluble P2 = acid tested	

There is very good evidence that plants need selenium, nickel, silicon, and other elements for good health and high yields, however there is very little research on the best levels for the soil.

Sources organic nutrients

➤ Allowable organic inputs

All of the nutrient that plants need can be supplied from sources that are allowed in certified organic agriculture. If your farm is certified, please check with the certifier before using any of these. Some certifiers have different requirements from others.

Nitrogen	Analysis of percentage
Manure	4-8%
Compost	1-4% av. 2%
Legumes	20 – 300 kg per ha
Green manures	0.5-5%
Fish emulsion	4-11%
Micro-organisms (azotobacter, cyanobacteria, nitrosomas and nitrobacter and other micro-organisms)	up to 40kg per hectare
Phosphorous	
Manure compost	up to 2%
Compost	up to 1%

Rock phosphate	24-30%
Bone meal	21-30%
Fish emulsion	1%
Potassium	
Naturally mined potassium sulphate	50% up to 1%
Basalt dust	4%
Granite dust	3.6-6%
Kelp	4-15%
Wood ashes	7%
Manures	0.3-2%
Compost	1 - 5%
Sawdust	1%
Fish emulsion	1%
Calcium	
Calcium carbonate (lime)	30-40%
Gypsum	22%
Dolomite	2%
Rock phosphate	16-30%
Magnesium	
Dolomite	20%
Granite dust	6%
Sulphur	
Elemental sulphur	100%
Potassium sulphate	18%
Gypsum	17%
Manures	0.1 – 0.2%

☐ Trace elements

- Rock Dusts – basalt, granite, rock phosphate, gypsum, lime and dolomite contain a wide range of trace elements.
- Compost (only if the materials used to make the compost are not deficient in the required trace element).
- Soluble mineral fertilizer forms are allowed to correct a recognized deficiency, i.e. zinc sulphate, sodium borate, copper sulphate, iron sulphate etc.
- Manures, seaweed, fish emulsion.

Soil organic matter has a carbon to nitrogen ratio of between 11-1 and 9-1. Most of this nitrogen is in amino acid form and the current body of science shows that it is biologically available to most plants.

☐ Carbon – Nitrogen Interactions – Add carbon to increase nitrogen

Soil organic matter, particularly the humus fractions tend to have a carbon nitrogen ratio of 9 to 1 to 11-1. As the carbon levels increase, the amount of soil nitrogen increases in order to maintain the carbon-nitrogen ratios.

This has, in part, led to the belief within conventional agronomy that it is necessary to add nitrogen into the soil to increase carbon. However the reality is the opposite.



Conventional farming systems that use synthetic nitrogen fertilizers generally have declines in soil carbon. There are published studies that show the clear relationship between the addition of synthetic nitrogen and soil carbon. **The more synthetic nitrogen that is added, the greater the loss of soil carbon in the system (Khan *et al.*).**

The exceptions are some of the conventional no-till systems that are getting small short term increases in the top centimeters of the soil. However longer term studies are showing that this small increase is limited to certain soil types, tends to plateau rather than continuously increase and does not deposit carbon into the deeper levels of the soil. The studies of the best organic systems are showing continuous increases in soil carbon and the deepening of the carbon levels in the soil profile.

One of the critical differences in organic systems is that by adding organic matter into the soil to increase carbon, the nitrogen levels increase in the 11-1 to 9-1 ratio.

The reality is that the conventional 'wisdom' has things backwards – the cart before the horse. Farmers should add carbon to increase nitrogen rather than adding nitrogen to increase carbon.

Much of this soil nitrogen is fixed by free living soil micro-organisms such as azobacters and cyanobacterias. It has been consistently shown that there is a strong relationship between higher levels of soil organic matter and higher levels of soil biological activity. This biological activity includes free living nitrogen fixers – and they turn the atmospheric nitrogen, the gas that makes 78% of the air, into the forms that are needed by plants. They do this for no cost and they are a major source of plant available nitrogen that is continuously overlooked in most agronomy texts.

❑ Understanding the ratios

It is important to get an understanding of the **potential for how much nitrogen can be stored in the soil organic matter for the crop to use**. Soil organic matter contains nitrogen expressed in a Carbon to Nitrogen Ratio. This is usually between 11:1 to 9:1, however there can be further variations. The only way to firmly establish the ratio for any soil is to do a soil test and measure the amounts.

Example

For the sake of explaining the amount of organic nitrogen in the soil we will use a ratio of 10/1 to make the calculations easier.

The amount of carbon in soil organic matter is expressed as Soil Organic Carbon (SOC) and is usually measured as the number of grams of carbon per kilogram of soil. Most texts will express this as a percentage of the soil to a certain depth.

There is an accepted approximation ratio for the amount of soil organic carbon in soil organic matter. This is $SOC \times 1.72 = SOM$.

The issue of working out the amount of SOC as a percentage of the soil by weight is quite complex as the specific density of the soil has to be factored in. This is because some types of soils are denser and therefore heavier than other soils. This will change the weight of carbon as a percentage of the soil.

To make these concepts readily understandable we will use an average estimation developed by Dr Christine Jones, one of Australia's leading soil scientists and soil carbon specialists. According to Dr Jones: "[...] a 1% increase in organic carbon in the top 20 cm [8 inches] of soil represents a 24 t/ha [24,000 kilograms] increase in soil OC..." (Jones, 2006).

This means that a soil with 1% SOC would contain 24,000 kilograms of carbon per hectare. With a 10 to 1 carbon to nitrogen ratio this soil would contain 2,400 kilograms of organic nitrogen per hectare in the top 20 cm.

Table of the amount of organic nitrogen held in the soil

1% SOC	2,400 kg of organic N per hectare	1.72% SOM
2% SOC	4,800 kg of organic N per hectare	3.44% SOM
3% SOC	7,200 kg of organic N per hectare	5.16% SOM
4% SOC	9,600 kg of organic N per hectare	6.88% SOM
5% SOC	12,000 kg of organic N per hectare	8.50% SOM

Good management of soil organic matter means that the soil around the root layer of the crop will contain enormous amounts organic nitrogen. It contains tons and tons of nitrogen rather than the hundreds of pounds or kilograms that are recommended to be added in most agronomy texts. This shows that there is no need for farmers pay the huge costs to purchase the synthetic nitrogen. Good farm management will mean that the farms can get considerably more crop available nitrogen for free.

❑ Nitrogen drawdown

Some organic matter sources with **carbon to nitrogen ratios of more than 100 to 1** such as sawdust, branches, dried leaves and bark, peanut shells etc. **can cause a temporary soil nitrogen deficiency** when they are still fresh and added to soils with limited biological activity.

This is because most microorganisms that break down organic matter need carbon to nitrogen ratios of between 20 to 1 and 30 to 1. They will draw nitrogen from the soil to make up the ratio, thereby creating a temporary deficiency until the decay process returns nitrogen into the soil.

The best way to avoid this temporary nitrogen deficiency is either to compost or to age the organic materials before they are added to the soil. This way they will be partially or completely decomposed and will be added to the soil with their appropriate decomposing microorganisms. This will negate or reduce the need for the microorganisms to use the soil nitrogen as they have already started the decay process using other sources.

Experience has shown that good organic soils tend to have enough microorganisms and soil nitrogen to breakdown these types of organic materials without causing a temporary nitrogen deficiency.



2.3.7. Developing nutrition a program for crops

It is important to get a complete soil test that will give the levels of all the nutrients in the soil.

The amount of nutrient needed

It is only necessary to add the nutrients where soil test levels are lower than the minimum level in the list above.

([recommended level in the list] - [soil test level]) x 2 = [the amount of nutrient that you need apply] in kilograms per hectare (kg/ha).

[2 is a conversion factor based on 150 mm of soil depth. A soil depth of 300 mm soil depth would require a conversion factor of 4].

Amount of organic fertilizer to apply

Units of the nutrient x % concentration of nutrient in fertilizer = amount of fertilizer to be applied to the field per ha.

Cost effectiveness

Very often Farmers cannot afford all the nutrients needed in one year in severely depleted soils. They should plan to apply it over several years to build up the soil mineral levels to optimum. Once optimum levels are achieved it is relatively easy to work on a nutrient budget based on estimates of nutrients lost through crop exports, runoff and periodic soils test every three years.

Exercise for soil analysis:

Nutrient: (N)

Recommendation: (R)

Soil test results: (S)

{ [recommendation] - [soil test level] } x 2 = [amount of nutrient you need apply] kg/ha

{(R) - (S) } x 2 = (U) units of (N) needs to be applied kg/ha

Fertiliser: (F) contains (F%) % (N)

(U) x (F%) = kg/ha

= t/ha (F) to be applied to the field



Example: **Calcium (Ca)**

Soil test indicates 1000 ppm
The list recommendation is 1800ppm

$(1800 - 1000) \times 2 = 1600$ units of Ca needs to be applied

Gypsum contains 22% Ca

$1600 \text{ Ca} \times 0.22 = 7,270 \text{ kg/ha} = 7.3 \text{ t/ha}$ Gypsum to be applied to the field

or

Lime contains 33% Ca

$1600 \text{ Ca} \times 0.33 = 4,850 \text{ kg/ha} = 4.85 \text{ t/ha}$ Lime to be applied to the field



2.4. Avoid farming techniques that destroy soil organic matter

The continuous application of organic matter as composts, manures, mulches and via plant growth will not increase soil organic matter levels if farming practices destroy soil organic matter. The following are some of the practices that result in a decline in soil organic matter and the alternatives that prevent this loss.

2.4.1. Only use organic nitrogen forms

Synthetic nitrogen fertilizers are one of the major **causes of the decline of soil organic matter (SOM)**. This is because it stimulates a range of bacteria that feed on nitrogen and carbon to form amino acids for their growth and reproduction. These bacteria have carbon to nitrogen ratios of between 20 to 1 and 30 to 1. In other words every ton of nitrogen applied results in the bacteria consuming between 20 to 30 tons of soil carbon (SOC). Using the standard ratio of $\text{SOC} \times 1.72 = \text{SOM}$ this means that around 35 tons of organic matter being lost from the soil.

Freshly deposited carbon compounds tend to readily oxidize into CO_2 unless they are converted into more stable forms. Stable forms of carbon take time to form. In many cases it requires years to rebuild the bank of stable carbon back to the previous levels.

Ensuring that a carbon source is included with nitrogen fertilizers protects the soil carbon bank, as the microbes will use the added carbon, rather than degrading the stable soil carbon. Composts, animal manures, green manures and legumes are good examples of carbon based nitrogen sources.

Where possible nitrogen should be obtained through rhizobium bacteria in legumes and free living nitrogen fixing micro-organisms. These micro-organisms work at a stable rate fixing the nitrogen in the soil air into plant available forms. They can utilize the steady stream of newly deposited carbon from plant roots to create amino acids, rather than destroying humus and other stable carbon polymers.

Research shows a direct link between the application of synthetic nitrogenous fertilizers and the decline in soil carbon.

“The application of soluble nitrogen fertilizers in the petroleum-based system stimulates more rapid and complete decay of organic matter, sending carbon into the atmosphere instead of retaining it in the soil as the organic systems do” (La Salle and Hepperly, 2008).

Scientists from the University of Illinois analyzed the results of a 50 year agricultural trial and found that synthetic nitrogen fertilizer resulted in all the carbon residues from the crop disappearing as well as an average loss of around 10,000 kg of soil carbon per hectare. This is around 33,000 kg of carbon dioxide per hectare on top of the many thousands of kilograms of crop residue that is converted in to CO_2 every year.

The researchers found that the higher the application of synthetic nitrogen fertilizer the greater the amount of soil carbon lost as CO₂. This is one of the major reasons why conventional agricultural systems have a decline in soil carbon while organic systems increase soil carbon. (Khan *et al.*, 2007; Mulvaney *et al.*, 2009).

2.4.2. Carbon builders rather than carbon eaters

The use of synthetic nitrogen fertilizers changes the soil biota to favor micro-organisms that consume carbon, rather than the species that build humus and other stable forms of carbon. By stimulating high levels of species that consume soil carbon, the carbon never gets to increase and usually continues to slowly decline.

Legumes, free living micro-organisms and compost are carbon based nitrogen suppliers. They **provide a carbon source as well as a nitrogen source so they do not consume existing soil carbon and convert it into CO₂.**

The use of composts with micro-organisms that build stable carbons will see soil carbon levels increase if the farm avoids practices that destroy soil carbon.

The aim is to change the balance of the soil biology away from the species that consume carbon and turn it into CO₂ so that there are more species that build stable carbon forms such as humus and glomalin.

2.4.3. Use organic forms of weed, pest and disease control

Research shows that **the use of biocides** (herbicides, pesticides and fungicides) **causes a decline in beneficial microorganisms**. As early as 1962, Rachel Carson quoted research about the detrimental effect of biocides on soil microorganisms in her ground breaking book *Silent Spring* (Carson, 1962). Since then there have been regular studies confirming the damage agricultural chemical are causing to our soil biota (Cox, 2001, 2002).

Research by of one of the world's leading microbiologists, Dr Elaine Ingham has shown that these chemicals cause a significant decline in the beneficial micro-organisms that build humus, suppress diseases and make nutrients available to plants. Many of the herbicides and fungicides have been shown to kill off beneficial soil fungi. (Ingham, 2003) These types of fungi have been shown to suppress diseases, increase nutrient uptake (particularly phosphorus) and form glomalin.

Avoiding the use of toxic chemicals is an important part of the process of developing healthy soils that are teeming with the beneficial species that will build the stable forms of carbon



2.4.4. Use correct tillage methods

Tillage is one of the oldest and most effective methods to prepare planting beds and to control weeds. Unfortunately it **is also one of the most abused methods** resulting in **soil loss, damage to the soil structure and carbon loss** through oxidation of organic matter when used incorrectly.

As a result of this opinions have shifted, with many farming industries pushing no till using herbicides and GMOs as sustainable agriculture. The pendulum of opinion is beginning to swing back to tillage now that the various problems of chemical no till systems are emerging.

Tillage will always have a role in weed management, soil aeration and building soil health. Appropriate tillage does increase soil organic matter and ensure minimal erosion. (Reganold *et al.*, 1987; Zimmer, 2000)

It is important that tillage does not destroy soil structure by pulverizing or smearing the soil peds. Farmers should be aware of the concept of good soil 'tilth'. This is soil that is friable with a crumbly structure. Not a fine powder or large clumps. Both of these are indicators of poor structure and soil health. These conditions will increase the oxidation of organic matter turning it into CO₂.

Tillage should be done only when the soil has the correct moisture. Too wet and it smears and compresses. Too dry and it turns to dust and powder. Both of these effects result in long term soil damage that will reduce yields, increase susceptibility to pests and diseases, increase water and wind erosion and increase production costs.

Tillage should be done at the correct speeds so that the soil cracks and separates around the peds leaving them in tack, rather than smashing or smearing the peds by travelling too fast. Good ped structure ensures that the soil is less prone to erosion.

The Rodale Farm Systems Trial and the Long term FiBL trials show that it is possible to increase soil carbon with correct tillage. (Mader *et al.*, 2002; Pimentel, 2005).



Deep tillage using rippers or chisel ploughs that result in minimal surface disturbance while opening up the subsoils to allow better aeration and water infiltration, are the preferred options. This will allow plant roots to grow deeper into the soil ensuring better nutrient and water uptake and greater carbon deposition. Minimal surface disturbance ensures that the soil is less prone to erosion and oxidation thereby reducing or preventing organic matter loss.

Research by Ohio State University compared carbon levels between no-till and conventional tillage fields and found that, in some cases, carbon storage was greater in conventional tillage fields. The key is soil depth.

They compared the carbon storage between no-till and plowed fields with the plow depth – the first 8 inches of the soil the carbon storage was generally much greater in no-till fields than in plowed fields. When they examined 12 inches and deeper, they found more carbon stored in plowed fields than in no-till.

The researchers found that farmers should not measure soil carbon based just on surface depth. They recommended going to as much as 1 meter below the soil surface to get a more accurate assessment of soil carbon (Christopher, Lal, and Mishra, U., 2009).

2.4.5. Control weeds without soil damage



A large range of tillage methods can be used to control weeds in crops without damaging the soil and losing carbon. Various spring tynes, some types of harrows, star weeders, knives and brushes can be used to pull out young weeds with only minimal soil disturbance.

Example

Rotary hoes are very effective however this should be kept shallow at around one inch (25 mm) to avoid destroying the soil structure. The fine inch layer of soil on the top acts as a mulch to suppress weed seeds when they germinate and conserves the deeper soil moisture and carbon. This ensures that carbon isn't lost through oxidation in the bulk of the topsoil

There are several cultivators that ensure precision accuracy for controlling weeds. These can be set up with a wide range of implements and can be purchased in sizes suitable for small horticultural to large broadacre farms.

2.4.6. Avoid erosion

Erosion is one significant ways that soil carbon is lost. The top few inches of soil is the area richest in soil organic matter. When this thin layer of soil is lost due to rain or wind, the organic matter is lost as well.

2.4.7. Encourage vegetation cover

Vegetation cover is the best way to prevent soil and organic matter loss. It is not always necessary to eradicate weeds. Effective management tools such as grazing or mowing can achieve better long term results.

Maintenance of soil organic matter requires a continuous supply of plant residue to the soil.



2.4.8. Avoid burning stubble

Practices such as burning stubble should be avoided. **Burning** creates greenhouse gases as well as **exposing the soil to damage from erosion** and oxidation. It **wastes valuable organic matter** that can add more carbon to the soil.

2.4.9. Bare soils should be avoided as much as possible

Research shows that bare soils lose organic matter through oxidation, the killing of micro-organisms and through wind and rain erosion. Cultivated soils should be planted with a cover crop as quickly as possible. **The cover crop will protect the soil from damage and add carbon and other nutrients** as it grows. The correct choice of species can increase soil nitrogen, conserve soil moisture through mulching and suppress weeds by out competing them.

There are various forms of organic no till systems that sow directly into rolled, grazed or cut cover crops and pastures with very effective yields. As the soil carbon builds up, the yields increase with many outperforming the conventional crops in the district.



Chapter 3

Phytosanitary protection

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3.1. Prevention

3.1.1. Preventive methods

❑ Proactive/Preventative pest management

Successful organic farming requires a whole-farm approach. This means managing a crop or animal as an integral part of the farm system rather than in isolation.

❑ Substitution farming

Good organic farming is not just a matter of substituting an organically acceptable input for a synthetic chemical. Initially some farmers convert to organic farming by using allowable organic inputs to replace chemicals. This is called substitution farming and it is seen as the first steps in the process of developing high output low input organic systems. It is very useful for many conventional farmers to take this approach as it is not such a great paradigm shift from their current practices.

❑ Move to whole systems approach

The best organic farmers redesign the farming system so that it has a series of integrated systems that prevent pests and diseases to give the crop a significant advantage.

The aim is to have a whole of systems approach that results in a resilient low input, high output farm. This is where ecological sciences are applied to agriculture to produce systems that fit within the paradigm of agroecology.

❑ Eco Functional Intensification (EFI)

Definition of the Eco Functional Intensification (EFI) process

IFOAM defines this process as: “As an ecosystem based sustainable production system OA relies on the **utilization of biodiversity and the optimal utilization of ecosystem services**. The use of these services is the key to the success of OA. To maximize multi-functional benefits OA utilizes ecological rather than chemical intensification. Ecological intensification **optimizes the performance of ecosystem services**. These services include pest and disease regulation, water holding and drainage, soil building, soil biology and fertility, nutrient cycling, nitrogen fixation, photosynthesis and carbon sequestration, multiple agricultural crop and animal species, pollination and others”.

❑ Setting up natural systems to prevent or reduce pests and diseases

➤ **Biodiversity**

Standard agriculture is currently causing a decline in biological diversity and this is leading to a number of sustainability and environmental problems. **The greater the biological complexity** designed into a farming system **the less the chances for pests and pathogens to colonize and dominate that system**. The aim is to create robust sustainable bio-diverse systems with mechanisms that prevent and control most of the pest, disease and weed problems and help increase the bio-availability of nutrients. These types of farming systems do exist and require a minimum of input costs, making them the most efficient in returns to the farmer and the environment.

➤ **Soil health**

Soil health is the key principle to successful sustainable farming. **Correctly balanced soil ensures minimal disease and insect damage**. There is a large body of good scientific evidence showing that plants growing on fertile soils are more resistant to pests and diseases than plants that are deficient or stressed due to poor soils and or poor management.

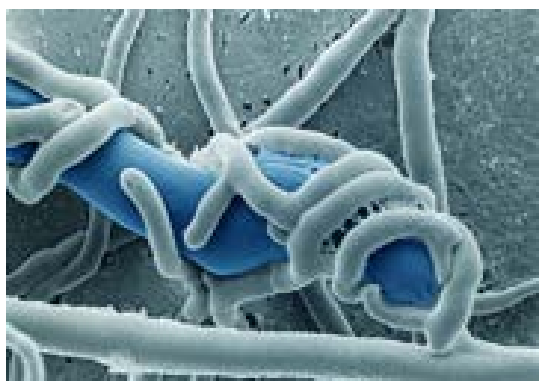
An increasing number of scientific studies are showing that **healthy plants** produce a **range of compounds that prevent or reduce damage from pests and diseases**, particularly the phenolic and flavonoid anti-oxidants. Interestingly other research is showing that these protective compounds **not only protect their host plants**, they are **beneficial to the health of people who consume them**. These compounds have been shown to have multiple benefits such as being an anti-inflammatory for reducing the pain of rheumatism, arthritis, headaches, asthma and heart disease and anti-cancer properties. Several studies show that organic foods have higher levels of these types of beneficial phytonutrients.

There is a growing body of evidence showing that **healthy plants send out scent signals to each other warning of disease and insect attack** and that these plants will then generate a range of protective compounds to prevent damage. Researchers are currently studying a range of compounds plants emit when under pest attack that attracts beneficial predators to control the pests.

Many years of research have shown that well balanced soils with high levels of calcium, humus and a neutral pH encourages a range of beneficial species and suppresses pests and diseases. These soils are rich in beneficial organisms.

Examples are *Trichoderma* sps that controls pathogens such as *Rhizoctonia*, *Phytophthora* pathogens such as *Rhizoctonia*, *Phytophthora* and *Armillaria*. Actinomycetes control many pests and diseases. Predatory nematodes control root burrowing nematodes and organisms such as *Metarhizium* and *Bacillus thuringiensis* kill range of insects.





Trichoderma attacking a plant pathogen (Rhizoctonia sp.)

3.1.2. Pest characterization and monitoring

The most efficient method dealing with pests and diseases is to be proactive and have a pest management plan. Generally the best results are obtained by developing a plan that uses a range of strategies taking a whole of farm approach.

Unfortunately in most of agriculture, pest management is an *ad hoc* process. It is either a belated reaction to a pest event or a very inefficient spray program that usually kills all the beneficials, causes environmental damage and health problems.

Integrated Pest Management (IPM) has been introduced to many industries and is seen as **useful starting point in moving towards an agro-ecological system**. The IPM tools of monitoring, setting pest level thresholds and 'Hot Spot' spraying are very useful.



Effective monitoring is not exclusive to IPM and has always been regarded as an essential tool in good farming. There is an old saying: "*The footsteps of the farmer are the best fertilizer*". This saying refers to the fact that monitoring and understanding what is happening in the crop and the farm as a whole is one of the most important management tools as it allows the farmer to take timely actions to prevent crop damage and loss.

Pest monitoring in a Kenyan farm

This means that the pests and diseases should be continuously controlled by the ecological systems the majority of the time. However no system, natural or manmade is infallible. Good farmers will monitor and have a back-up strategy to deal with problems when they arise.

Good organic farmers move beyond IPM by applying Eco Functional Intensification. One of the great advantages of Eco Functional Intensification is that once these systems are in place the ecology is doing the work to control the pests and disease with the help of the farmer.

Management is the critical issue with dealing with pests and diseases.

1. The first stage of a plan is to identify all the pests and diseases that cause problems for each specific crop. While this isn't always possible, as nature always tends to throw something new into the system, this process allows the farmer to effectively deal with the vast majority of the problems.
2. It is important to know how to identify the pests and diseases. It is also important to be able to identify the beneficial species and those numerous species that are just part of the system but do no harm. Without this knowledge it becomes difficult to understand what is being monitored. **Constant monitoring will give good warning of known and unknown pests in most cases.**
3. The next stage is to make **lists of all the control agents that can be used**. These can be ecological, cultural, biological and natural chemicals. It is important to find as many methods as possible and not be locked into one solution. Experience has shown that pests and diseases become resistant to one control method. **A combination of solutions** that uses different modes of action is always the most effective and will be **useful for the long term**.
4. **Divide these strategies into short term and long term controls**. Ideally in organic agriculture it is best to set up self-sustaining ecological systems that control the pests. However there are times, especially in the beginning when converting to an organic system, when pests can get out of control. These are the times when farmers need an organic spray or the rapid use of a biological control.
5. **Write down how, where and when to apply these control methods**. Remember constant monitoring to determine pest damage and levels is the key to applying the control strategies.
6. **Keep good records**. It is now a requirement of organic certification that a spray and inputs diary is kept. This is an extremely useful tool for analyzing the effectiveness and trends in pest control methods.
7. **Constantly monitor and review the plan every season**. Pests and crop production are dynamic systems. Like the weather they are constantly changing. A good plan is continually improved.



3.2. Curative methods of protection

3.2.1. Biological control

Biological methods of controlling pests are excellent examples of eco function intensification. A range of ecological solutions are used to replace the need for spraying to kill the pests and diseases. The ecology does the work.

□ Insectaries - Beneficial insects and their host plants

Insectaries are groups of plants that attract and host beneficial insects, arthropods and higher animal species. These are the species that remove arthropod (insect) pests from farms, orchards and gardens. They are known collectively as beneficials.

Many beneficial insects have a range of host plants. Some useful species such as parasitic wasps, hoverflies and lacewings have carnivorous larvae that eat pests however the adult stages live mostly on nectar and pollen from flowers. Flowers provide beneficial insects with concentrated forms of food (pollen and nectar), to increase their chances of surviving, immigrating and staying in the area.

Very importantly flowers also provide mating sites for beneficials, allowing them to increase in numbers.

Without these flowers in a farm the beneficial species die and do not reproduce. Most farming systems eliminate these types of plants as weeds so consequently they do not have enough beneficials to get good pest control. Buying and releasing commercial quantities of these insects is usually very expensive, especially if they cannot reproduce due to lack of suitable food.

Example

Parasitic wasps prefer very small flowers, however they have been found in large scented flowers such as water lilies. Flowers with high nectar and pollen content are regarded as the most valuable. Many weed species have these characteristics and are therefore very important in the control of insect pests.



*Parasitic wasp on a Marigold flower
(Calendula officinalis)*

Research into insectaries has been conducted at the University of California, Davis, the Dietrich Institute in California, Michael Field Research Station, Wisconsin, Rutgers University New Jersey, Lincoln University in NZ, FiBL in Switzerland and several European universities. They have shown that planting these host plant species as ground covers, in rows or in marginal areas, can cause a dramatic decline in pest species.



Trials of insectary plants at the Michael Field Institute

Farmers in the USA who have planted out rows of these host plants, as 'insectaries', in their fields no longer have to spray and have similar levels pest control as their neighbors who are heavily spraying with toxic chemicals.



Border of insectary plants around the field



Rows of insectary plants in the cropping system



Encouraging nectar and pollen rich flowers in and around the farm will improve the efficiency of these areas by changing the species mix in favor of these beneficials. Ongoing research is determining the most effective mixes of plant species and distances between these nature strips.

University of California Davis researchers have shown that high levels of vegetation species diversity will ensure a constant low population of many arthropods that serve as 'food' for the beneficials. The vegetation also helps to protect the beneficials and will ensure that they will stay in the area.



High species diversity along with small flowering plants left on pathways and a barrier hedge give good insect control.



Taller plants and higher plant biodiversity contain more beneficial.

Taller host vegetation will contain significantly more beneficials than short vegetation. It is similar to high rise buildings holding more people per sq km than single storey houses.

The research also showed that a high diversity of host plant species resulted in higher levels of beneficials and better control of pest species.

➤ **Three good rules for designing insectaries**

1. Any flowering plant that attracts bees is suitable as an insectary plant. Beneficial insects prefer species that are rich in pollen and nectar.
2. Smaller flowers are best for parasitic wasps.
3. The greater the diversity of species the more effective the insectary system.

Research from Lincoln University in NZ and in California has shown that it is **best to weed in stages**, always **leaving good refuges of weeds** in and around the farm to ensure a **healthy supply of beneficial species**. Never control all the weeds in the farm at the same time.

Dust interferes with predatory insects' ability to locate hosts and can lead to outbreaks of pests like spider mites. **Planting insectary plants as windbreaks and ground covers will reduce dust.**

❑ **Trap crops**

Trap crops are a variation of insectaries and are used to trap pest species. There are a range of methods and types of crops that are used.



Marigold as a trap crop

1. **Continuous preferred hosts**

These work by **drawing the pest species away from the crop** because they prefer the trap crop to the cash crop.

Example

American cotton farmers plant rows of lucerne (Alfalfa) in their fields because lygusbugs prefer lucerne over cotton. The farmers alternately mow half the row for the full length very two weeks. This creates continual a strip of lucerne that is in the correct state for the lygusbugs as well as leaving most of the beneficials in the Lucerne.



2. Timed alternate hosts

These work by planting crops that attract the pest species before or after the season. The pests are then destroyed to break the breeding cycles and reduce the pest population.

Example:

Some crops attract nematodes. These are usually planted early in the season and ploughed in as a green manure before the nematodes begin laying eggs. Used properly this system will break the pest cycle, reduce weeds and provide valuable organic matter and slow release nutrients for the cash crop.

A variation is to plant the trap crop straight after the cash crop. Usually the pest species is at its greatest at this point. A combination of a trap crop and a rotation cash crop the following year have been shown to be the most effective in significantly controlling pests.

Another version is to plant a few small areas of the cash crop a few weeks earlier and plough it is just before planting the main cash crop. Timed properly this can significantly reduce pests.

Examples of this can be the use of Jaboticabas trees flowering just before lychees or mangos. These will attract the monolepta beetles where they can be destroyed before they attack lychee and mango flowers.

The use of alternate hosts that attract the pest early in the season can be useful.

Example

Chickpeas (*Cicera rietinum*) make the best trap crop for the pesticide resistant heliothis (*Helicoverpa armigera*). Linseed (*Linum usitatissimum*), canola (*Brassica napus*) and field peas *Pisum* sp.) were shown to be good trap crops for heliothis and host plants for predators and parasitoids such as lacewings, ladybeetles and wasps.

3. Lures

Insectaries can be used as trap crops by placing/spraying lures and baits to attract the pest species out of the cash crop and into the predator rich insectary.

□ Repellent species

Some plants repel insect pests. Interplanting repellent species within the crop will make it less attractive to the pest. Having a non-crop plant that is a preferred host planted near the crop will attract the pest away from the crop.

Desmodium is planted to repel the stem borer and also to attract the natural enemies of the pest. Its root exudates stop the growth of striga which is a parasitic weed of maize. Napier grass is planted outside of the field as a trap crop for the stem borer. The *Desmodium* repels (Push) the pests from the maize and the Napier grass attracts (Pull) the stem borers out of the field to lay their eggs in it instead of the maize. The sharp silica hairs on the Napier grass kill the stem borer larvae when they hatch to break the life cycle and reduce pest numbers.



The Desmodium, suppresses weeds, adds nitrogen, conserves the soil, repels pests and provides high protein stock feed.

High yields are not the only benefits. The system does not need synthetic nitrogen as *Desmodium* is a legume and fixes nitrogen. Soil erosion is prevented due to a permanent ground cover. Very significantly the system provides quality fodder for stock.



The Napier grass is progressively cut and fed to a cow. The excess fresh milk is sold daily as a cash income.

The border of Napier grass is systematically strip harvested to provide fresh fodder for livestock. Livestock can also graze down the field after the maize is harvested. Many Push-Pull farmers will integrate a dairy cow into the system and sell the milk that is surplus to their family needs as a regular source of income.

❑ Barriers

Trap crops and permanent insectaries can be used as a barrier to **prevent the entry of pests into a cash crop.**

Farmers in Myanmar plant barriers of sunflowers around their fields. These works as barriers to stop pests entering as they get attacked by the beneficials in the sunflower barriers. The beneficials can also enter the field to protect the crop.



Sunflowers planted as barriers in Myanmar

Many farmers, traditionally, have hedge borders of different plants along the pathways and farm boundaries with a diverse collection of native and introduced species. This is very common in some parts of Africa. These border hedges act as refuges for beneficials as well as barriers for pests.



Hedge Borders along pathways in Kenya

☐ Higher animals

Insectaries or nature strips are also hosts to valuable higher animals. A large range of higher species plays very significant roles in controlling pests in agriculture.

Many bird species will eat pest insects. Examinations of the crop and stomach contents of most bird species commonly found on farms show that they can consume large numbers of insects. Each bird can eat thousands of insects per year.

Other published research has shown that one of the major problems with widespread herbicide use is the loss of the habitat refuges of birds and beneficial insects. The bird numbers plummet in these districts, resulting in higher pesticide use.



Studies of orchards using total exclusion netting have demonstrated that these orchards need to use more insecticides to kill pests that were previously eaten by birds.

Dense bushes, small trees, shrubs and bamboos are the plants to use to attract insect eating birds. Most of these are small birds like to shelter and nest under thick canopies to avoid predators.



Bat houses

Micro bats are very effective in controlling many of the night flying insect pests. Each bat has to eat one third of its body weight in insects every night. This is a massive number of insects. Farmers build bat houses to keep them on farm. They also place lights in the crop to attract insects for the bats to eat. Many farmers also collect the bat guano around the houses as fertilizer.

Micro bats can be used to control fruit sucking and piercing moths by putting a battery powered light in the sections of the orchards where pest control is needed. The bats are attracted to the light, as they know light attracts many insects. They can locate and eat nearby moths with their sonar.

Lizards, frogs and toads eat a wide range of pest insect species. A light placed on the ground at night will attract frogs and toads to consume the insects that are drawn by the lights. Many pest beetle and moth species can be controlled this way.

Poultry – chickens, ducks, peafowl and guinea fowl are very effective in cleaning up pest species like grasshoppers and beetles. These animals have been used traditionally in all farming cultures as an essential part of pest control.

Owl nesting boxes in high trees are proving effective in controlling rats. It is important to have perch trees and a cleared border, at least 2 meters wide around the field, so that the owls can see and catch the rats as they run in and out of the fields.

Planting non pest host species and pest resistant varieties

Where possible it is important to source crop varieties that are resistant to the major pests and diseases.

Many weed or garden plants can host insect pests. As an example some pest beetle species such as cane beetle, *Monolepta* and *Rhyparida* larvae live on the roots of grasses.

Many pest rat species nest and live in long grasses. Replacing these with shrubs and trees and other flowering plants will reduce their numbers.

Eliminating or reducing these pest host species (except when used as trap crops) with beneficial plant species will significantly reduce the damage the pests cause in the crop.

❑ Purchasing beneficial arthropods

Many beneficial insects can now be purchased. The following groups of arthropods are usually available:

- Predatory nematodes
- Predatory mites
- *Trichogramma* and other parasitic wasps
- Lacewings (*Chrysoperla sp.*)
- Lady beetles (*Coccinella sp.*)
- Assassin bugs and other predatory bugs



Predatory mites

❑ Baits, lures, traps and pheromone disrupters

A range of traps, baits and lures are used to control insects. These are some of the best methods as they concentrate on the controlling pest species, without adversely affecting non-target species.

Examples of these are protein hydrolysate baits for fruit flies. These tend to mostly attract the females; however they will also attract many males. The flies feed on enterobacteria that live in the protein bait. The bait should be contained in a vessel that prevents escape and/or has enough water to drown them.



Traps baited with pheromone lures

Pheromones and/or parahormones can be used as baits or as methods to disrupt mating. Variations of these are now being used very effectively with codling moths and fruit flies and are available commercially.

Borax and sugar baits can be used for the control of a large range of insect pests, particularly cockroaches and ants. Use soil tests to ensure that the levels of boron are not too high as it can be toxic to plants. If the tests show boron deficiencies then it can be used without causing any soil problems.

Sticky pastes can be applied around the trunks of trees to trap insects, such as ants that climb up the trunk. Colored sticky traps are used, however they tend to be better as a method of monitoring the pest numbers rather than as a significant control method.

3.2.2. Physical control

☐ Allowable organic sprays and spray technology

Spraying pesticides and fungicides should be regarded as the **tools of last resort in organic systems**. Ideally a good organic farmer tries to avoid pests by having healthy fertile soil and good biodiversity on the farm. However there are certain pests that can periodically cause economic damage if they are not controlled at critical times.

Constant monitoring and timely action can control these before they increase into a significant problem. As stated in section 3.1., it is important to be able to identify the pests and also the threshold levels where they cause economic damage.

Just finding a few pests does not necessarily mean that there will be any economic damage to the crop. In fact **small levels of the pest are good in balanced ecological systems as these will provide constant food sources for the predator (beneficial) species that feed on the pest**. Wiping out all the pests with a widespread spray program means that the beneficial species will starve and also be wiped out.

This means that when the pests arrive back in the crop, they will have no natural bio-controls and quickly multiply to cause economic damage. This tends to lock farmers into never ending and at times escalating spray programs.

This needs to be avoided by developing by using eco function intensification systems to attract the beneficials that will control the pests.

The critical issue is to understand the threshold levels of the pest that will cause economic damage. It is at this point where a spray maybe necessary.

☐ Monitoring and only spraying hot spots

Many organic sprays are broad spectrum, killing both pest and beneficial species. The best approach is to avoid complete cover sprays of the crop, unless using a spray that only targets a specific pest such as *Bacillus thuringiensis*.

When using a broad spectrum spray such as natural pyrethrum, potassium soaps, diatomaceous earth, clay, flour and water or vegetable oils, monitor the crop and **establish the areas that have the highest numbers of the pest**. These areas are the 'Hot Spots'. Only spray the hot spots. This allows the beneficial species to survive in the rest of the crop and they will help to give good control.



Killing all the beneficial species can lead to an increase in the pests and also allow new pests to get established. It will also lock organic farmers into the same spray dependency as conventional farmers.

One of the important differences between allowable **organic insecticides** and most **synthetic pesticides** is that most **organic formulations biodegrade within 24 hours** or become plant nutrients.

This has good implications to the environment and for consumers; **however the lack** of persistence means that they **need to be applied more often**. Monitoring is crucial to determine the best time and places to spray.

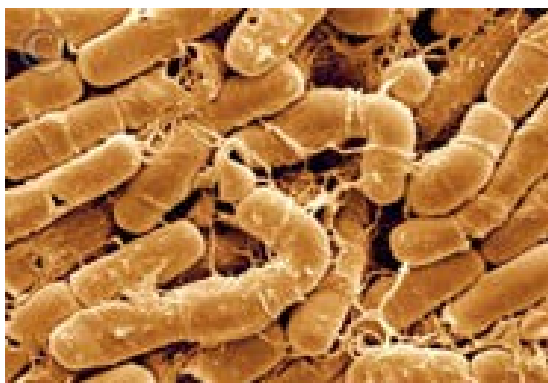
Avoid calendar spraying such as weekly or fortnightly etc. This can result in spraying when there are no pests and not spraying when there are pests. Always monitor and check pest levels before deciding on the appropriate control strategy.

A valuable control method is to monitor pest numbers following a spray application and then use another spray two days later. This will give excellent pest control as it tends to catch the pests that were hiding under leaves. They will often move to new areas where they can be caught by the spray droplets.

The only time it is useful apply pesticides and fungicides on a regular cyclical basis, is when this is based on known life cycles. This timing should be usually based on the period after eggs hatch to before they are mature enough to reproduce. Spraying three of these life cycles are usually sufficient to significantly disrupt the breeding cycle of most pests and diseases.

□ Biological sprays

➤ *Non-toxic sprays*



Biological pesticides such as *Bacillus thuringiensis* and *Metarhizium* are usually pest specific and do not harm beneficials – or people.

These can be used as complete cover sprays over the whole crop to get effective control.

Bacillus thuringiensis colony before sporulation

Many people have failures with biological sprays, due to not realizing that **they are dealing with living organisms** rather than a chemical. **Biological sprays need to live in suitable conditions to be effective**. It is important to understand these requirements otherwise they die soon after application and are useless.

This is one of the fundamental reasons why the results of biological products can be unreliable. They can work exceptionally in some trials and have no effect in others.



As an example: *Bacillus thuringiensis* var. *Kurstaki* (Bt) is very effective in the control of lepidoptera (caterpillars).

It is most effective **when the caterpillars are in the early stages of growth**. It works only when the caterpillar ingests the living bacteria. These bacteria make sharp protein crystals called lectins that literally cut up the digestive system of the pest. The pests immediately stop feeding and die over a few days.

Bt is killed by ultraviolet light. Spraying it out in the morning or middle of the day will kill it before it has a chance to work in warm temperate and tropical climates. It is important spray in the late afternoon or early evening so that it can work all night. It will die in the sunlight of the following day. The product is sold as a dormant spore. It is best to culture this for several hours to break the dormancy and get the spores to grow and multiply as active bacteria. This increases the odds of caterpillars eating the BT.

Just mixing the spore powder with water and spraying will mean that it will take several hours after spraying before any bacteria will become active. By the time the numbers of bacteria are multiplying they will be killed by the morning sun.

The most effective method is to mix the spore powder in milk or a diluted water and molasses mix and leave in a shaded area for a few hours.

The cultured mix is later added to bonding agent such as an emulsified vegetable oil. The oil will ensure the droplets will stick to the leaves of the plants when sprayed.

Effective rates: 100 gms of BT mixed with 500 mls of molasses and 2 liters of water for 2 to 3 hours. 500 mls of emulsified vegetable oil (Spray-tech Oil, Synetrol Oil, Eco Oil) is then blended into this. This will make 100 liters of spray. Keep the tank regularly agitated or shaken to stop the spores from settling to the bottom.



Emulsified vegetable oils are very effective at killing all arthropods (insects and related species). These **work by clogging the breathing pores so that they suffocate**. It is important to ensure complete coverage of the pest species.

Natural soap sprays such as potassium soaps kill insects by **dissolving the outer cuticle** and also by clogging the breathing pores.

*Farmer preparing a spray with emulsified vegetable oils
Clays (Kaolin), flour and water.*

These types of sprays work by **clogging up the pores**.

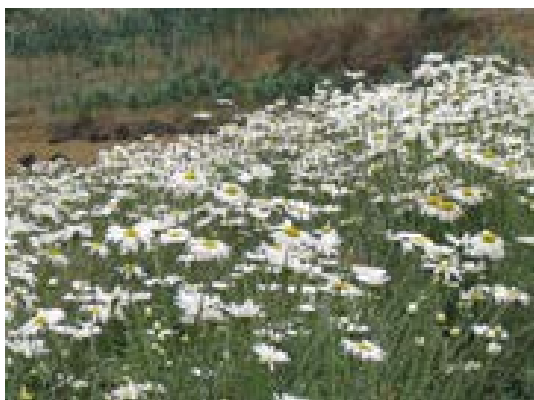
The research on Kaolin as an effective means of controlling pest and some diseases continues to increase

Diatomaceous earth. This works by both **clogging up the pores** and the fine silica **sharps shred the joints of the pests**.

These types of sprays are non-specific and will kill beneficials so they should only be **used on 'Hot Spots'**. The oils and soaps can also burn leaves if used at strong rates so it is important to do test sprays first.

➤ **Toxic sprays**

Natural pyrethrum is very effective for every pest, as at this stage no insect has developed resistance to it. This is because it is a natural extraction of a mixture of different pyrethrums, with every batch having different combinations. This means if an insect pest begins to develop resistance against one batch, the following year's batch of natural pyrethrum will be different enough to ensure that the pests have no resistance to it.



Pyrethrum daisy flowers

Pyrethrum is a **nerve poison** and has caused blindness in people who have been exposed to it. It is highly toxic to all cold blooded animals, especially fish, so it must be used with care. It completely breaks down in four hours in warm blooded animals and in 24 hours in the natural environment leaving no toxic residues.



Rotenone – Derris dust is a very toxic and **effective nerve poison for all species especially cold blooded animals**. Like natural pyrethrum it completely breaks down in a few hours in warm blooded animals and in 24 hours in the natural environment.

Derris tephrosia leaves containing rotenone

Eucalyptus oil is highly toxic. As little as a teaspoon can kill a child. Used correctly it makes a very effective insecticide.



All of these insecticides work by contact with the insects. Mixing them with soaps ensures they work more effectively as the soap dissolves the outer cuticle of insects allowing the toxin to penetrate more effectively.

When the soap and toxin mixture is combined with the vegetable oil bonding agent they are even more effective. The oils ensure the spray droplets stick to the pest. Also the oils can smother the pests and the soap damages the cuticle, giving three modes of action.

Never use these types of sprays as cover sprays as they are highly toxic and disruptive to beneficial predators. They should be restricted to 'Hot Spot' spraying.

➤ **Repellents**

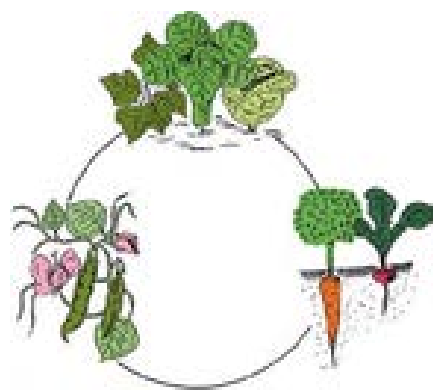
Several compounds have been shown to work effectively by repelling rather than killing the pests. These have **major advantages as they protect the crop without killing the beneficials.**

Examples of these are garlic, chili, tea tree oil, lavender oil, citronella oil (this oil can also attract some species like fruit flies due to the eugenol content) and cypress pine oil.

3.2.3. Mechanical control

☐ **Crop rotations**

Crop rotations are regarded as one of the **most effective ways of controlling pest and disease cycles.** Many pests and diseases are crop specific. By ploughing out the previous crop and planting a very different crop the pest or disease dies due to a lack of suitable hosts.



It is one of the oldest and most consistently proven methods. F.H. King gives numerous examples of how it has been used for thousands of years in sustainable systems in China, Japan and Korea in his book *Farmers of Forty Centuries – Permanent Agriculture in Japan, China and Korea*. Even though this book was published in 1911, the numerous examples of rotation systems, especially for horticultural production of fruits, vegetables and beans are still valid today. Many of these systems are still being used in the remote rural areas of China now as effective ways to reduce pests and diseases.

Another variation of crop rotation systems is the planting of trap crops. Rotation crops can also be used as Insectaries. Winter cereals such as wheat, sorghum and maize have been used as beneficial nursery crops for the following crop.

There are some situations where breaking the cycle can also severely reduce beneficial micro-organisms like *Metarhizium* that controls cane beetles and phosphorous producing VAM fungi in wheat. There is evidence that the best way to overcome this problem is to inoculate the new crop with the spores of the beneficial species. Adding good locally

made compost can be another way to stimulate the growth of the beneficial micro-organisms.

❑ Strategic tilling

This is where tillage is timed in combination with some biological methods. Tillage is used in conjunction trap crops and is timed so that the host crop is destroyed before the pest can reproduce. They are particularly used for soil pests and disease such as nematodes and eel worms. The key is to allow the pest the time to lay their eggs and have them hatch and destroy the food source at this point. It will decimate a whole generation of these pests and significantly lower the pest levels.

This should be followed with a crop rotation of species that are not hosts to these pests. This will further disrupt their reproduction cycles and reduce the pest levels down to the point where there should be no economic thresholds of crop loss.

❑ Pruning

Pruning crops to **allow air movement and sunlight penetration** is one of the most effective ways to control fungal disease. Most fungal diseases like damp shady conditions. The **ultra violet light in sunlight is fatal** to many plant diseases. Air movement can dry out many surface dwelling disease organisms and desiccates them.



The correct pruning methods are also very important if crop needs to be sprayed for pests or diseases. This will allow the spray to penetrate and surround the whole plant and make contact with the pest or disease. The normal structure of many plants means that that dense canopy of leaves will prevent the spray from entering the inside of the canopy, allowing the pest or disease to escape from contact from the spray.

It is important to understand **the shape of any crop** and if it needs to be pruned to allow sunlight and air movement to control pests and diseases. In most cases this is not necessary and can even be detrimental to high yields. Plants need their leaves for photosynthesis. The more leaves, the more photosynthesis.

A dense canopy is better for small birds so that they can hide away from their larger bird predators. They will feel safe inside the canopy and spend hours searching for the pests as their food sources. This is also the same for many beneficial insects.

The need for pruning has to be a considered management decision based on the specific crop and its major pests and diseases.



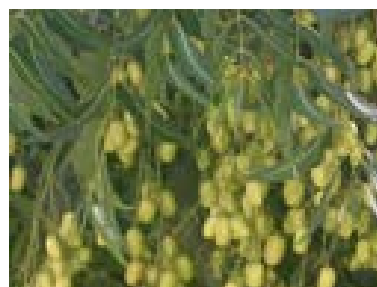
3.2.4. List of organic insecticides, fungicides and biological controls

Below are lists of many of the natural compounds and biological controls that are allowed to be used in certified agriculture. This is by no means a complete list and there are many other natural compounds and biological controls that are available. It is always worth doing more research.

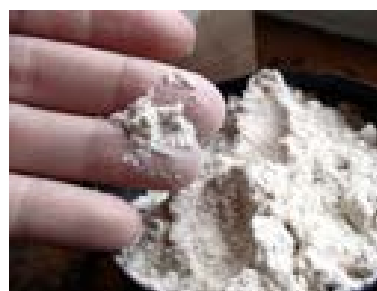
Good farmers will always use a diverse range of these as part of their pest and disease management systems. Certified organic farmers must check with their certifiers first before using any of these as some certifiers may have restrictions on some of the compounds on the lists below.

☐ Botanical and simple natural chemicals

- Natural pyrethrum
- Rotenone
- Quassia
- Ryania
- Propolis
- Emulsified vegetable oils
- Mineral oils
- Essential oils - tea tree (*Melaleuca alternifolia*), eucalyptus, citronella (*Cymbopogon citrates*), lavender (*Lavandula sp.*), cypress pine (*Cupressus sp.*) etc.
- Potassium soap
- Plain soap
- Sodium silicate (waterglass)
- Neem (*Azadirachta indica*)
- Copper sulphate
- Lime
- Sulphur
- Potassium permanganate
- Borax
- Baking soda
- Diatomaceous earth
- Stone meal
- Sea salts
- Kaolin
- Flour and water
- Chilli sprays Garlic
- Vinegar and wood vinegar
- Tobacco (usually as tobacco teas – not pure nicotine)
- Bluish dogbane
- Pheromones
- Synthetic chemical lures and baits are allowed if they are enclosed so that they do not leach into the environment.



Neem leaves and seeds



Diatomaceous earth

□ Biological controls

➤ **Biopesticides**

Various bacteria, fungi, viruses and their naturally produced metabolites are allowed. Please note that many of these are very susceptible to insecticides, fungicides and particularly many herbicides.

- *Bacillus thuringiensis* – var. *kurstaki* for caterpillars
- *Bacillus thuringiensis* – var. *enebrionis* for beetles
- *Bacillus thuringiensis*– var. *israeliensis* form mosquitoes and some flies
- *Metarhizium* species or grasshoppers, beetles, white flies and a range of insects
- *Trichoderma* species for controlling diseases
- *Cliocladium virens* for controlling diseases
- *Bacillus subtilus* for controlling diseases
- *Verticilliumlecanii* for scale insects, aphids and white flies
- *Beauveria bassiana* for a wide range of insects.



Green vegetable bug infected with *Metharizium*

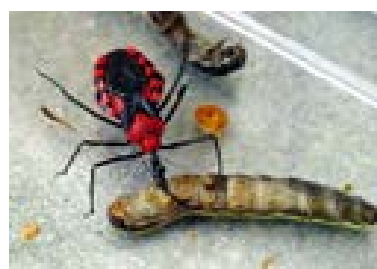
A fresh good quality compost should have high levels of actinomycetes, protozoa and beneficial fungi that will control a wide range of pests and diseases.

➤ **Beneficial insects and arthropods**

Many beneficial insects can now be purchased. The most effective way to introduce these creatures into the farm is to provide insectaries. Insectaries provide the equivalent of many thousands of dollars' worth of beneficial species weekly at no cost.

Predatory nematodes:

- Predatory mites
- Trichogramma, *Telenomus* and other parasitic wasps
- Lacewings
- Hover flies
- Lady beetles
- Assassin bugs
- Spiders
- Praying mantis
- Dragon flies



Assassin bug eating a caterpillar

➤ **Insectary plants**

Any flowering plant that attracts bees is suitable as an insectary plant. Insects prefer species that are rich in pollen and nectar. Smaller flowers are best for parasitic wasps.

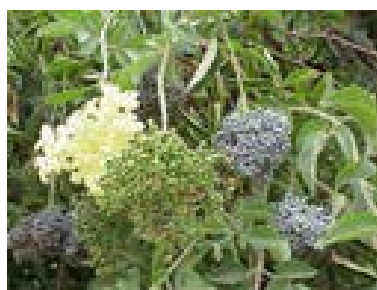
Most flowering weeds are valuable insectary plants. Also many native flowering plants should be very suitable.

➤ **Temperate species**

- Willow sp. (*Salix* sp.)
- Lucerne
- Clovers (*Trifolium* sp.)
- Vetch (*Vicia* sp.)
- Coriander (*Coriandrum sativum*)
- Buckwheat (*Fagopyrum esculentum*)
- Lobelia (*Lobelia* sp.)
- Tansyleaf
- Yarrow (*Achillea millefolium*)
- Elderberry (*Sambucus* sp.)
- Alysium (*Alyssum* sp.)
- Marigolds
- Dill (*Anethum graveolens*)
- Coriander (*Coriandrum sativa*)
- Fennel (*Foeniculum vulgare*)
- Linseed
- Canola
- Field peas
- Wheat
- Sorghum
- Maize
- Water lilies (*Nympheaceas*)



Coriander flowers



Blue Elderberry in flower, unripe and ripe berries

➤ **Tropical**

- Sensitive weed (*Mimosa pudica*)
- Pinto peanut
- *Stylosanthes* sp.
- Marigolds
- Water lilies
- Sorghum
- Maize
- *Crotalaria* sp.
- Pigeon peas (*Cajanus cajan*)



Crotalaria field

➤ **Fungicides**



Sodium bicarbonate powder



3.3. Examples of pest management plans

3.3.1. An example of pest plan for controlling fruit flies

The following is an example of a pest plan to control fruit flies so that undamaged pest free fruit can be sent to markets. Fruit flies are one of the major trade quarantine issues because of the extensive damage they can cause to a large range of fruits.

They are mostly controlled by the spraying and the post-harvest dipping into solutions of highly toxic organophosphate chemicals. These are in the process of being banned by most markets because of a range of serious health effects they can cause to humans, especially children who consume low levels of the toxic residues in the fruits.

The alternative to chemicals treatments being proposed by several governments is to irradiate the fruit with ionizing radiation. The organic movement does not permit ionizing radiation as a food treatment as the science shows that the radiation creates a range new compounds called unique radiolytic compounds. These have been shown to damage the DNA and other part of the body in test animals and being precursors for cancerous changes in cells.

It is important that organic producers can have alternatives to toxic chemicals and ionizing radiation to produce fruit that are not damaged or infected by fruit fly larvae.

❑ Management plan for controlling fruit flies

Good organic pest and disease management plans always use a range of multifunctional strategies to deal with the pest and disease, rather than just relying of on one type of treatment whether chemical or by irradiation for achieving effective control.

The plan below utilizes a number of strategies to beat the fruit flies:

- 1. Keeping fruit fly numbers as low as possible by not feeding them**
Fruit flies live on entero bacteria that feed on the excess nitrates that are excreted on the undersides of leaves. By avoiding soluble nitrate fertilizers and only using nitrogen in organic forms organic farmers can ensure that very little nitrate is excreted by the leaves on the trees to feed the entero bacteria and fruit flies.
- 2. Encourage beneficial species**
The use of insectary systems and not destroying beneficial species with toxic chemicals means that there are a lot of predator species in the fruit trees like spiders, ants and assassin bugs that eat fruit flies.
- 3. Use protein hydrolysate baits to kill the female fruit flies**
Adult fruit flies do not eat fruit. They eat entero bacteria. The females lay their eggs into the fruit and when the larvae hatch they start to eat the fruits. One of the most effective strategies is to use protein hydrolysate baits to attract and drown the females before they lay eggs in the fruit and catch the males before they mate.

These are easy to build by making a hole about 25mm in diameter near the top of a used plastic drink bottle. The bottom third of the bottle is filled with a mixture of hydrolyzed protein and water. This is usually a common yeast extract that can be bought in most supermarkets.

The lid is screwed back on and the bottles are hung in trees. Enteric bacteria will quickly grow in the liquid. The fruit flies smell them, enter the bottle and drown in the non-toxic liquid. Top up the baits every week with fresh mixture of the protein hydrolysate.

4. Male eradication

Commercial parahormone lures are available for the males. The aim of these lures is to trap them before they can mate with the females to break the cycles. These lures tend to use organophosphate pesticides that are prohibited in organic agriculture. Some certifiers will permit their use if the lures are in containers and disposed of outside of the farm so that it has no pesticide residues.

Farmers can make their own lures by building the same soft drink trap as described in section III above however filling them with water and small amounts of essential oils that contain Eugenol, such as clove oil, nutmeg oil or citronella oil. Eugenol is a parahormone that is used by many species of young fruit flies to produce the hormones they need to become sexually mature. Organic producers have found from experience that a mixture of the oils is better than just one oil. This is because there are several variations of these Eugenol type compounds and some are more attractive to different fruit fly species than others. Having a mixture means that there is a better spectrum of these compounds to attract the desired species of fruit flies.

5. Constant harvesting to remove ripe fruit from the trees

Fruit flies prefer to sting ripe fruit. It is critical to develop regular harvest cycles that remove all of the ripe fruit and only keep the fruit on the trees or vines at the hard green stage. This significantly reduces the breeding cycle and helps to ensure that harvested fruit is not stung.

6. Remove and destroy all fallen fruit from under the trees

The larvae live in the over ripe fruit and pupate in the ground. Removing and destroying the fallen fruit stops larvae from developing into the next generation of adults.

The use of geese and other fowls to eat all fallen fruit and mature fruit is a good way to prevent the breeding cycle. Fowls such as chickens that scratch around the ground will find many of fruit fly larvae or pupae and eat them.

7. A strict post-harvest inspection system

Develop a strict post-harvest inspection system to remove any potentially infected or damaged fruits. Fruit flies prefer to sting fruit with broken or damaged skin. These fruits should be destroyed and not sent to market. Removing these fruits from a consignment sent to market improves the visual and eating quality of the fruit. This should return a higher price to the grower because of the higher quality

8. Packaging that will prevent contamination

It is important the harvested fruit is packed in containers that do not have any holes that fruit flies can pass through to sting the fruit. Harvested fruit is more attractive to fruit flies because it is starting to ripen.

3.3.2. An example of an organic pest control plan for tropical fruits

This is an example of a generic plan that can be used as a template as the basis of a pest and disease control plan for fruit orchards.

It is the nature of organic farming that each region will have different issues that they have to deal with, even when they are growing the same crop. This is why good organic farmers rarely use the simple recipe systems that tend to be used by conventional farmers.

Organic farming is about developing management systems that are **specific to each farm and its unique requirements**. These systems will not just have one strategy. They will have several strategies that are integrated into the whole of systems approach.

☐ Step 1. Identified pests and diseases

The first step in pest plan is to identify the pests and disease. Write down in a list.

☐ Step 2. Identify the multiple control mechanisms and strategies

This step involves listing the control mechanisms and strategies that the farmer knows that will control or partially control the pest.

An example of this type of list is below.

Pest: Lepidoptera (caterpillars)

Controls:

- *Bacillus thuringiensis* var. *kurstakis*
- Nuclear polyhedrosis virus
- Fungal diseases such as *Nomuraea rileyi* and *Beauveria bassiana*
- Potassium soap
- Emulsified vegetable oils
- Natural pyrethrums
- Assassin bugs, *Trichogramma* and other miniature wasps
- Lace wings, hover flies
- Insect eating birds

Pest: Coleoptera (beetles – *Monolepta*, *Rhyparida* and other sps)

Controls:

- *Bacillus thuringiensis* var. *enebrionis*
- *Metarhizium* sp.
- Potassium soap
- Emulsified vegetable oils
- Natural pyrethrums
- Repellent sprays such as chili, pine oil, eucalyptus oil
- Assassin bugs, spiders, green ants
- Insect eating birds

Pest: Mites

Controls:

- Predatory mites
- Spiders
- Wettable sulphur
- Emulsified vegetable oils
- Potassium soap

Pest: Mealybugs and Scales

Controls:

- Predatory mites, ladybeetles, assassin bugs, lacewings, spiders
- Emulsified vegetable oils
- Potassium soap

Pest: Nut borers

Controls:

- Ladybeetles, assassin bugs, lacewings
- Spiders, hover flies, green ants
- *Trichogramma* and other miniature wasps
- *Bacillus thuringiensis* var. *kurstakis*
- Nuclear polyhedrosis virus
- Fungal diseases such as *Nomuraearileyi* and *Beauveria bassiana*
- Potassium soap
- Emulsified vegetable oils
- Natural pyrethrums
- Insect eating birds

Pest: Shield bugs and fruit spotting bugs

Controls:

- Assassin bugs
- Big eye bugs
- Spiders
- Insect eating birds
- Natural pyrethrum
- Emulsified oils
- Repellent sprays such as chili, pine oil, eucalyptus oil

Pest: Fruit sucking and fruit piercing moths

Controls:

- Micro bats
- Improved netting systems

Pest: Vertebrate pests

Controls:

- Improved netting systems
- Improved scaring systems

Disease: Fungal problems

Controls:

- Wettable sulphur
- Emulsified vegetable oils
- Potassium soap
- Copper sulphate
- Micronized copper
- Tea tree oil
- Sodium bicarbonate
- Potassium permanganate
- Lactic acid bacteria
- Trichoderma sp.

Step 3. Divide these mechanisms and strategies into short term (immediate) and long term

The purpose is to have strategies to deal with immediate pest and disease problems when they arise and also strategies that will prevent the problems from occurring.

The long term prevention must always be the most important aim with the short term seen as the back-up for the times when the pests or diseases become acute problems.

➤ **Short term pest control**

Examples

Spray wettable sulphur on the emerging crop flowers to protect them from mite damage. At this stage use BT to protect the flowers from caterpillars and a combination of repellent sprays to prevent beetle damage.

Hot Spots of damaging beetles to be controlled with a mixture of natural pyrethrums, natural soap and emulsified vegetable oils.

These short term pest control treatments are applied on a needs basis, based on daily monitoring of the flowers, not on a calendar based program. The products, rates, dates and areas treated should be recorded in the farms spray and inputs diary.

➤ **Long term pest disease controls**

• **Soil health**

Use soil testing to understand the levels of nutrients and organic matter in the farm. This is the **critical first step in developing a resilient high yielding system**.

Develop a plan with timelines on the stages needed to get the soil up to the required level.

• **Biocontrols**

Most orchard pests are to be controlled through a number of bio controls strategies. The most important of these are to **develop insectaries within and around the orchard** to attract the beneficial species that control the pests and diseases.

Develop time table to **introduced host plants for beneficials** either as ground covers throughout the orchard or as dedicated nature strips in the marginal areas of the farm.

Never clear all the weeds in the orchard. It is important to leave pockets as refuges for beneficial insects and other organisms. These refuges are cut down in a later slashing cycle to stop the weeds from getting out of control, however new areas are then left as refuges. By doing this the weeds are stopped from competing with the crops as well as allowing them to have a range of useful functions, such as beneficial habitat, mulch, nitrogen fixation and soil stabilization. Research has shown that these insectaries breed thousands of beneficial organisms.

Encourage small flowering plants to grow throughout the orchard, as these are essential to the adult stage of beneficial predators such as lacewings and *Trichogramma* wasps.

Allow native vegetation to regenerate in marginal areas on the farm and watercourses by planting a range of species to provide habitat for the bird



species that spend many hours every day of the week removing pest species from fruit trees. These areas also host a variety of beneficial insects, mites, amphibian, reptile and mammal species that help control the pests in the orchard.

➤ **Resources and further reading**

There are numerous good quality books available. The following are useful reference material.

For more information on Push Pull: www.push-pull.net.

For more information of biological controls in the tropics, especially in Africa: www.icipe.org.

Citrus pests and their natural enemies provides detailed description of citrus pests in Australia. The information is useful for a range of crops.

Citrus pests - a field guide is companion to *Citrus pests and their natural enemies* and is designed to help with identification.

Cotton Pests and Beneficial Guide. Cotton research and development Corporation, PO Box 282, Narrabri, NSW 2390.

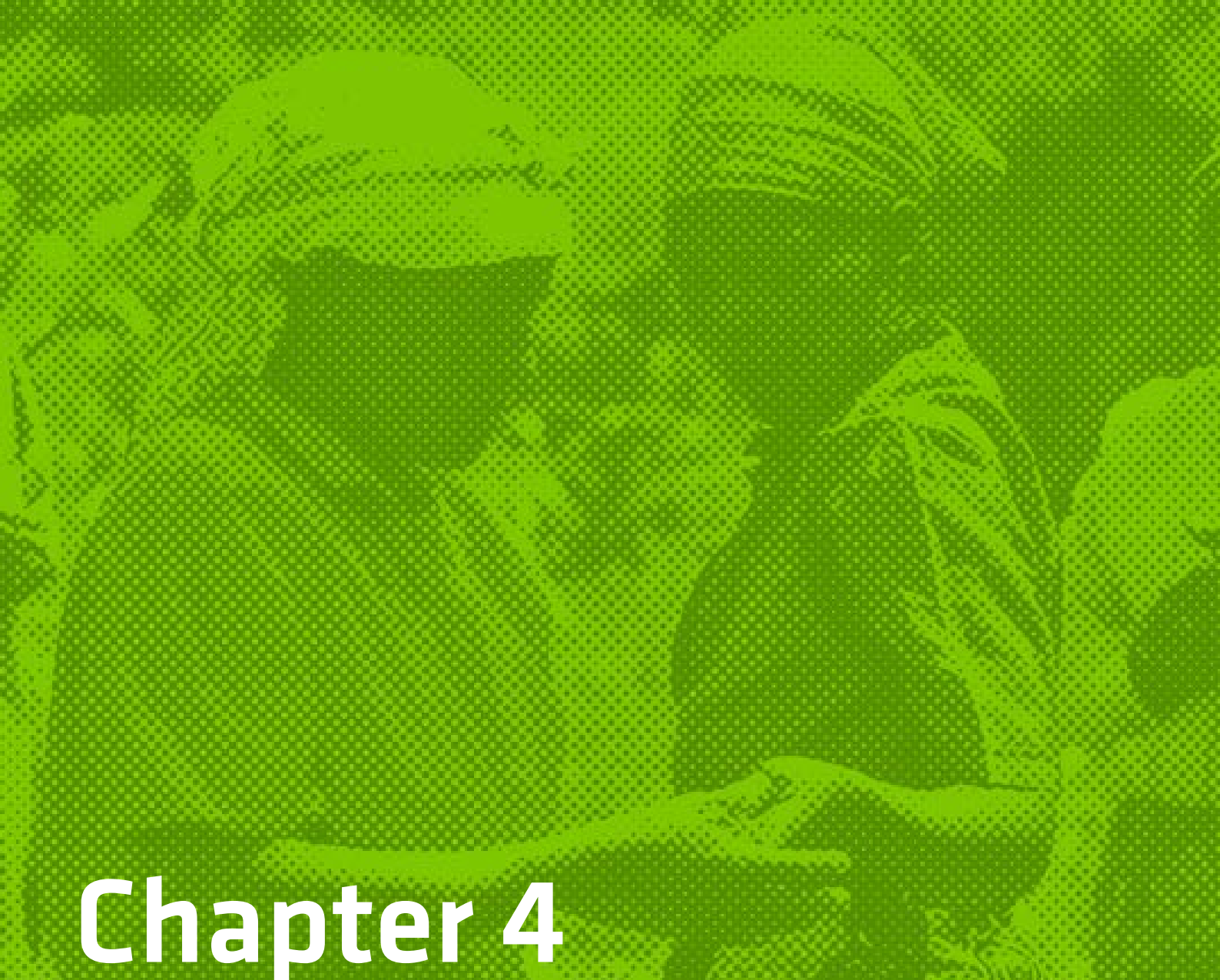
The Good Bug Book provides detailed information for organic and IPM systems. Compiled by the Australasian Biological Control Group, 1995.

Natural Enemies Handbook, University of California. This is an excellent resource.

Australasian Biological Control (ABC) – Association of Beneficial Arthropod Producers. Information on beneficial insects and mites available in Australia <http://www.goodbugs.org.au>.

BioControl Ltd, pheromone mating disruption specialists in pome and stone fruit. www.biocontrol.com.au.





Chapter 4

Weed and vegetation management

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4.1. Prevention

4.1.1. Introduction

Weeds can be one of the most significant problems in many farming systems.

There are numerous methods to manage weeds. Currently the use of herbicides is the main weed control strategy in conventional agriculture. This has replaced the range of methods used in the past. Those management systems were far broader than just tillage, however much of this knowledge has been lost to the current generations of conventional farmers.

There are a range of new methods being used to manage weeds that are based the current understanding of plant physiology and Eco Functional Intensification (EFI). These systems use applied ecology to increase biodiversity to manage weeds.

It is important to understand that organic farming is about **weed management rather than weed eradication**. Organic farmers develop an approach to minimise weed problems so that they do not adversely affect the cash crop and integrate weed management into the farming system as part of the rest of their farm management.

4.1.2. Weeds – Friend or foe?

There are many definitions of a **weed**. Probably the most common one is: **“A plant in the wrong place”**.

In agriculture a better definition is: **“A plant that adversely affects the production of the crop”**.

Generally it assumed that any plant, other than the crop, is a weed because it competes for soil moisture, nutrients, light or it harbors pests etc. The normal solution is the removal of these through herbicides, tillage, fire etc.

Weeds however can have many benefits such as preventing soil erosion, increasing soil fertility, correcting poor soil structure, indicating poor drainage, mineral deficiencies and pH imbalances and as host plants for beneficial insects and animals.

Multiple benefits of weeds are:

1. Prevent soil loss

Loss of topsoil is one of the most significant problems in nearly all farming areas in every country on this planet. Nutrient rich healthy topsoil is the basis of high yielding sustainable farming, yet many farming practices squander this precious resource.

Inappropriate tillage practices, herbicide use, poor irrigation methods and allowing soil to remain bare of plant cover are some of the major causes of soil loss. Ironically the loss of this valuable resource results in degradation of downstream aquatic environments due to these systems being overloaded with nutrients and lack of light due to the muddiness of the water.

Having a ground cover of weeds will minimize or prevent soil loss. **The tops of plants help cushion the impact of rain or wind on soil while the roots help to hold the soil together.**

2. Carbon gift

If soil nutrient levels are optimum and the weed management methods ensure that the nutrients they use are recycled into the soil – weeds can actually **increase soil fertility through the carbon gift** and nitrogen fixation.

3. Insectaries

Weeds can be used as insectary species **to attract beneficial insects and other animal species to suppress insect pests.**

4. Nutrient storage

Weeds can help to **take up excess soluble nutrient** in wet periods, stopping them from leaching, running off farm and eutrophying water.

They can be very useful in preventing leaching of soil minerals especially anions like nitrogen, boron and sulphur. They can take up and store the soluble ions that are in excess to the needs of the cash crop. Later when the weeds are managed, microorganisms will break down the residues and release a steady flow of these nutrients back into the soil for the cash crops to use.

As plants get around 95% of their nutrients from the air, sun and water, the correct management of weeds can increase soil fertility and help the crop, rather than stunt and compete with the crop.

5. Nitrogen fixation

Weed legumes can **fix significant amounts of plant available nitrogen** per hectare.

6. Disease suppression

The **micro-organisms associated** with many weeds can be **effective in suppressing diseases** in crops.

4.1.3. Weed characterization and monitoring

Weed management strategies

Weeds mostly cause problems by:

1. Competing for sunlight
2. Competing for soil nutrients
3. Competing for soil water
4. Host for pests and diseases and contamination of crop with weed residues





❑ Weed management priorities

When deciding on strategies for managing weeds it is important to analyze weeds using the four criteria.

1. Competing for sunlight

Competing for sunlight is the **most important of all negative attributes of weeds**. Apart from some crops such as cocoa, coffee and salaks (*Salacçalacca*) most plants need all the sunlight they can get.

Photosynthesis is the basis of most crops. They are living solar energy collectors. Given that 95% of the biomass of plants comes from the products of photosynthesis, optimizing the crops sunlight is critical to good achieving outcomes.

Weeds that reduce the amount of solar energy collected during photosynthesis by the crop **will reduce the yield of the crop**.

It is important that weed management strategies ensure that the weeds are kept below the leaves of the crop.

2. Competing for soil nutrients

Good soil nutrition is essential to ensure that weeds do not take up nutrients and leave the crop deficient.

As an example if the weeds take up a significant proportion of a trace element such as boron to the point where there is not enough for the crop, the crop will not be able to properly set seeds or utilize calcium. Calcium is essential for the uptake and movement of many other minerals within plants. This deficiency will lead to a poor crop and possible pest and disease problems.

The correct strategies are:

- To ensure luxury levels of soil nutrients that will supply enough for both the crop and the weeds.
- Regularly return the weed nutrients to the soil through slashing, grazing, tillage etc. The constant decay of weed organic matter will ensure a steady release of nutrients back to the soil.

The correct strategies will ensure the weeds are always returning the nutrients that they use; however with the Carbon Gift they should really be returning more nutrients and feeding the crop.

3. Competing for soil water

It is important that adequate water is provided for both the weeds and the crop. In some instances such as dry land farming this is not possible due to limited soil moisture. **When water is limited** it is important to **eliminate or reduce the weeds**.

Slashing and using the residue for mulch to retain soil moisture can be one of the best strategies however grazing or very shallow tillage before sowing the crop can also reduce weed induced water loss.

In areas where there is **ample water**, this **competition can be used to the advantage of the crop**. In some areas with wet winters and dry summers weeds can use excess winter water to produce mulch to increase the water holding capacity of the spring and summer crops.

Similarly in areas in areas with heavy summer monsoonal rains, weeds can be used to store water and nutrients as dry season mulches.

4. Host for pests and diseases and contamination of crop with weed residues

These are the weed species that should be concentrated on to be eradicated and/or replaced with beneficial species. **Weeds that can contaminate crops with seeds or extraneous matter can be eliminated, kept small or prevented from seeding.**

4.1.4. Key issues in weed/ground cover management

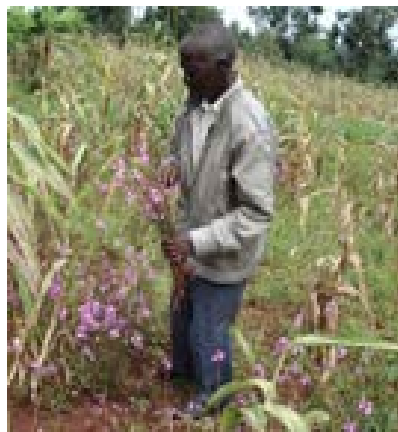
Timing

Timing is critical to efficiently control weeds. This does not mean a 3 monthly or other calendar based spray program.

It is important to **know the flowering times** of all the weeds and to ensure they are **controlled before they set seeds**. Over time this strategy will lessen the weed load by lowering the germination rate due to less weed seeds.

There is an old farmers saying: “*One year’s seeding; seven years’ weeding*”.

Many weeds are much easier to control when they are young, especially a few days after germination. Tillage, hoeing, flame weeding and steam weeding are very effective at this stage.



A flowering Striga weed-infested maize field in Kenya

❑ Working with the correct seasons

Most weeds are **easier to control in cooler drier seasons than in the warmer wetter months** when they are in active growth. Quite often the control methods have been largely ineffective in the active growth periods. Some weeds can have the energy to recover from the damage caused by herbicides, grazing, slashing, tilling and will regrow very quickly.

Sometimes it is better to wait for the right time rather than waste valuable time, resources and money on failed strategies that do not achieve any useful weed control.

4.1.5. The carbon gift – How plants increase soil carbon and soil fertility

It is estimated that between **30-60%** of the atmospheric carbon dioxide (**CO₂**) **absorbed by plants is deposited into the soil as organic matter** in the form of bud sheaths that protect the delicate root tips and as a range of other root excretions.

The best way to understand the amount of organic matter that is shed by plant roots is to look at the amount a plant biomass that is above the ground. **The amount of biomass in the top of a plant is similar to the amount of biomass in the roots.** Plant roots also shed or secrete about the same amount of biomass that is above the ground.

These complex carbon compounds contain the complete range of minerals used by plants and are one of the ways that minerals are distributed throughout the topsoil. They feed billions of microbes – actinomycetes, bacteria and fungi that are beneficial to plants. This complex of living organisms is often called the soil food web.

The greatest concentrations of microorganisms are found close to the roots of plants because of all the organic carbon compounds that are shed or secreted by the roots. This important area is called the Rhizosphere. These organisms perform a wide

range of functions from helping to make soil minerals bio-available to protecting plants from disease (see Chapter 2).



Plant roots put many tons of complex carbon molecules and bio-available minerals per hectare into the soil every year and these are the most important part of the process of forming topsoil and good soil structure.

This means that **well managed weeds/groundcover plants can put more bio-available nutrients into the soil than they remove from it**. Also the nutrients they put into the soil are some of the most important to the crop, to beneficial organisms and to the structure and fertility of the soil.

Root biomass according to plant development stages

4.1.6. Managing weeds/groundcovers to increase soil organic matter

Managing weeds and groundcovers needs to be looked at from the perspective of the Carbon Gift. Rather than only concentrating on **the 5% of a plant biomass that comes from the soil**, it is also extremely important to concentrate on the **95% that is produced** via photosynthesis from water and CO₂.

This means that the priorities in weed/groundcover management should be for the cash crop to have **priority access to the sunlight and water**.

If the weeds/groundcovers are managed properly, and their residues are allowed to return to the soil, their nutrient removal from the soil is zero. In fact, because they are adding between 30% to 60% of the organic compounds that they create through photosynthesis into the soil, they are increasing soil fertility.

If correctly managed weeds are creating nutrient deficiencies, the problem is solved by correcting the nutrient deficiencies so that there are sufficient soil nutrients for the recycling of the weed/groundcover organic matter and for the cash crop.

Simply removing weeds because they cause a nutrient deficiency is in reality ignoring the real problem. The soil is actually deficient in the nutrient. Good nutrient management should mean that the levels are **high enough to support appropriately managed weeds/groundcovers and the cash crop**.

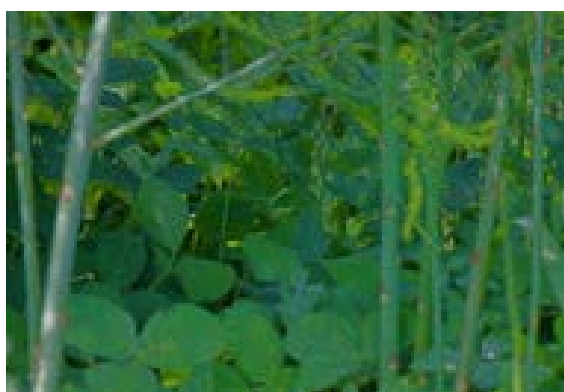
Studies of weed/pasture fallows and the micro-organisms that they feed show that they help with increasing the bioavailability of the minerals that are locked into the soil. Soil

tests show an increase in soil fertility after weed/pasture fallows and when plants are grown as green manures.

It is one of the reasons why groundcover fallows restore soil health. They return tons of carbon based organic matter into the soil, feed the microorganisms that make nutrients bio available and reduce soil pathogens.

The important thing is to ensure that the soil has adequate levels of all the minerals and moisture necessary for growth and that the vegetation management practices allow the cash crop to be the dominant plants.

❑ Managing groundcovers to feed the cash crop



Techniques where weeds/groundcovers are cut, rolled down, pulled or grazed and so that their residues are returned to the soil means they will feed the cash crop. **Cutting and grazing plants** will result in **significant percentages of roots being shed off** so that the weed or cover crop plants can re-establish **equilibrium between their leaf and root areas**.

Soybeans ground cover under emerging asparagus bed

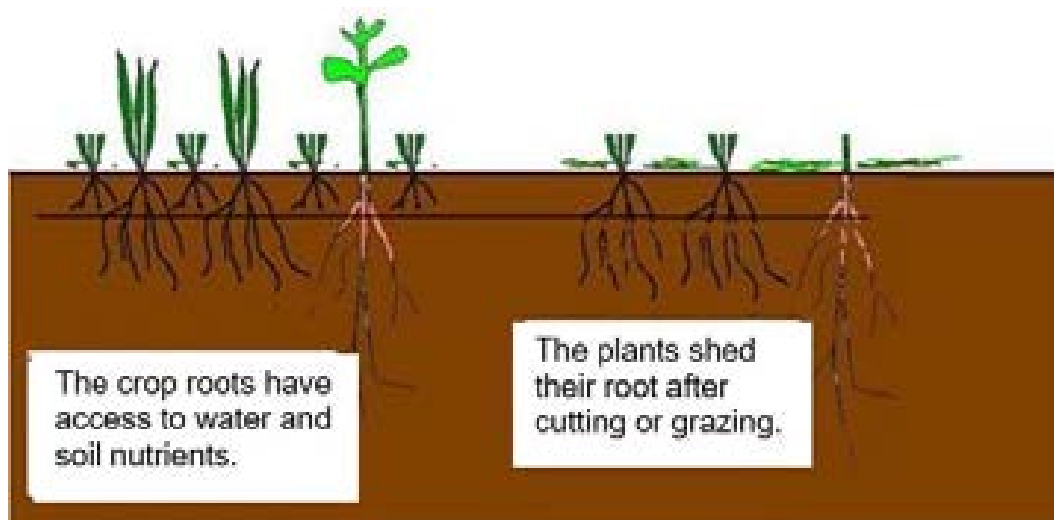
Plants feed themselves from their leaves through photo synthesis. When the amount of leaf area is reduced through grazing or slashing the amount of sugars and amino acids needed to feed the plant, especially the roots is significantly reduced. The plant can only feed the roots in direct proportion to the amount of these photosynthesis products. They cast off the roots that they cannot feed to ensure that they are in balance otherwise all the roots will be starved and the plant will die.

These cast off roots from the weeds/groundcovers not only add carbon and feed the soil microorganisms, they release nutrients to the crop and significantly lower nutrient and water competition. This addition of nutrients encourages the cash crop roots to grow deeper in the soil, below the weed roots resulting in larger crop root systems and better access to water and soil nutrients.



Plants shed their roots after being mowed or grazed. Loss of the leaves means a reduction of the sugars and amino acids produced through photosynthesis. Without these food sources the roots can starve and die killing the plant. The plant shed the roots leaving just enough to be fed by the leaves. The shed biomass from the roots is decomposed by micro-organisms releasing the nutrients into the soil for use by the cash crop.

Crop has access to sunlight



This has become **the basis of the emerging organic no till and minimum till systems** where crops are planted into pastures or previously sown cover crops. The critical issues in these systems is the **choice of the right species for the pasture and cover crops**, and the management of these so that they do not compete with the crop for sunlight, water and nutrients. Rolling, grazing or cutting can usually achieve this. These techniques can leave a thick cover of mulch that will suppress weeds, conserve water and encourage beneficial micro-organisms.



These techniques **also increase the efficiency** of the farm surface area **capturing sunlight** and using photosynthesis to make the carbon based molecules that eventually result in the fertile soils that feed plants.



Increasing solar efficiency by capturing the light not used by the cash crop. The light not intercepted by the leaves of the cash crop is intercepted by cover crop to provide carbon, nitrogen and attract beneficial insects. The cover crop is cut to act as a living mulch in the drier seasons to conserve water, increase soil carbon and to add nutrients to cash crop.

The other concept is a perennial cover crop. Cover crops do not have to annuals or ploughed into the soil to return nutrients in the soil. They can be periodically cut or grazed to achieve this.

The nutrients that are lost off farm, either through selling the crop, through soil leaching or erosion need to be replaced every year. Good fertilization should always ensure that the soil has the optimum level of all the necessary minerals. If the management system does not replace the minerals that are removed from the soil when by the crop, the system is mining the soil and running it down.

One of the reasons why good organic farmers notice that weeds do not become a problem in their systems is because they ensure they have excellent soil nutrition and health by using weed/covercrop management techniques that build up the soil. *The process becomes one of effective weed/groundcover management rather than weed eradication.*

4.1.7. Examples of using the carbon gift in successful farming systems

There is a growing list successful farming systems using these principles to produce low input high yielding systems. These systems have the ability to increase to profitability of agricultural systems by significantly lowering the costs of production and increasing the output from the systems.

❑ Rodale no/low till systems – Cover cropping

The Rodale trials are excellent examples of these principles. They had a reduction of fossil fuel input of up to 75% and significant increases in yield.

These systems work through a combination of low till and no till in the crop rotation sequence in farming. All organic annual cropping systems must incorporate a crop rotation system. Continuous monocultures of the same crop year after year are not permitted.

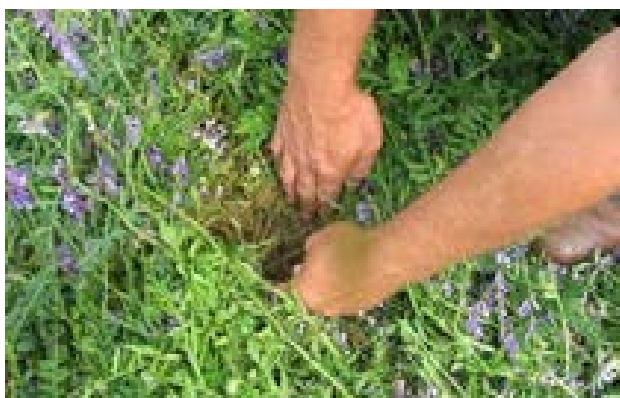
The basis of these systems is to choose a suitable fast growing cover crop such as vetch, rye, oats etc. These are generally planted in the season prior to the season for the cash crop or early in the season. Farmers around the world are successfully modifying and adapting the timing and choice of cover crops to their specific climates.

In the Rodale system they use a specially designed crimping roller that flattens and suppresses the cover crops instead of spraying with synthetic herbicides or ploughing in the crop. The current system has the roller on the front of the tractor and the seeder on the back so the crop is planted in one pass.

“The resulting living-mulch mat acts as a barrier against weeds, conserves moisture, protects the soil, provides an extensive rhizosphere (root zone) for beneficial microorganisms, and – in the case of leguminous cover crops such as hairy vetch – provides a source of nitrogen to the cash crop” (Rodale,2008).



Rolling and seeding the vetch in one pass



Checking the seed placement in the freshly rolled vetch





The seedlings emerge from the dead vetch. It is acting as a mulch to suppress weeds and conserve soil moisture



The crop shades out any emerging weeds

“Rodale Institute’s organic rotational no-till system can reduce the fossil fuel needed to produce each no-till crop in the rotation by up to 75 percent compared to standard-tilled organic crops” (LaSalle, T. and Hepperly, P., 2008).

Energy used in different corn production systems expressed in liters of diesel per hectare

Conventional tillage	231 liters per hectare
Conventional No-till	199 liters per hectare
Organic tillage	121 liters per hectare
Organic No-till	77 liters per hectare (Pimentel <i>et al.</i> , 2005)

“The 2006 trials resulted inorganic yields of 160 bushels an acre (bu/ac) compared to the Country average of 130 bu/ac.[...] the average corn yield of the two organic no-till production fields was 160 bu/ac, while the no-till research field plots averaged 146 bu/ac over 24 plots. The standard-till organic production field yielded 143 bu/ac, while the Farming Systems Trial’s (FST’s) standard-till organic plots yielded 139 bu/ac in the manure system (which received compost but no vetch N inputs) and 132 bu/ac in the legume system (which received vetch but no compost). At the same time, the FST’s non-organic standard-till field yielded 113 bu/ac. To compare, the Berks County average non-organic corn yield for 2006 was 130 bu/ac, and the average yield for Southeastern Pennsylvania was 147 bu/ac” (Rodale, 2006).

Plans for the roller and for more comprehensive information on the various cropping systems are available on the Rodale Institute Website: www.rodaleinstitute.org. The book by Jeff Moyer (Moyer, J., 2011), *Organic no-till farming, Acres USA*, Texas, USA, is a very useful manual of how to get the best results.

❑ Pasture cropping – Annuals in a perennial system

A very successful variation of cover cropping is pasture cropping. This is **where the cash crop is planted in a perennial pasture** instead of planting it in an annual cover crop. This was first developed by Colin Seis in Australia. The principle is based on a sound ecological fact. Annual plants grow in perennial systems. The key is to adapt this principle to the appropriate management system for the specific cash crops and climate.

The pasture is first grazed or slashed to ensure that it is very short. This adds organic matter in the form of manure, cut grass and shed roots. The crop is directly planted into the pasture.

According to Colin Seis: “It was also learnt that sowing a crop in this manner stimulated perennial grass seedlings to grow in numbers and diversity giving considerably more tones/hectare of plant growth. This produces more stock feed after the crop is harvested and totally eliminates the need to re-sow pastures into the cropped areas. Cropping methods used in the past require that all vegetation is killed prior to sowing the crop and while the crop is growing.

From a farm economic point of view the potential for good profit is excellent because the cost of growing crops in this manner is a fraction of conventional cropping. The added benefit in a mixed farm situation is that up to six months extra grazing is achieved with this method compared with the loss of grazing due to ground preparation and weed control required in traditional cropping methods. As a general rule, an underlining principle of the success of this method is ‘One hundred percent ground cover One hundred percent of the time’”.





"[...] a 20 Ha crop of Echinops oats that was sown and harvested in 2003 on... 'Winona'. This crop's yield was 4.3 tons/ha (31 bags/ acre). This yield is at least equal to the district average where full ground disturbance cropping methods were used".



"This profit does not include the value of the extra grazing. On Winona it is between \$50 - \$60/ha because the pasture is grazed up to the point of sowing. When using traditional cropping practices where ground preparation and weed control methods are utilized for periods of up to four to six months before the crop is sown then no quality grazing can be achieved.

Other benefits are more difficult to quantify. These are the vast improvement in perennial plant numbers and diversity of the pasture following the crop. This means that there is no need to re-sow pastures, which can cost in excess of \$150 per hectare and considerably more should contractors be used for pasture establishment.

Independent studies at Winona on pasture cropping by department of land and water have found that pasture cropping is 27% more profitable than conventional agriculture this is coupled with great environment benefits that will improve the soil and regenerate our landscapes".

➤ **Builds soil fertility without synthetic fertilizers**

Dr Christine Jones has conducted research at Colin Sies's property showing that in the last 10 years 168.5 t/ha of CO₂ was sequestered.

- The sequestration rate in the last two years (2008-2010) has been 33 tons of CO₂ per hectare per year.
- This increase occurred during the worst drought in recorded Australian history.

The following increases in soil mineral fertility have occurred in 10 years with only the addition of a small amount of phosphorus.

- Calcium 277%, magnesium 138%, potassium 146%, sulphur 157%, phosphorus 151%, zinc 186%, iron 122%, copper 202%, boron 156%, molybdenum 151%, cobalt 179% and selenium 117%.¹



Comparison of soil between Winona and neighbor.

Pasture cropping

Conventional

☐ **Pasture cropping and cover cropping in horticulture**

These systems have been used very successfully in horticulture with numerous advantages. A good ground cover will suppress weeds, add nitrogen, conserve water and give nutrition to the cash crop from organic matter that comes from the shedding of roots and decay of the leaves and stems.

¹ Carbon that Counts: www.ofa.org.





Onions grown in rye grass (Lolium sp.). The rye grass is mowed down as short as possible. The onions are seeded into small ploughed strips. The grass is regularly mowed with a side throw lawn mower. The mowed grass clippings act as a mulch to suppress weeds and conserve water. The discarded roots of the rye grass are broken down by micro-organisms to provide a range of complete nutrients to the cash crop.

❑ Perennial horticulture

The concept of groundcovers has been used extensively in perennial horticulture, especially in orchards and vineyards. Plantings of swards of legumes, grasses and flowering plants can provide nitrogen, organic matter, mulch and attract beneficial insects.

In most perennial systems there is a season that gets the most rainfall. In many temperate climates, especially Mediterranean climates, this is in winter when there isn't much growth from the cash crop. Planting winter growing groundcovers such as vetch is a way of capturing the sunlight and rainfall not used by the crop to improve the farming systems. The cover crops can add nitrogen and carbon and provide valuable mulch for water conservation in the drier and hotter summer months.

In **tropical climates the groundcovers** can do the same and provide **mulch for the drier winter months**. There is the added advantage that they protect the soil from erosion during the intense tropical downpours and prevent nutrient leaching by taking up the nutrients in the biomass. These nutrients are released to the cash crop when the cover crop is cut down at the beginning of the dry season.

Letting the groundcovers grow tall and coarse will improve their content in lignin and so on the quantity of carbon rich organic matter in the soil. The general rule is the taller the plant the deeper the roots. This will increase the depth of the carbon rich topsoil.

Consequently tall coarse ground covers are better for deepening and improving the stable carbon levels in soils



Tall course ground covers being mowed down. Deepens the soil, increases soil organic matter, provide nutrients to the cash crop (Lychee trees) and mulch to conserve water.



4.2. Curative weeds treatments

4.2.1. Mechanical control

☐ Tillage

Tillage is one of **the oldest and most effective weed control methods**. Unfortunately it is also one of the most abused methods resulting in severe soil loss and damage when used incorrectly.

One of the important methods used to control weeds is the turn over the weeds to expose them to be desiccated by the sun.

Another is to turn them into the soil as a green manure. It is important not to do this too deeply, as occurs in some practices where the topsoil is turned under the subsoil, as this will reduce soil fertility instead of improving it.

Freshly turned soil encourages weed seeds to germinate and these can later be exposed to the sun with shallow cultivation to lessen the weed seed load.

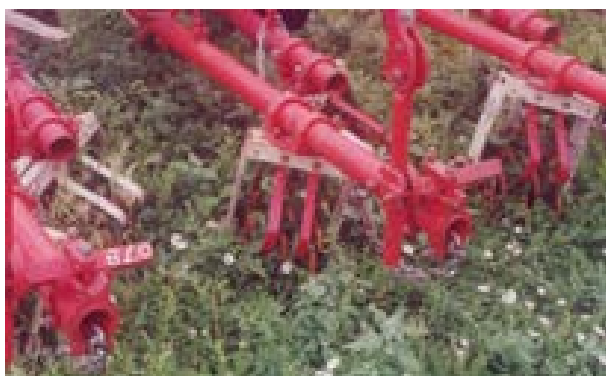
A large range of methods can be used to control weeds in the rows between crops.

Rotary hoes are very effective however this should be kept very shallow at around 25mm to avoid destroying the soil structure.

Various spring tynes, some types of harrows, star weeders, knives and brushes can be used to pull out young weeds without disturbing the crop.



Leyley spring tyne weeder (Photo: Google Pictures)



Star weeders – Light tillage (Photo: Google Pictures)

Disking the inter row and hilling the crop with soil will destroy most of the weeds between the crop and smother many of the weeds growing in the crop row.

There are several cultivators with guidance systems that ensure precision accuracy for controlling weeds. These can be set up with a wide range of implements and can be purchased in sizes suitable for small horticultural to large broadacre farms.



Guidance systems for precision weed tillage



Correct tillage can give good weed control

Organic farmers in the USA, Europe and Australia are using these to get excellent control over weeds in their crops.





Strategic tillage can give very good results

➤ **Tillage and soil erosion**

Organic farmers are criticized for using tillage for weed control with critics stating that this leads to more soil erosion and loss of soil organic matter.

The published science shows that correct tillage (see tillage section) in organic systems does not cause either.

“We compare the long-term effects (since 1948) of organic and conventional farming on selected properties of the same soil. The organically-farmed soil had significantly higher organic matter content, thicker topsoil depth, higher polysaccharide content, lower modulus of rupture and less soil erosion than the conventionally-farmed soil. This study indicates that, in the long term, the organic farming system was more effective than the conventional farming system in reducing soil erosion and, therefore, in maintaining soil productivity” (Reganold et al., 1987).

Critics of organic systems point to conventional no till production systems as superior to organic systems because the organic systems use tillage. There is only one published study comparing conventional no till with organic tillage systems. The researchers found that the organic system had better soil quality.

“[...] the OR [organic] system improved soil productivity significantly as measured by corn yields in the uniformity trial [...] These higher levels of soil C and N were achieved despite the use of tillage (chisel plow and disk) for incorporating manure and of cultivation (low-residue sweep cultivator) for weed control”.

“Our results suggest that systems that incorporate high amounts of organic inputs from manure and cover crops can improve soils more than conventional no-tillage systems despite reliance on a minimum level of tillage” (Teasdale et al., 2007).

❑ Slashing

Cutting weeds with tractors and slashers, lawnmowers and brush cutters or by hand with scythes, sickles, cane knives and machetes etc. are all very useful tools to control weeds. This method ensures that the **weeds still hold the soil together to prevent soil loss and return nutrients and organic matter to the soil**. The cut weeds can also provide valuable mulch.



Tractor mounted slasher for weed control

Constant mowing – slashing will favor the more prostrate species. This can eliminate some of the worst weeds however it is important not to limit the ground covers to one or two low growing grass species.

Ongoing research since the 1930's has shown that limiting biodiversity through constant mowing will promote pest species. It is better to encourage a high biodiversity, especially of flowering plants to encourage beneficial species. **The aim should be to produce a lush meadow style rather than a city park look.**

❑ Flame weeding

Flame weeders are used to quickly sear weeds with a naked flame. **The aim is not to burn the weed, but to make most of its cells burst and blister through boiling the cell liquid.** Many plants shoot back and recover from a complete burn; however they usually die if enough cells are injured through heat.

Flame weeders come in a range of forms from back pack or hand trolley mounted forms for small orchards and horticultural crops to large tractor pulled implements.

The flame is surrounded by a shroud to ensure that the crop is not burnt. The burners and the shrouds are adjusted to the row widths and the farmer quickly passes down the rows searing the weeds.

There are several commercial models that are readily available from broadacre to hand use.





Flame weeders for small farms



Flame weeders for large farms

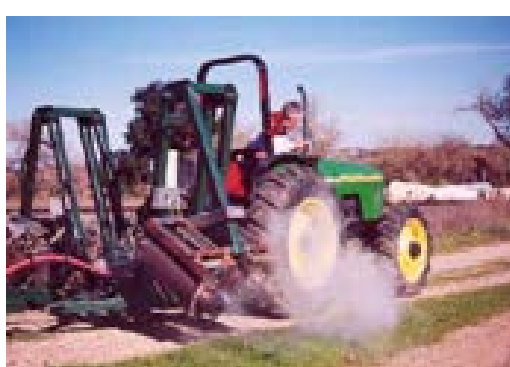
The advantage is that it is very quick. The major disadvantage is that it cannot be used when the weeds are drying out as it can burn the crop – and the district.

Steam weeding

Steam weeding works on the same principles as flame weeding except that high pressure steam is used instead of a flame.

The **major advantage is that it will not cause a fire**. Most steam weeding systems are still in prototype stages however it will become one of the major replacements for herbicide use due the ease of use and safety to the environment.

There are several commercial models that are readily available.



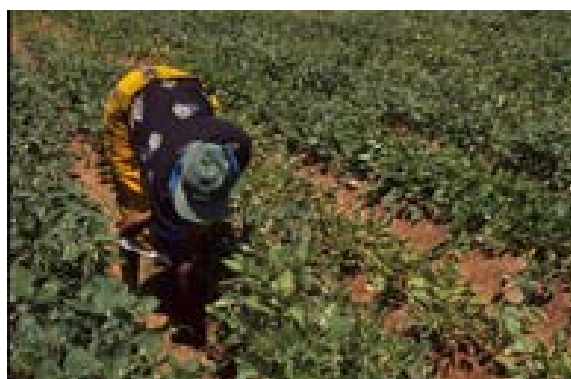
Various types of steam weeders (Photos: Google Pictures)

A practical way to develop a steam weeder in horticulture is to buy a normal steam cleaner and modify it for the farm. There are lots of models available. Look for ones that are portable and can be used with a small portable electrical generator.

❑ Hand weeding – Pulling, hoeing and cutting

One of the most effective and efficient methods of weed control has become a lost art due to the use of mechanization and chemical spraying – hand weeding. In these days of factory style production it is not considered an economically viable option.

However **when done properly and systematically as part of an overall weeds management strategy** many commercial organic farmers regard these methods as **very efficient and cost effective**.



Usually these methods are confined to the hard to get at areas or for the worst weeds.

Examples are the weeds that cannot be reached by cultivation or mechanical slashing, or those that grow out of ground covers.

Woman farmer hand weeding cowpea field

The correct well maintained tools are important in hand weeding. Usually these are the traditional tools that farmers have used for centuries. These tools have been repeatedly refined and improved by each generation and are now tried and proven as very effective. Examples of these are hoes, sickles, scythes, cane knives and machetes. It is important that blades of these instruments are kept razor sharp so that the blade and the weight of the tool does the work. Each tool has a correct method of use that allows the user to weed a large area quickly and efficiently with the minimum of effort.

In Germany the word Morgen ('Morning' in English) is used as the unit of measurement for about an acre of land. (One hectare = 2.5 acres). A Morgen was the area that a farmer could slash with a scythe in the morning. This clearly shows that the correct forms of hand weeding are economically viable and practical in most family sized horticultural farms.

Skilled farmers can easily keep many hectares well maintained through hand weeding methods. Given that most of the world's farmers only have **around two hectares, hand weeding is the obvious and most cost effective solution to weed management.**

Farmers should learn these and practice them, in order to prevent bad backs and other repetitive strain injuries.

❑ Crop rotations

Crop rotation can be **used very successfully to suppress weeds**. Dense crops of canola can be used before a crop such as soybeans as the canola tends to smother weeds. High density plantings of grain such as oats, wheat and sorghum can be used to shade out weeds for the following crops of vegetables or lucerne and other legumes. These crops can be planted in the stubble of the harvested grain crop.

Crop rotations break weed cycles smothering and/or disrupting their germination and seeding cycles.

4.2.2. Physical control

❑ Cover crops

Cover crops suppress weeds by out competing them and also when used later as living or dead mulches.

The advantages of this method are that the sward can provide useful nitrogen, suppress weeds, retain soil moisture through mulching and also protect the soil from wind and water erosion. This method also increases the organic matter levels and fertility.

In orchard situations useful ground covers can be selected to suppress weeds and replace them with beneficial plants. The aim is to change the ground cover balance from negatives that compete with crop to positives such as soil stabilization, nitrogen fixation, habitat for beneficials, mulch and organic matter for trees and soil. Examples of this are introducing legumes, such as pinto peanut, hairy vetch (*Viciavillosa*), barrel clover (*Medicagotruncatula*) and lucerne as ground covers.



Low growing legumes. Legumes such as clover, alfalfa, Desmodium, and pinto peanut make ideal ground covers. They are prostrate, suppresses many weeds, provide nitrogen and the flowers function as insectaries for beneficial insects.

Insectary plant species, especially flowering plants can be used as ground covers to suppress unwanted species and to encourage beneficial arthropods and higher animal species.

❑ Mulching

Mulching is a very effective way of suppressing weeds. The **weeds are completely covered by the mulching material**, resulting in death due to lack of light. Mulches are very beneficial in **retaining soil moisture, preventing soil loss** and as they biodegrade they provide organic matter and stimulate soil organisms.



Mulching with raised beds in Kenya

Harvested weeds can be used as mulch to suppress other weeds, however it is important to ensure that they are used before they seed – otherwise they could lead to later weed problems. Harvested weeds with seeds should be composted with temperatures over 70° C to destroy most of the seeds.

Commercial mulches such as weed mats are available. Plastic mulch is now being phased out in the organic industry due to the pollution resulting from disposal. A variety of biodegradable mats and films are being tested as commercial mulches to replace black plastic and many of these will be available in the near future.



❑ Living mulches

Ground covers can be used as living mulches. Correctly selected ground covers can help conserve soil moisture as well as suppress weeds and diseases, increase soil fertility and acts as insectary plants to attract beneficial species. The **system is capturing the solar energy not captured by the cash crop** – increasing the efficiency of the farming system and lowering input costs.



Living mulch under fruit trees. Conserves water, maximizes solar capture, fixes nitrogen and soil carbon and the flowers attract beneficial insects.



Desmodium as a living mulch in maize suppresses weeds, adds nitrogen, conserves the soil, repels pests and provides high protein stock feed

❑ Sheet composting

Sheet composting can be a very effective method of **suppressing weeds**, as well as **improving the soil and feeding the crop**. A thin layer of fresh manure is put over the

weeds. Cover this with a thick layer of organic mulch to shade the weeds and trap the ammonia gas. Be careful that the manure or green compost does not burn the crop.

❑ **Shade as weed control**

Competition for sunlight is the most important of the interaction between crops and weeds. Reversing the situation so that the crop shade the weeds is one of the most useful situations.

High density planting of crops will control many weeds by shading them out. This can be used very successfully in crops like sugar cane, corn **and many vegetable crops**, where good control of weeds while the crop is small, will ensure minimal weeds once the crop begins to reach the size where it shades the soil.

The selection of **crop varieties with larger leaves** that overhang the soil, **quickly creating shade will suppress the emergence of weeds.**

There are techniques with vine crops that utilize Y shaped trellises or complete canopies to shade out the majority of weeds.

Dense large canopies on fruit trees will do the same in orchards.

This will not work with all weeds. There are several weed species that tolerate shade and some vine weeds can still find their way to the top of the crop, including tall fruit trees.

❑ **Organic herbicides**

There are a range of natural compounds that can be used as herbicides in organic systems.

- **Acetic acid (vinegar)**
USDA research shows that 9% acetic acid will kill all weeds after repeated applications. 3% is effective for soft weeds.
- **Pine oils**
Mixed results. Effective in hot dry – ineffective in hot humid conditions.
- **Essential oils, emulsified oils, soaps**
Mixed results – work well in some circumstances

All of these **work as burn down herbicides** similar to paraquat. They do not poison the weed, just burn down the stems and leaves. The weeds will shoot up again, so that effective control will mean regular applications until the plants burn out their starch reserves.

The major advantage of these compounds is that farmers can use their existing spray equipment.

Most organic organizations are not very supportive of the concept of organic herbicides due to the concern that the farmers who use them will just become substitution farmers, with farming systems that are almost identical to conventional farms, only using non-toxic inputs. Some organic certifiers will not allow them for this reason.

There is a role for organic herbicides when they are just one part of a well-designed multifunctional weed management system rather than the only method.

❑ Quarantine

It is **important to have systems to stop the introduction of new weeds**, especially noxious weeds.

One strategy is not to allow any vehicles on the farm fields apart from dedicated farm vehicles. Do not allow visitors to drive off the farm road or past the sheds and house. This will make it easy to monitor these areas for new weed introductions. It is usually easy to eradicate a small patch of weeds, before they take over large areas.

If stock feeds or mulches are being brought onto the farm, it is important to be vigilant for any new weeds that might come up in the manure or the mulch beds. Where possible hot compost all vegetative material (hay, mulch etc.) brought onto the farm to destroy most of the weed seeds.

Ensure contractors clean all heavy machinery used on the farm. This is one of the most common ways of spreading weeds.

4.2.3. Biological control

❑ General biological control

Organic agriculture does have several very good methods of bio-control of weeds and these involve integrating animals and weed competitive beneficial plants into the farming system.

These are good examples of Eco Function Intensification (EFI) where the system uses applied ecology to manage the weeds. It is the opposite of the complete eradication of all plants other than the crop, with herbicides, that is the dominant paradigm of conventional agriculture. These organic systems are actively increasing the functional biodiversity of the system rather than reducing it through poisoning it.

Building a healthy and bio-diverse rich farm ecology will ensure that many weeds will also have their natural bio-control agents.

The world's worst weeds are plants that have been taken from their native countries without their natural bio-controls. In a limited number of cases their insect or disease bio-controls have been introduced into the new regions and these have been effective in significantly reducing the weed problem.

An example of this is the water hyacinth (*Eichhornia crassipes*) which was widely introduced around the world as an ornamental water plant from its home in the upper reaches of the Amazon. It quickly spread and choked out river and lake systems in the warm temperate to the tropical regions of the world. In some places it formed mats that were so dense that it stopped boats as well as killing much of the native aquatic species due to outcompeting them for all the light and reducing oxygen.

The introduction of several of the water Hyacinth's bio-controls has cleared it from most

tropical areas, although this has not been as successful in subtropical and warm temperate regions.

However the general principle of building high biodiversity into the farming systems, especially by incorporating insectaries will ensure that there will be some of the natural weed bio-controls in the systems.

These are generally not sufficient in their own to control the problem weeds and it is always necessary to use a range of strategies in an integrated whole of farm system.

□ Grazing

Many of the most aggressive weed species in cropping and orchard systems were introduced for the grazing industries. The characteristic that makes a fast growing pasture also makes hard to control weeds.

Grazing is one of the most effective methods of weed control, and when done sustainably will also increase soil fertility by increasing humus and soil nitrogen.



*Grazing is a very effective form of weed control
(Photo: Google Pictures)*

The microorganisms in the guts of grazing animals break cellulose down into glucose and also fix air nitrogen to synthesize proteins and other important organic compounds.

Most of these compounds are utilized by the animal and the balance is excreted as valuable plant food and soil improver. Research shows correct grazing will increase exchangeable soil minerals including nitrogen.

Grazing improves the efficiency of the system. It is a way of value adding fertility and increasing production.

Traditional cultures have always used grazers and foragers – such as geese, ducks chickens, guinea fowl, pea fowl, goats, sheep, cattle, llamas, yaks, water buffalo, rabbits, guinea pigs etc. to turn weeds into food and fertilizer. Poultry also eat many of the weed seeds and destroy them.



Rotational grazing of egg laying poultry

Geese can be very useful in managing weeds. Young Chinese Geese can be trained to eat specific weeds by feeding these weeds to the geese when they are very young and just starting to graze on plants. They develop a taste for these weeds as their preferred forage and they will actively seek them out and graze them down.

Cell grazing

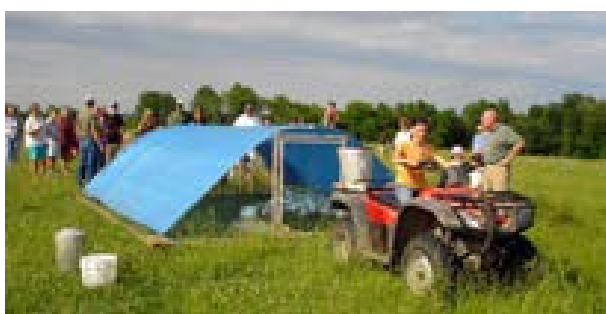
One of the most successful methods of controlling weeds in pastures is called Cell or Controlled grazing. In many current grazing systems the animals tend to concentrate on the species that they prefer and continuously eat them out. This leaves the weeds to proliferate.

The **cell grazing system confines the stock to smaller paddocks for several days forcing them to thoroughly graze all the edible plants**. The higher stock density also ensures the weeds are crushed and trampled and that the manure is kicked and well scattered across the ground. The animals are then moved to another cell and the process is repeated. There is a continuous rotation of controlled grazing in the cells with the animal returning to the original cell when the feed has regrown.

Some of the most successful examples use multiple species in succession such as cattle, followed sheep, followed by poultry as each will tend to eat different species.



Cell grazing with sheep (Photo: Google Pictures)



Cell grazing with young poultry (Photo: Google Pictures)

Cell grazing has been shown to significantly reduce weeds, increase biodiversity and improve productivity in Australia, Africa and the USA.²

Poultry and pigs eat weeds and weed seeds. They are very effective in reducing the load of weed seeds in the soil.

❑ Out competing weeds with beneficial plants



One of the most effective ways to reduce weeds is to plant beneficial species that will out compete them. Some good examples are useful legumes such as soya beans, *Desmodium*, pinto peanut planted in the rows between the crops in orchards and vegetable plots. This is the same concept of the living mulch and cover crops.

Shade and replacing with beneficial species as weed control –Soya beans in sugar cane

² See Savoury Institute for more information.



The correct choice of species will not only out compete the weeds for sunlight and nutrients, they should be beneficial for the cash crop by adding nitrogen, conserving water and capturing the sunlight not used by the cash crop to produce useful organic matter. Their flowers should also be able to attract beneficial insect to help with pest control.

This is a relatively new area of organic farming and more research is needed to work out the best combination of plant species and the methods to use them effectively.

It is worthwhile to experiment on different species. Just do a few small areas first to ensure that the introduced legumes are effective at suppressing weeds and can be effectively managed.

It is important to ensure that there are adequate nutrients and moisture for both the cash crop and the living mulch and that the cash crop has access to the sunlight.



4.3. Use a whole of farm approach

4.3.1. Use multiple integrated strategies

Research shows that the best organic farmers use multiple integrated strategies for weeds and achieve very good control.

It is important to look at weeds from the four criteria. In most cases the first three strategies apply. By ensuring that the weeds do not shade the crop, that there is enough nutrition and water for the weeds and the crop, the weeds are usually helping rather than hindering the crop. In these cases it is counterproductive to kill or remove them.

In some crops, growers are penalized for extraneous matter, especially if these are weed seeds. Strategies like preparing a weed bed to encourage germination and ploughing this in before planting will lessen the weed load. This should be followed by dense planting to encourage early shading and various methods of cultivating or steaming the inter row to remove all weeds. Several people on hoes can be used to remove the few weeds remaining in the rows.

Good organic farmers find that their weed loads significantly reduce over the years. Many of the worst weeds seem to disappear and tend to be replaced with softer easier to manage species.

Weeds are not always bad and should not be removed because they are not part of the crop. A **good organic farmer** develops a **series of management strategies** that minimise the negative aspects of weeds and enhances the positive aspects. By doing this, the farmer ensures that weeds increase the productivity of the agricultural system.

There is no such thing as a weed problem. There are only management problems and these can be solved.

4.3.2. Weed management plans

Good organic farmers manage weeds rather than just try to destroy them. Effective management means good planning and the best way to do this is to prepare a plan.

Example of a generic weed plan for a tropical fruit orchard.

Firstly consider the four criteria for management strategies:

- 1 Competing for Sunlight
- 2 Competing for Soil Nutrients
- 3 Competing for Soil Water
- 4 Host for pests and diseases and contamination of crop with weed residues

❑ Short term strategies

Slashing/mowing will work effective for all the weeds in an orchard, especially those in categories 1, 2 & 3. This will ensure they do not compete for light and by cutting them down, they will shed roots and this will severely reduce their competition for nutrients and water.

Category 4 weeds general need extra treatments. Regular slashing/mowing treatments are needed to stop them from regenerating. This will see them die when they use all their starch reserves. Cutting them out with a sharp hoe is a very effective way to deal with them.

Only ever slash part of the orchard at one time and leave other areas untouched until later in the season. Never remove all the weeds from one section of the orchard, as it is necessary to **encourage small flowering plants as hosts for beneficial insects, fungi etc.** These plants should be managed as insectaries.

Depending on the size of the orchard the weeds between the rows can be controlled with a tractor and slasher, lawn mowers, scythes and grazing from small animals and poultry. Once or twice a year use a cane knife, sickles or machetes as well hoeing and hand pulling under the trees to clear plants missed by the slashing and grazing.

❑ Long term strategies

Biodiversity is essential to healthy environmental systems. The more complexity built into the system means fewer spaces in that system for pathogens (diseases, insect pests, noxious weeds etc.) to colonize. This is achieved by **having other species out-compete them** for space, directly predate them or actively aid the crop species through symbiosis.

The aim is to change the ground cover balance from negatives that compete with crop to positives such as soil stabilization, nitrogen fixation, habitat for beneficials, mulch and organic matter for trees and soil.

Examples of this are **introducing prostrate legumes, such as pinto peanut, as a ground cover.** This low growing species spreads by runners and adds nitrogen to the soil. It chokes out many of the weed species, stabilizes the soil and builds humus.

Some of other legumes such as centro, mimosa, calopo and stylo are usually considered as weeds by conventional farmers; however the use of geese and other fowls will graze them so they don't choke the trees. **Use chicken feed to direct the poultry to areas of orchard where they are needed to work.** Every morning scatter the feed under the trees in the area of the orchard where they are needed. After a week or so take them to another area so that it can be grazed and the previous area rested.

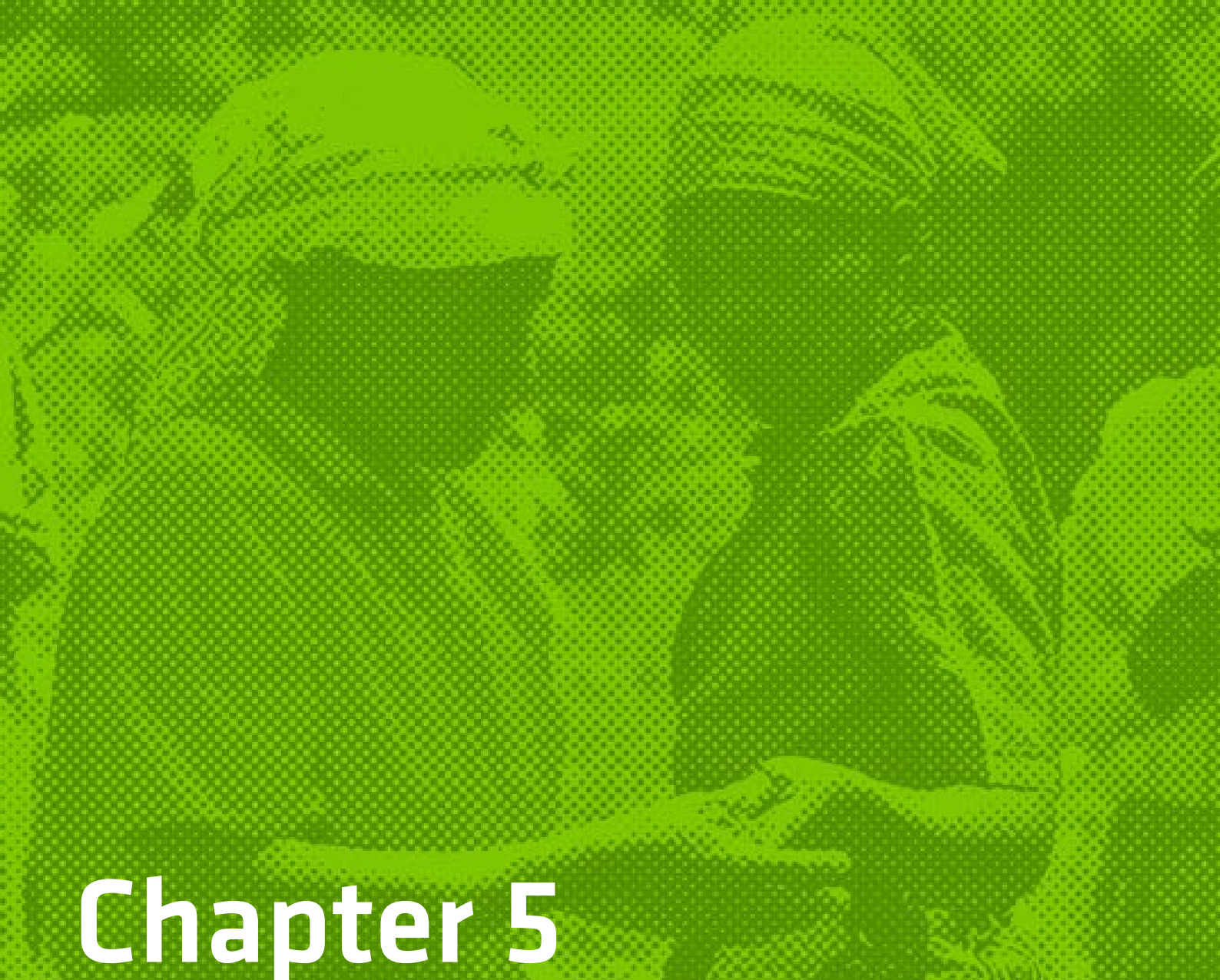
Poultry also eat many of the weed seeds and insect pests as well as fertilizing the soil.

Use shade as weed control. The canopy of the fruit trees shade out many weed species. The marginal areas should steadily planted out with taller species such as bamboos and native flowering trees. These will shade out the worst weeds such as tall grasses like guinea and elephant grasses, while providing wind breaks and food and shelter for useful insect, bird, mammal, reptile and amphibian species.



The aim is to produce a lush meadow style rather than a city park look. This should be a **robust system that requires very little maintenance**, provides nitrogen and other nutrients to the cash crops, works as an insectary attracting beneficial species, protects and build up the soil health, retain soil moisture and reduces pests and diseases





Chapter 5

Organic seed and plant production

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5.1. Varieties characteristics

5.1.1. The importance of the correct varieties

The correct choice of varieties is essential to successful organic farming. Many of the modern cultivars are a result of breeding programs that rely in high levels of inputs, especially water, synthetic water soluble fertilizers and synthetic pesticides, fungicides and herbicides. Consequently their performance is not always optimal in organic systems.



On the other hand **varieties that cope with organic growing conditions** can give **higher yields** and better quality crops **under lower input organic conditions**.

One of the world leading authorities on this, Professor Bernd Horneburg, wrote: *"In paired organic/conventional selection experiments with wheat (Murphy et al., 2007, Reid et al., 2011) and maize (Burger et al., 2008) it has been demonstrated that the best genotypes for organic cropping are selected within the organic system.*

*Murphy et al. (2007) have demonstrated that **the top yielding soft white winter wheat breeding lines in organic management did not correlate to the top yielding ones in conventional management** in four out of five paired trials.*

*In the words of Murphy et al. (2007), **'With crop cultivars bred in and adapted to the unique conditions inherent in organic systems, organic agriculture will be better able to realize its full potential as a high-yielding alternative to conventional agriculture'***" (Horneburg 2011).

One of the keys to obtaining good yields in organic agriculture is selecting the best performing varieties. This can be done by trialling many varieties and selecting from those that perform the best.

On farm variety testing should look for the following characteristics when selecting the best varieties:

- High yields
- Weed suppression
- Weed resistance
- Pest and disease resistance

- Low input
- Acceptable to the market
- Multiple varieties to extend the season

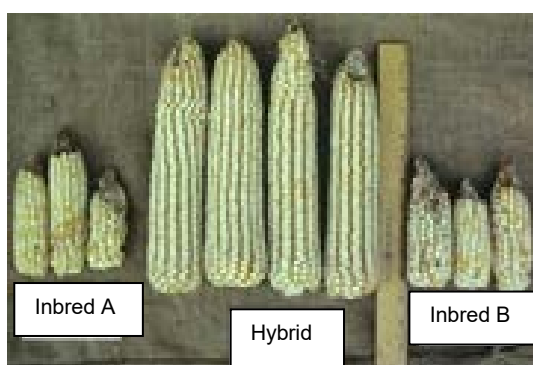
These characteristics will be covered in more detail in 5.3., “Varieties breeding”.

5.1.2. Understanding hybrids and open pollinated varieties

There is a debate in organic agriculture about whether to use hybrid or open pollinated varieties. **IFOAM accepts the uses of hybrid seeds however** “*IFOAM’s position on development of organic seed production is to stimulate the importance of seed supply from the open pollinated varieties, traditional sources, home gardens and on farm seed, as diverse populations that have evolved in response to local pressures*”.

☐ Hybrid seeds

Hybrids are created when the two different varieties or accessions of plants are crossed and they create offspring with some of characteristics of both parents. This **occurs naturally all the time** and is why **they are allowed in organic agriculture**.



Plant breeders have been hybridizing new varieties for thousands of years. Also since the beginning of agriculture, 10,000 years ago, farmers have selected natural hybrids for their improved characteristics and this has been one of the reasons for the continuous improvement and development of locally adapted varieties.

Parental inbred lines A and B and the hybrid A x B

A very important critical reason why first generation (F1) hybrids are commonly used is due to a phenomenon known **as hybrid vigor**. The first generation tends to be more productive than either of the parents.

The **down side** is that when the seeds of the F1 hybrids are saved and planted their offspring, **the second generation (F2), are highly variable** and do not give consistent results. The best performing varieties of the F2 generation have to be selected and then self-pollinated (the variety is crossed with itself) to produce a 3rd generation (F3) that starts to be stable. This can required further generations of self-crossing to make a truly stable line that reproduces consistently from seed.

☐ Open pollinated

Open pollinated varieties are **stable lines of accessions that come true to type from seed when they are pollinated by the same accession**. These are **preferred by many organic farmers** as they can **save the seeds** and grow consistent crops from them.



Open-pollinated maize varieties

Open pollinated varieties can naturally hybridize with other varieties due to pollen drift if they are too close together in space and time.

❑ Traditional varieties, and races and farmers' varieties

Traditional varieties or land races are those plants that have been developed by farmers and used traditionally for long periods. These have been passed down through the generations from parent to child.

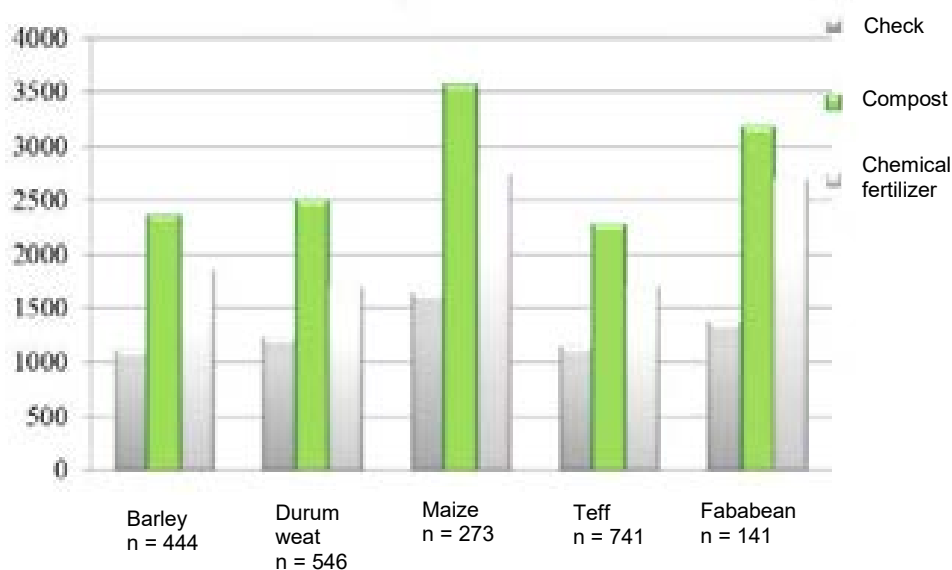
These varieties tend to be **well adapted to the local conditions** and are generally more **resilient to climate extremes, weed pressure** and **low input** farming systems.

They tend to perform **very well to good organic management systems**.



Research by the Institute of Sustainable Development (ISD) in Ethiopia has shown more than 100% increases in yield when compost is applied to fields where the traditional varieties are grown. The composted yields were higher than when chemical fertilizers were applied. (Edwards, 2011).





Average mean grain yield in kg/ha for 4 cereals and 1 pulse crop for Tigrae, Northern Ethiopia, 2000-2006 inclusive.

Unfortunately due to the **introduction of improved hybrid varieties** thousands of these **traditional varieties** along with their tremendous genetic potentials **are going extinct**.

The loss of these varieties is the greatest of all the extinction events that is occurring around the world at the moment.

Equally critical is the **loss of the knowledge** about the specific characteristics and performances of these farmers' varieties. Traditionally farmers would have a range of varieties that they knew would perform better in different soil types, different seasons and were resistant to various pest and diseases.

Fortunately there are numerous groups around the world that are doing their best to conserve these valuable high biodiversity accessions.



Organic farmers have always been actively involved in conserving traditional varieties of agricultural plants and animals. Many more varieties tend to be cultivated in organic systems than conventional systems due to its roots being based in traditional agriculture and the need for diverse rotation systems.

Conservation of traditional coconut varieties in Samoa

The advent of **industrial agriculture** has seen a massive **decline in on-farm biodiversity** as these commercial systems focus on fewer and fewer varieties to concentrate on uniformity in production to supply supermarket chains and brand lines.

Research by Pat Mooney and colleagues at the ETC group has identified this continuous decline in the biodiversity used in our industrial farming systems. *“The industrial food chain focuses on far fewer than 100 breeds of five livestock species. **Corporate plant breeders** work with 150 crops but **focus on barely a dozen**. Of the 80,000 commercial plant varieties in the market today, well over half are ornamentals. What remains of our declining fish stocks comes from 336 species accounting for almost two-thirds of the aquatic species we consume”* (ETC Group, 2009).

The majority of the world farmers are involved in traditional farming systems that clearly fit within the organic umbrella. These **farming communities** are responsible for **conserving an enormous amount of unique farm based biodiversity**.

When the ETC group researched the traditional systems that fit within the organic paradigm, they found that: *“Peasants breed and nurture 40 livestock species and almost 8000 breeds. Peasants also breed 5,000 domesticated crops and have donated more than 1.9 million plant varieties to the world’s gene banks. Peasant fishers harvest and protect more than 15,000 freshwater species”* (ETC Group, 2009).

All farmers should be encouraged to trial and preserve as many of these accession as possible.

❑ **GMOs**



Organic agriculture uses the precautionary principle when it comes to new technologies, especially those technologies do not occur naturally. Genetic engineering transfers genes across species and kingdoms in ways that have never occurred in nature.

The organic sector has serious concerns about GMOs based on the published science.

Genetically modified plants and animals are prohibited in organic systems.

➤ **IFOAM's position on seeds**

*“The overall goal is to provide organic farmers with **sufficient quantity of excellent starting plant material of a wide range of suitable varieties propagated according to the organic guidelines**. Considering the diversity of organic agriculture with respect to farm size, crop rotation, intensification level, as well as the diverse range of markets around the world, different site specific strategies need to be developed to promote the organic propagation of seeds. For example, supermarkets in many countries demand uniform organic products with a long shelf life that are certified for compliance to organic regulations by an independent third party. On the other hand, consumers of local farmer markets or niche market are more interested in locally adapted varieties that have a cultural heritage. In addition, not all countries have established organic certification systems that would allow for certified organic propagation. However, **local seed production is essential for an autonomic organic farming and needs to be promoted**.*

Ideally all plant production should be based on organically bred and organically propagated varieties. Where the number of organically bred varieties are very limited or non-existent for certain crops, conventionally bred varieties can be allowed, except for varieties derived from genetic engineering (GMO crops). However, the seeds of conventionally bred varieties should be propagated under certified organic systems”.



5.2. Seed and plant production

5.2.1. Technical aspects

❑ Seedling propagation

Seedlings are usually started in a nursery when seeds are planted into pots or seed beds that use a potting mix instead of pure soil. The purpose of using a potting mix is to have a medium that is close enough **to allow the easy movement of shoots and roots** while at the same time have large amounts of air, water and nutrients to ensure optimum growth. Heavy soil mixes make it difficult for the new roots to travel through it and for the leaves to emerge to collect the light.



Mixes need to **be well drained to stop water logging** which will cause roots to die from lack of air or from pathogenic diseases that thrive in damp conditions. At the same time it has to **hold sufficient water** so that young seedling is not drought stressed from insufficient water.

Mixing potting mix

➤ **Seed beds for sowing**

These criteria are just as important when preparing seeds beds for sowing seeds in the field. **Adding good amounts of compost in the planting furrows** will ensure a **loose soil that is well drained and consistently holds water**. It is important to remember that over 95% of a plant's biomass comes from water and air combined by capturing the energy of sunlight through photosynthesis.

Always put concentrated biology and nutrients next to seeds/seedlings at planting to give them a boost. Crops that germinate quickly and grow rapidly are better at out-competing weeds and tend to produce higher yields.

Research in Australia has found that as little as 50kgs of pelleted compost per hectare applied next to the seed at planting gives a significant boost in yield. Similarly pelleted composted chicken, pig and other high nitrogen composted manures applied next to the seed, seedling, sugar cane billet or cutting at planting will make a significant difference. Liquid composts or compost teas have also proven effective.

The simplest and cheapest way to make potting mixes is from easily and cheaply available local materials.

A good example is a potting mix that is **one third coarse river sand, one third dark organic matter rich loam top soil** and **one third compost**. The compost should be available from the farm and the others should be easy to obtain locally and in many cases freely with transport back to the farm nursery as the major cost.

Many commercial nurseries use mixes that are without soil for a number of reasons. One of the main ones is the fear of soil borne diseases. This shows a complete lack of understanding about the concept of healthy soils that are biologically active with beneficial micro-organisms.



Potting mix ingredients

These types of nurseries tend to feed the plants with water soluble chemical fertilizers in a manner that is close to hydroponics. Consequently these nurseries have to constantly spray the plants with fungicides and pesticides to prevent pests and diseases damaging the nursery plants.

A potting mix that uses a healthy organic matter rich soil combined with good quality compost should prevent most pests and diseases. Most fungal and damping off diseases can be controlled by having well drained potting mixes and regular air movement in the nursery.

Examples of components

Vermiculite, zeolites, coir fiber or dust, peat, peat moss, pine bark, peanut shells, rice husks and many other products can be used in potting mixes. Over time most people experiment with a range of mixes and settle on the one that works best for them. One of the critical aspects for choosing the input mix is that they are available locally and are cheap and easy to obtain.

➤ **Nutrition in the nursery**

The nursery plants can be regularly fertilized with liquid seaweed, compost teas, compost, gypsum and other organically allowed nutrients. The same nutrition rules apply for nursery plants as those in the ground.

➤ **Farm nursery**

It is important to have **any area** that is the **dedicated farm nursery** where all the pots, potting mixes can be stored and the plants can be propagated. The critical reason for the farm nursery is to have an area where the temperature, light, humidity and water can be controlled to ensure optimum success in the propagation of the seedlings.



In areas that have a cooler winter, this is usually a plastic covered green house. These are not as necessary in most tropical areas. The important issue of shade can be solved by finding a suitable area under trees. Water can easily be control by regular misting through a hose with a fine nozzle. It is better to regularly mist seedlings than to give them heavy watering. One of the advantages of using trees as a cover for a nursery is that the seedlings will receive constant air movement. This will prevent a lot of the fungal and bacterial diseases that cause damping off and leaf damage.

One of the main mistakes made in green houses is not opening them up enough to allow sufficient air movement to prevent fungal and bacterial diseases.

➤ **Hardening-off seedlings**

One of the other advantages of shady trees is that **seedling** can be **progressively moved into full sun to harden them off before planting out.** Plants, like humans, can get sunburnt if they have been in the shade and then exposed to full sun for a long period.



Hardening of onions, leek, parsley

Sun hardened plants that are transplanted well will **recover and grow very well and out-compete weeds.**

When hardening seedlings always cover the side of the pots with mulch otherwise the heat from the sun will cook the sides of the pots killing the roots that are close to the sides.

It helps when hardening plants to face them in the same direction to the sun as the direction they will be planted in the field. This means that their leaves will be able to take maximum advantage of the sun after transplanting.



➤ **Plant seedlings in the late afternoon**

Always plant seedlings in the cooler period of the late afternoon rather than in the morning. Planting in the late afternoon reduces the water stress from transplanting. It means that the plants have a night and the next morning to grow new rootlets into the soil to get enough water to cope with the heat of the middle of the day.

When seedlings are planted in the morning they have to cope with the midday and afternoon heat and this causes them to stress and wilt. Seedlings planted in the morning generally have to shut down their metabolic activities and close their stomata to prevent water loss. This will stress them out and slow their growth. The exception can be on wet overcast days. These are some of the best conditions for transplanting seedlings as long as it is not so wet that the soil is damaged by the activity.

Ensure that all the seedlings have **good root growth** before they are transplanted. The roots are critical to give the plants much needed water when transplanted. **The larger the root area, the more water they can take up.** Denser root systems mean that less of the potting mix will fall off when transplanting. Ensuring that potting mix soil surrounds the roots is critical to help the roots function in the soil in a 'business as usual' state.

☐ **Seed production**

Many crops are produced for seeds either for food or for the basis of the next season's crop. **In horticulture** these seeds are **usually for producing the seed stock for future crops** rather than for human production. There are a good number of seeds crops for human production such as nuts and seeds that are usually for herbs and spices such as pepper, cardamom, dill, fennel, poppy, sesame etc.

Each of these will have their specific requirements and these will have to be learnt on an individual basis. Some of these requirements are covered in section 5.2.3. Quality Standards.

➤ **Seed soaking**

Soaking seeds overnight before sowing has also been shown as an effective way to speed up germination, increase vigor and give seeds a head start over weeds. This also results in higher yields.



5.2.2. Quality standards

☐ Certified seeds

Many countries have laws requiring that seed varieties are certified to quality standards. These are usually done in qualified seed testing laboratories.

The following are examples of the types of tests that are needed:

➤ *Physical purity*

This test ensures that the sample is free or within the guidelines for impurities such as weed seeds, stones, other varieties of seed, extraneous organic matter and live insects.



Physical purity test on peas

➤ *Germination rates*

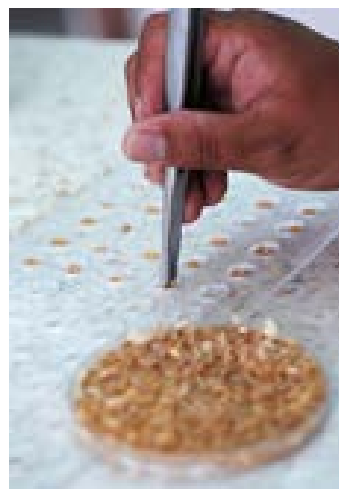
This tests the seeds to ensure high germination rates.

➤ *Moisture content*

This test ensures that the seeds have the right moisture content. Too much water can cause seeds to germinate while in storage and too little can dehydrate the embryo causing low germination rates.

➤ *Varietal purity*

This test grows the seeds to ensure that they are consistent and the correct variety.



Germination test

☐ UPOV Convention



In developed countries and some developing countries most seeds and new varieties are subject to the various laws that enforce the rules of the UPOV Convention or variations of it. **UPOV stands for *International Union for the Protection of New Varieties of Plants***. This international convention

outlines the rules for plant breeding rights. It was first adopted as an international convention in 1961. Currently 65 countries are signatories of this Convention.

IFOAM acknowledges **variety protection as long as breeder exemptions and farmers' privilege are guaranteed**. IFOAM will strongly advocate against the patenting of living organisms that violate these rights.

➤ **Plant Breeders' Rights (PBR)**

Plant Breeders' Rights (PBR), are designed to **give breeder** of the new variety the **exclusive right to market, license and sell the new variety**. These rights will allow a breeder to apply for Plant Variety Rights (PVR) on new varieties. This right will stay in force for a limited number of years – **usually around 20 to 25 years**.



PBR was advocated as a way to allow breeders a financial return on their years of investment in developing new varieties. There have been many cases where people have spent years and a lot of money developing a new variety and then not make any money to pay for these costs because other nurseries can simply buy one plant or a few seeds and then easily propagate and sell them at a cheaper cost. This is unfair on the plant breeder and discourages investment in new varieties.

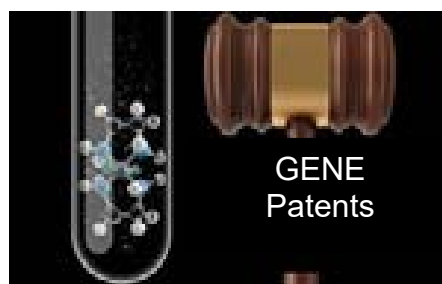
➤ **Exemptions**

Some countries allow exemptions to PBRs to allow other breeders access to PVR varieties for the purpose of developing new varieties or for research. This is called Breeder Exemption.

IFOAM advocates for exemptions that allows farmers to save their own seeds for protected varieties and not have to pay a royalty. Saving seeds per personal use is very different from selling the seeds. This is known as Farmers' Privilege.

➤ **Patents**

IFOAM opposes plant and gene patenting on the basis that it gives exclusive rights to the patent owner without exemptions.



IFOAM is strongly opposed to the patenting of genes as these have been found naturally and have not been created by the patent owner. The patenting of genes means that **the patent owner has rights to charge royalties over any future varieties that have the gene**, even when the patent owner has not done any of the breeding development.

5.3. Varieties breeding

Most of the current high yielding varieties that are used in commercial agriculture have been bred under high input conditions and artificial conditions. They tend to require high levels of synthetic chemical fertilizers and water. They tend to be less resistant to pests and diseases and need regular applications of synthetic pesticides and fungicides to maintain high yields.

Some of these varieties will perform well under organic conditions, however many do not and can give significantly lower yields.

Selecting and breeding varieties that perform well under organic conditions is very important.



Researchers in sorghum population selecting individual plants for variety development

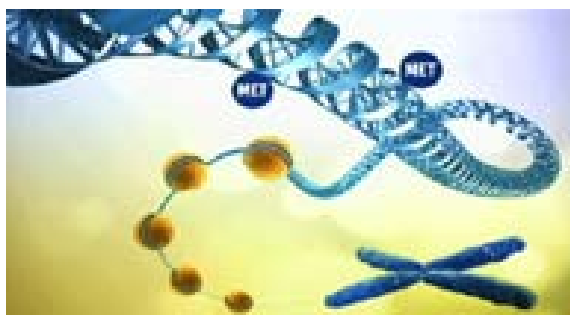
The bulk of the breeding and development of organic varieties is done informally by farmers selecting their best lines. This is still the preferred method and farmers need to be actively encouraged to trial many varieties and learn how to select the best of these as the basis of breeding programs for high yield, well adapted varieties for their farms.

A limited number of organizations such as MASIPAG in the Philippines, Michael Field Institute and Seeds of Change in the USA, FiBL in Switzerland and Georg-August-University Göttingen in Germany have been actively **involved in developing organic varieties**. However compared to conventionally bred varieties, there are very few organizations breeding specifically for the organic sector.

5.3.1. Epigenetics

The science of epigenetics is beginning to understand **how a range of environmental factors can affect the way genes work in organisms** (such as plants) **without making fundamental changes to the DNA of the organism.**

Environmental factors can inhibit genes or cause them work more actively. This changes the way a plant will grow and produce fruits, seeds, flowers and leaves.



This emerging science of epigenetics is a key to our understanding of how all organisms, including plants and animals adapt to their environmental conditions.

These changes in the way the genes work (express themselves) can be passed down through generations.

This knowledge is very important when breeding for organic conditions. **Selecting material that has been bred for generations in climate controlled laboratories and glass houses means that that epigenetic process have modified the genes to adapt to that environment, rather than in farm environments.**

This is why **participatory breeding** on actual farms under the actual growing conditions is **critical to get varieties that are optimally adapted to that environment.**

5.3.2. Beneficial neglect

Beneficial neglect is the concept where plants that are being trialed for breeding purposes are selected on the basis of how they **perform under limited input conditions such as low water, low nutrition inputs, weed pressure and no treatments for pest and diseases.**

The best performing seedlings are selected as these will have characteristics that make them more resilient and higher yielding in good practice organic systems.

5.3.3. Always select the best

It is important to always select the best performing plants when selecting the seeds for the next crop or generation. **Never select the slow growing runt – unless deliberately breeding for smallness.**

An example of this is over sowing the seedlings and thinning out the runts and stragglers to only keep the strong growers. This is a very good strategy for selecting the best performing plants for the seeds for the next crop.

The characteristics of the best performing plants are usually passed on to the next generation.

5.3.4. Self-improving varieties

There are **lines of accessions** that are known to be **self-improving with every generation**. Good plant breeders know these lines and continue to plant out the seeds and select the best of the next generation as new varieties. This is particularly **the case with many varieties of lychees, rambutans, salaks, durian, mangos and dukus**. The continuous improvement of crops can come from making hybrids; however many of the better varieties have come from planting lots of seeds from each new generation of the self-improving lines and selecting the best new ones.

This is also the case in many crops. By trialing many varieties, particularly the traditional farmers' varieties and land races and selecting the seeds from best performing plants every season, farmers can progressively develop better performing varieties.

5.3.5. Crucial traits

Farmer based breeding needs to select for **many crucial traits**. There is no point selecting a high yielding variety if the taste or color characteristics are not acceptable to the market or the shelf life is too short for it to reach the consumer in a good condition.



Bean varieties

The key traits need to be:

- **reliable and consistent high yields;**
- **color acceptable** or preferred by market;
- **taste acceptable** or preferred by market;
- travels well to the market;
- acceptable shelf life so that the quality is still good after purchase by the consumer;
- adapted to the local climate including the regular extremes of heat, cold wind and rain;
- **performs well under good organic nutrient programs;**
- is efficient at using water;
- **is resistant to pests and diseases;**
- copes well with weeds or suppresses weeds;
- easy to reproduce for the next crop via seed or vegetative propagation.

Other specific factors may include:

- salinity tolerance;
- perennial – to reduce the need for replanting;
- copes well with being grazed;
- makes good animal fodder;
- produces large amount of biomass that can be used for improving soil organic matter levels or for composts etc.;
- higher levels of nutrition.

5.3.6. Restrictions imposed by UPOV Convention

The rules set by the **UPOV Convention usually means that farmers cannot use protected varieties as the basis of on farm breeding programs**. This is unfortunate as many of these newer varieties have characteristics such as color, size, shape and shelf life that are desirable to the markets. However in organic systems they can end up with lower yields due to the increased susceptibility to pests, diseases, weeds and the need for higher levels of water and chemical fertilizers.

Crossing these protected varieties with farmers land races with resistant traits has the potential to produce varieties that are high yielding and result in excellent quality in organic systems.

5.3.7. Usefarmers varieties and land races

There are thousands of accessions of traditional varieties, farmers varieties, land races that are not subject to the UPOV Convention, patents and other protective rules and these can be used for breeding.

These collections contain some of the most valuable genetic resources that can be used for farming and should be used as the basis of any on farm breeding program.

As well as using these accessions for breeding purposes **farmers** should be **encouraged to conserve the original accessions** to ensure that they are not lost. This is critical to **prevent the extinction** of this important collection of biodiversity.

Ifoam's position is that it: *"[...] strongly recommends the **maintenance of genetic resources in the form of on farm or in-situ conservation** of landraces, farmer's varieties, regional specialties, wild relatives and other accessions to allow for an ongoing process of evolution and adaptation within the plant's habitats. To be able to guarantee sustainable plant production meeting all kinds of present and future challenges, it is essential to continue the genetic progress of new varieties. The **development of improved varieties suitable for organic agriculture** requires that a special emphasis must be put on the **diverse organic management systems**. In addition, breeding strategies and techniques which are in line with organic agriculture need to be defined. Special attention has to be drawn to exclude genetically modified organisms from the organic breeding, propagation and cultivation".*

5.4. Definitions

The term 'accessions' is used in this document to cover all species, sub species, registered varieties, unregistered cultivars, landraces, and farmer's varieties. This includes seeds and vegetative propagation material.

The term 'variety' is used for different types of a single species. It is one of the terms for a sub species. For example wheat, oats, rice, oranges, carrots are all different species. Each of these species can have different varieties. As an example: oranges have different varieties such as 'Valencia', 'Blood', 'Navel', 'Washington Navel', etc. Oranges are not a variety of wheat or oats. Collectively wheat, oats and oranges are accessions and not varieties. The term 'variety' also includes seeds and vegetative propagation material.

Chapter 6

Organic conversion

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6.1. Conversion principles and objectives

6.1.1. Introduction

Organic farming is based on enhancing the natural biological cycles in the soil, in the crops and livestock. An often important factor is to **build up soil fertility** through nitrogen fixing legumes and use of manure and compost to enhance organic matter in the soil; it is also about not using chemical pesticides and generally avoiding pollution. These are important factors modifying the farming system but **equally important** are the **conversion in the heads, the mentality of farmers and their families, of farm staff** and others involved. It is the same for both small and big farmers. Often this is a more cumbersome process compared to the technical changes needed. The conversion time and requirements set by standards and regulations is an additional factor to take into consideration.

Organic production is possible for everyone, from the smallholder farmer to huge estates, and for extensive as well for intensive production. There are different obstacles for different kind of production and it can be less or more difficult to convert to organic farming depending on a long range of conditions. In Western Europe as an example the organic farming methods have developed considerably in the last 20 years and crops which were seen as very difficult to get a high yield and of good quality is today grown with good results.

Smallholder farmers with extensive farming converting to organic farming have to put huge efforts into the farming system but will often have to use resources for organising as a group for handling of extension, documentation, certification and marketing.

Smallholder farmers which have more intensive farming and uses chemical fertilisers and pesticides will have some more difficulties in converting, also mentally. For bigger estates and plantation dedicated for export it is often a major shift in the whole production system. There might be needed to shift which crops are grown, crop rotations and marketing.

6.1.2. Reasons for organic production

There are many reasons for converting to organic production:

Environmental, ethical and quality reasons

- It is an ethical and environmentally friendly production
- Biodiversity conservation



- Food quality



Mixing crop helps promote biodiversity, like this mixed-crop field of amaranth, sunflowers and broom corn

Financial motives

- Premium prices on the market for organic production
- Subsidies, either through direct payment or project development
- Solving existing financial problems on the farm
- Cost saving, lower production costs
- Secure future of the farm
- Keep a position on a specific market

Political reasons

- Organic is a tool for empowerment of farmers and social development



Farmers' meeting

Personal reasons

- Health risks and problems related to pesticides
- Encouragement from other farmers



Advanced farmers

- Responding do consumer demands
- Personal challenge with a new farming system

❑ **Extensive farmers**

- Small farms
- Marginal production areas
- Inputs are too expensive
- Lack capital or skills

❑ **'Do nothing farmers'**

- Farmers that think organic farming is easy

Normally it is a mixture of several of the above factors.



6.2. Feasibility indicators

6.2.1. Planning of conversion



There are several factors which affect the feasibility of conversion, **knowledge, planning and strategy** are some of the main components. Changes are almost always easier to go through after a thorough planning and in farming it is a lot of factors affecting the final result. **Good financial estimates** also make the conversion safer from an economical perspective. Conversion plans are recommended and are feasible in many situations. But humans are different and some do thorough planning and uses the plan in all steps through conversion. Others maybe do or get help to make a plan, put it in the drawer and never open it again, but have through making the plan get an overview to make a functional conversion. Some individuals don't make any planning on paper but still manage well with their farm conversion.

Some standards and regulations are requiring a conversion plan as a base for certification of the farm. For illiterate smallholder farmers this requirement can be transferred to the farmer who should be knowledgeable about the conversion and have the plan in her/his head.

6.2.2. Knowledge and information

Organic production is often **more knowledge intensive** compared to conventional production of the same crop, this is especially the case for intensive production with use of several agricultural inputs. Starting conversion in a type of production system and crops which many others already are growing with known technique good results is much more secure than to start conversion of a crop type which haven't been farmed organically under the conditions where the farm is located.



Organic farm visit

There are **many sources of information**:

- Other farmers with the same kind of production. If there is competition on the market farmers might not want to reveal their production methods but normally farmers are often willing to share experiences.
- Organic movements, NGOs working with information to farmers and sometimes also joint marketing efforts
- Advisers and consultants. The availability of advisers and consultant are often depending on the stage of development the organic sector is in. In early stages it might be none available while in more developed setting there might be much specialized persons and organization to get help from.

6.2.3. Intensive or extensive production

As stated before it is a **huge difference to convert extensive crops compared to intensive crops**. **Extensive crops** where no inputs are used are sometimes called '**organic by default**'. Some of this production is good organic sustainable production but in some cases the extensive production methods are depleting the soil and leads to erosion. If that is the case the farming system has to be changed to conserve soil and enhance soil life. In many other farming systems there has to be some moderate changes while in conventional high input crops the whole farming system might have to be changed and inputs possible to be used in organic production has to found. **The more intensive the farming system is, the more important it becomes to develop long term sustainable soil fertility**. This involves for example green manures, applying composts made from animal manure mixed with all kinds of organic materials, rotation of shallow and deeper rooting plants.



Growing of crops like green beans or baby corn which are intensive crops with high hygiene requirements gives an additional challenge for new producers.

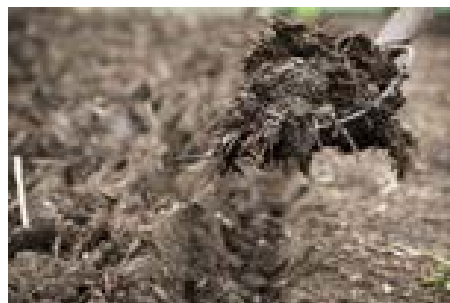
6.2.4. Soil and water

These are the **main resources in all farming**. It is always easier to convert a soil rich in organic matter and a good nutrient status but also depleted and eroded soils are possible to convert. **Important is to know as much as possible about the soil and the status of it and adapt the conversion actions to it**. A depleted soil is likely to need more inputs in the form of manure, green manure or compost to function in organic production. Water and the availability of water has the same importance in conventional and organic farming but soils which have a good organic matter content can retain water better.



6.2.5. Farm inputs as fertilizers, pest treatments

When more intensive production is converted one difficulty to become organic is to depend on the **local availability of organic fertilizers and the presence of alternatives for pest management**. Most problems can be handled through better management techniques, better microclimate, crop rotations, time for fertilization etc. but often there are also needs to buy in inputs.



A major change for some farms is that in the organic system it gets more focus on utilizing all possible farm waste, harvest residues and processing residues for composting or mulching. Many farms both small and big will find out that there are a lot of resources which previously haven't been used.

When **buying in inputs as fertilisers and substances for pest treatments** it is important to **check** with the **certification body** so that the **substances are accepted to the standards or legislations**.

6.2.6. Seeds and planting materials



The supply of organic seeds and organic planting materials are limited in several countries, and some countries even have a legislation which is requiring all imported seeds to be chemically treated. At the same time **several organic standards and legislations requires to use organic seeds and planting materials as the first choice**.

The second choice if it is proven that no organic sowing or planting materials are available is to use untreated seeds and it is only in some cases allowed to use chemically treated seeds and transplants. For some crops it is possible to take own seeds but it has to be remembered that in all growing and especially organic the seeds have to be of high sanity and have a good germination rate.

To get the right information about the requirements for seeds and seedlings the certification bodies are often the best source of information.

6.2.7. Labor

Organic farming **usually requires more labor** for example for weeding. If planned well the labor is needed in times when there are no other peaks of work. It constitutes a replacement of external inputs to family labor in the case of the smallholder and family

farmer. For estates and plantations bigger number of farm labor might have to be hired. The on-farm production of organic fertilizer may constitute an important labor cost but can save considerably in external inputs. In general, costs shift from external, often imported inputs, to local labor.

Income in organic agriculture is often generated through **a more diversified range of farm products than before, decreasing the dependence** on the price of just one product. The management strategy will vary depending on availability of resources most notably capital and labor (in some cases other resources may be the limiting factors).

6.2.8. Training

For smallholder **farmers certified in groups training is often a prerequisite** to get a functioning group. There can be several areas which need to be included, introduction to organic farming, what can be done and not in organic farming, documentation, farming methods, pest prevention, harvesting for quality and many other areas. Important to remember is that **the persons who actually do the farming actions have to be trained.**



Composting training session

To only train male farmers in East Africa when the majority of farm work is done by females is not a successful way of training.

6.2.9. Market

To know **the possibilities to sell the certified production** as organic on the market is very important for the financial success and part of the conversion strategy.

If the same kind of crop will be sold to the same buyer as before conversion it much easier and safer compared to new crops and new buyers. **To produce bigger amount of fresh products with high production costs without having a good market knowledge and market contacts is a high risk project.**



6.3. Positive and negative factors for conversion

Factors favorable for conversion are:

- interested farmer;
- good level of education and know-how by the farmer;
- existing diversified production system, especially if it includes animals;
- history of use of manure and/or compost;
- low or moderate use of pesticides and chemical fertilizers;
- existing markets and market contacts;
- comparably good farm economy already before the conversion;
- peer support (village, farmers' association etc.) ;
- knowledge on how to organize farmers in groups (for group certification).



In addition the general agricultural policy of the country will have a major indirect effect on the farmers' willingness to convert their farms.

The conversion can be difficult. The farmer or farmer group will have to face **a number of potential problems and difficulties**, such as:

- lack of proper information and assistance;
- need of investment to get a more diverse production;
- degraded land;
- high land prices if there is a need for extension of farmed land;
- inputs suitable for organic production is not available;
- certification costs and requirements;
- increased need of labor;
- specific production problem (e.g. a pest in a major crop);
- difficult production with high use of inputs;
- no premium prices during the conversion time.



6.4. Considerations when starting an organic project

It is quite **different for a single farmer to start conversion compared with a group of farmers**, and quite different for an exporter, a domestic distributor and an importer. All actors in a production line depend on each other.



- In the case of smallholders, it is best to work with groups of farmers who have their **fields in clusters**, maybe of whole villages converting. Individual small farmers with scattered fields are far more difficult to advise and expensive to inspect. **Mixed farms should be preferred**, or farms with ready access to organic matter for composting/fertilization.
- Good farmer **advise, extension, training** must be in place or set up in the first year.
- For arable crops there is a need for a market for all sales crops, not just one. If a conversion period is necessary, this has impact on the profitability of the project in the first years.

Do not start the conversion with the idea of marketing the products as organic without having serious contacts in that market. The products often need processing, and things become complicated. Any project needs the co-operation, the interest, and the commitment of all involved parties.

Below are some general aspects that should be taken into consideration when starting an organic project:

- **Farm gate price** should be **higher than for conventional**. Costs of overheads as organization, advise, education and certification is more costly, possibly more under conversion than after.
- Determine the minimum volume of sold products and price that makes the project self-financing in three years.
- **Secure local government tolerance**, or even better support towards the project. Consider who could be a threat to the project and try to neutralize these.
- **Know the certification requirements** of the different markets.

6.5. Speed of conversion

An issue is if conversions should be slow or fast.

One thing is clear if organic production is a new way of farming or if the plans are for new crops it would be wise **to test out the farming method and the crop** on a small piece of land **before taking off** at a large scale conversion.

Conversion is not a decision made easily because **the implication is that there will be difficult to go back**, but it is quite common that a delay or even reversal of some planned actions happens in many conversions. The market situation and the possibility to sell the organic crop for a premium price is often a factor especially for bigger farms. For some farmers it is mentally difficult to run to farming systems (conventional and organic) at the same time. Some standards and regulations, for example the EU regulation also restricts the possibility to grow the same kind of crop on both conventional and organic land on the same farm. In the end it is **only the farmer that can decide how fast to convert**, as only the farmer has the whole picture of the agronomic, economic and social pressures on the farm.

6.6. Conversion time set in legislations and standards

The length of the conversion time is a topic which often has been discussed in the organic sector. The proponents for a longer time state that the soil should have time to break down pesticide residues and soil fertility should have time to build up properly. The ones proposing shorter conversion times argues that the processes to build up the soil and break down pesticides can take much longer time than any practiced conversion times, therefore it is better to have shorter time so that more farmers convert and more land is farmed organically. Another argument is that the ones proposing a long time wants mainly to protect their own market from new comers.

In the **IFOAM Basic Standard**, the conversion time is **one year for annual crops and 18 months for perennial crops**.

The **EU regulation** requires **two years** before sowing of a certified **annual crop** and **36 months** before harvesting of a **perennial crop**. Both the IFOAM Basic Standard and the EU regulation for organic production require full organic management during an annual inspection during the conversion time.

6.7. Conversion plan

Conversion plans can look in quite different ways but below can a simpler version be found. The conversion plan has to be used with common sense and adopted to the conditions, farm size and capacity of the farmer. The example below can be used for an individual bigger farm. For a grower group most of the issues below can be done on the group level except the need for maps and names. In a conversion plan for a group the setting up of the group, maintenance of group documentation and handling of the internal control system should be included. It might also be a need for training of farmers which implementation can be included in the plan.

The conversion consists of different phases:

- **the knowledge phase;**
- **the goal description phase;**
- **the strategy phase;**
- **the realization phase.**

Factors that affect the conversion and the organic production:

- knowledge, engagement, patience, precision;
- the biological status of the soil;
- the farm economy.

Basic conditions for growing organic:

- soil in good condition;
- 30-40% of acreage must often be cultivated with leguminous plants;
- good farmyard manure strategy;
- biologically correct crop rotation;
- number of animals adapted to the farm size.

□ Planning the conversion for a farm

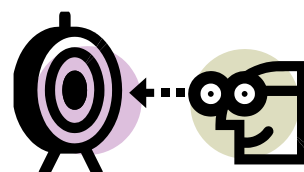
➤ **The knowledge phase:**

- where to get the knowledge;
- own experiments;
- Intercropping, green manure, fallow, catch crop, weed harrowing, etc.



➤ **The description of the goal phase:**

- the stockless farm – decide which cash crops;
- the animal farm – decide the need of fodder;
- make a crop rotation;
- estimate the total production;
- estimate the number of animals according to the production capacity;



- divide the acreage into fields according to the crop rotation;
- make a nutrient strategy:
 - nutrients circulating on the farm;
 - nutrients that have to be bought;
 - plant nutrient balance;
 - maturing plan for the acreage;
 - make an economical overview according to the goal;
- make a strategy for handling of pests.

➤ **The conversion strategy phase:**

- chose conversion strategy
- conversion crop
- decide conversion strategy for every field
- decide conversion rate
- decide fertilizing strategy during the conversion period
- decide measures for basic investments



➤ **The realization phase:**

- follow the conversion plan
- follow up the first years of the conversion
- revise the conversion plan if needed



One version of a conversion plan

The conversion plan must include the following aspects where applicable.

1. Name and address of the producer and name of the farm
2. A map of the holding including field numbers and acreage
3. A sketch map of the farm buildings, storages, processing facilities etc.
4. Field histories and up to date records. The previous history on the farm including detail of previous chemical usage and indicate dates of last prohibited input and any intensive systems
5. A timetable for conversion together with a five year forward crop rotation plan
6. A soil management programme including soil analyses where available
7. Manure management, storage, handling, and spreading of manures
8. Whole farm nutrient budget
9. Resources needed in the form of labor, equipment and finances
10. An individual section for all main enterprises. This should include the following where applicable:
 - growing covering all crops and crop rotation with potential varieties;
 - pest and disease control;
 - nutrient supply including composts and handling of crop residues;
 - sowing seeds, seedlings and perennial plants;

- supply of inputs;
 - weed control measures;
 - ley details, including legumes;
 - reference to manure and nutrient supply;
 - livestock;
 - breeds and breeding programme;
 - conversion of livestock;
 - housing or other wintering practices. Include details of cubicles, housing densities etc.;
 - feeding regimes;
 - a detailed health and veterinary plan (Animal health plan);
 - any other management issues e.g. stocking densities, mineral supply, health and bio security issues;
 - clean grazing and parasites control practice;
11. Environmental conservation measures, practice and policy
12. Marketing plans. Detail any plans for marketing



Chapter 7

Regulations and certification

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7.1. Regulations and international standards

Historically, **organic certification bodies developed their own standards**, something that can also be seen in the field of eco-labelling, fair trade, and social certification. In other sectors, certification bodies rarely develop their own standards, but certify to other standards in the public domain, e.g., ISO 9000 or 14000 guide series. The **IFOAM Basic Standards were first formulated 1980** and many other standards and regulations are heavily influenced by the IFOAM Basic Standards. There is also an **ongoing reciprocal action between private standards and legislations**.

With **the introduction of organic regulations**, this has also become common in the organic sector, *i.e.*, certification bodies which **do not set standards and certify only regulations**. Many certification bodies today offer a range of certifications to various government regulations and private-sector standards. In countries where there are no local organic certification bodies, there are usually also no government regulations. Therefore, emerging certification bodies often have to get involved in the development of organic standards.

Government can make adherence to its regulations compulsory, while the other actors depend on market acceptance and recognition for the uptake of their standards. In the early stages of sector development, organic standards are usually developed by certification bodies or national organic sector organizations. Today there are many legislations for organic production. The main international standards and legislations are described below. In total **there are 66 countries with fully implemented legislations and 44 countries which are in the process of drafting and implementing standards**. This is to compare with the number of private standards for organic production which in 2011 was 121.

7.1.1. European regulation

The **EU regulation for organic production** was introduced in **1991** and have after that been amended several times. When first introduced it was called EU Council regulation 2092/91. This was changed when the regulation had a major rewriting in 2007. The **main regulations** are today called **EU Council Regulation 834/2007** and **EU Commission Regulation 889/2008**. There is also a whole range of amendments as there is an ongoing update and expansion of the EU regulation for organic production. Consolidated versions are sometimes made to get a better overview of the regulation as a whole.

The **EU regulation is implemented in all 27 EU Member States** which means that all organic production has to fulfil the regulation as a baseline. In several countries in the EU there are also private certification standard which have additional requirements.

The key issue which is regulated is the use of the word 'organic' (in all languages of the Member States), the diminutives as eco, bio etc. and the use of the EU logo.



EU organic logo

The EU legislation for organic production cover crop production, livestock production, beekeeping, aquaculture, mushroom production, wild harvesting, processing and handling of organic products.

The EU legislation for organic production cover crop production, livestock production, beekeeping, aquaculture, mushroom production, wild harvesting, processing and handling of organic products. The regulation contain listings of all allowed input substances for both agricultural production and processing.

There is also a section of use of the EU logo and labelling and another for certification requirements. The **EU logo is mandatory for products packed in the EU**; these products can either originate from the EU or imported to the EU and thereafter repacked. For imported products it is voluntary. If the EU logo is used a special labelling of origin has to be used. There are three different statements which can be used.

If the EU logo is used, an indication of where the product has been farmed or where the agricultural ingredients have been farmed shall be displayed. The indication shall appear in the same visual field as the EU logo. The following statements can be used:

- 'EU Agriculture', where the ingredients has been farmed in the EU;
- 'Non-EU Agriculture', where the ingredients has been farmed in countries outside the EU;
- 'EU/non-EU Agriculture', where part of the ingredients has been farmed in the EU and a part of it has been farmed in a country outside the EU.

The indication 'EU' or 'non-EU' may be replaced or supplemented by a country in the case where all ingredients are produced in that country. For ingredients used in a small quantity and with a total maximum of 2% of the weight of the product, the indication is not needed.

❑ Import to the EU

There are today **three routes** to **get products from outside the EU** accepted in the EU.

➤ **First route**

There are a number of countries which the **EU approve their legislation** for organic production and their system for supervision of the certification as equivalent to the system inside the EU. There are **ten countries** on the list: Argentina, Australia, Canada, Costa Rica, India, Israel, Japan, New Zealand, Tunisia and USA.

The **agreement with the USA covers a mutual USA - EU acceptance of each other system**. There are a few exceptions where the US doesn't accept animal products from animals treated with antibiotics (which is allowed in the EU) and the EU doesn't accept the use of antibiotics on fruit against pests (which is allowed in the US).

The agreement also **cover products produced outside EU or USA** and which is imported to one of the two and then handled or processed to be exported to the other.

In practice this means that coffee produced in Kenya, which is certified only to the EU regulation can be sold in the US with the US logo if it has first been imported and handled in the EU but not if it is directly transported from Kenya to the USA.

➤ **Second route**

The second way of getting products accepted for import to the EU is **to let a certification body accepted by the EU doing the certification of the production**.

The system is under introduction and the first 30 certification bodies recognized to have a standard and certification system which is equivalent to the system in EU has been listed. It is expected that several more certification bodies and activities in many more countries will be included in the coming year.



Organic field inspection

There will also be a listing for certification bodies which are deemed by the EU to work in compliance with the EU regulation, but the work with this kind of acceptance has not yet started in the EU. Of the so far listed recognized certification bodies there are some that are active in ACP Member States. The first list is published in Commission implementing regulation (EU) No. 1267/2011.

➤ **Third route**

The third way to get import of organic products accepted into the EU market is **the so-called importer derogation** where the importer in the EU brings proof to the authorities in the EU country of import that the production is organic and that the certification body which have done the certification can be accepted. The system has worked for many years but **will be faced out in 2014** when it is foreseen that the system with accepted certification bodies are fully enforced. **The bulk of import goes still through this system**. On the homepage of the EU Commission a list over the majority of import approvals can be found.¹

¹ See ec.europa.eu/agriculture/ofis_public/r8/ctrl_r8.cfm?targetUrl=home. Web page: ec.europa.eu/agriculture/organic/splash_en.

7.1.2. FAO/WTO regulation

❑ Codex Alimentarius Guidelines

The *Codex Alimentarius* Guidelines for the **production, processing, marketing and labelling of organically produced foods** was **established in 1999**. They are the FAO/WHO, the two UN organizations for food and health. The role of the guidelines is to **facilitate harmonization of standards in the international level**. In *Codex Alimentarius* the decisions are taken by member governments.

The *Codex* Guidelines cover plant production including horticulture, livestock, handling and processing. There are also provisions regarding inspection and certification systems and import control. The **guidelines cannot be used for certification** in the field instead they are be a **platform for the development of other standards** and can as said above to be used for harmonization between different standards.²

7.1.3. IFOAM standards

IFOAM, International Federation of Organic Agriculture Movements is the worldwide umbrella organization for organic agriculture. It has over 750 member organizations in 115 countries: www.ifoam.org.



The IFOAM Basic Standards for Organic Production and Processing (IBS) were first published in 1980. **The Basic Standards** is published together **with the IFOAM Criteria for Certification Bodies** in the “*IFOAM Norms for Organic Production and Processing*”.

The **standards gives a framework** for certification bodies and standard setting organizations worldwide to develop their own certification standards, the **IFOAM Basic standards cannot be used for certification** on their own.

The standards in the IBS are based on the IFOAM Principles of Organic Agriculture with the four principles:

- the principle of health;
- the principle of ecology;
- the principle of fairness;
- the principle of care.

The standard covers crop production, animal husbandry, bee keeping, aquaculture, processing and handling of organic products. There are also requirements for ecosystems; labelling and social justice. Lists of products for use in fertilization and soil conditioning; pest and disease control and weed management; and approved additives and processing aids are contained in three annexes. An additional annex provides criteria for evaluating additional agricultural inputs and processing inputs.

² See www.codexalimentarius.org.

The **IFOAM Basic Standards** is in the process of being replaced by an **IFOAM certification standard** taking into consideration the need for harmonization with existing regulations in main organic markets and in particular the need to reach EU equivalence.

The historical function of the IFOAM Basic Standard as a 'Standard for Standards' has now been taken over by a **new norm approved in 2011 by IFOAM, FAO and UNCTAD, entitled the *Common Objectives and Requirements of Organic Standards (COROS)***. The COROS fulfils the role of the international reference against which all organic standards and regulations can be assessed for equivalence, either by governments in the context of their import approval regimes, or by IFOAM in the context of what is known as the *IFOAM Family of Standards* (a list of all organic standards and regulations approved as equivalent to the COROS).

IFOAM Accreditation is accrediting certification bodies active in certifying organic agriculture throughout the world. The program is **operated by the International Organic Accreditation Service (IOAS)**. In 2012 thirty certification programs are accredited. IFOAM accreditation and certification bodies will have a two year time period to adjust to bring their standards in compliance with the new IFOAM Standard.³



7.1.4. National organic program US

The National Organic Program is the **US legislation for organic production**. It covers crop production, livestock, mushroom, wild harvesting, processing and handling of organic products.



The NOP also has a list of substances used in farming and processing as '*allowed synthetics*' and '*prohibited non-synthetics*', thus allowing use of all non-synthetic inputs that are not specifically listed. A determination of whether an input is '*non-synthetic*' or '*synthetic*' is necessary in order to establish whether it may be used as a non-listed input.

The NOP regulates the term organic and there is a logo linked to the legislation. The logo is not mandatory but when introduced many private certification body logos disappeared from the market.

For import to the US the production has fulfil the NOP and be certified by a certification body which is accredited by the USDA.

³ See www.ifoam.org.

The US has bilateral trade agreements with Canada where the two countries accept each other organic production with a few exceptions. There is also a **bilateral agreement between the EU and the US**, read more under 7.1.1., “Import to the EU”.⁴

7.1.5. Japanese agricultural standard of organic agricultural products

The Japanese Agricultural Standard (**JAS**) of Organic Agricultural Products is the **Japanese legislation for organic production**. It covers crop production, livestock, mushroom, wild harvesting, processing and handling of organic products. The Japanese regulations also contain listings of all allowed input substances for both agricultural production and processing.



JAS logo

The use of the term organic in Japanese is regulated and there are also requirements and provisions for the use of the JAS logo. **All plant products** (foodstuffs) which shall be labelled with ‘organic’ for sales in Japan **must be labelled with the JAS seal** and must be certified according to the JAS standard.

□ Import to Japan

Japan has an approval system for certification bodies which can certify to the Japanese regulation.⁵

The Ministry of Agriculture, Forestry and Fisheries (MAFF) requires a ‘**Grading Systems**’ to describe the requirements applied to operators. The operators must have a grading system to control operations according to the requirements defined in the scope, in this case ‘organic production and processing’. Certified importers are able to import organic plants and organic processed foods of plant origin, which were graded under the overseas systems and attach the Organic JAS logos to the products.⁶

7.1.6. China

The **specific regulations and standards** for organic certification in China were **introduced in 2004 and took effect in 2005**. The organic standard is based on international norms with added emphasis on contamination by pollutants and prohibited materials and quality management systems, especially recordkeeping and traceability. The **Regulatory Measures on Organic Product Certification Management** defines organic certification and organic products, including the scope and requirements for certification bodies and inspectors. It also sets principles for organic certification, national organic labelling, import requirements and principles for international cooperation and supervision measures.

⁴ See www.ams.usda.gov/AMSv1.0/nop.

⁵ See www.maff.go.jp/e/jas/jas/pdf/rcb.pdf.

⁶ See www.maff.go.jp/e.

The Implementing Rules on Organic Certification regulates organic certification activities. It defines organic certification objectives, scope of application, standards, certification procedures, administration after certification, certificates, marks and logos, as well as certification fees.

Chinese organic logo



In China there are **three national agencies** that are important **for the organic system**. The **Certification and Accreditation Administration of the People's Republic of China** (CNCA), is the national administrative body overseeing all types of certification and accreditation within China. The national accreditation body is the **China National Accreditation Service for Conformity Assessment** (CNAS). All certification bodies for import of organic products have to be accredited by CNAS. In addition to the above, inspectors of all certification and certification training bodies must be approved and registered with the **China Certification & Accreditation Association** (CCAA). All inspectors must undergo training which is conducted only in China and only in Chinese language. Currently, there are 26 organic certification bodies which are approved, all are based in China.

7.2. Regional standards in East Africa, the Pacific, Asia and Central America

Organic agriculture is based on local resources and conditions. Consequently, there is a **need for standards to be adaptable to local conditions**. In crop production or animal husbandry, there may be a need for standards addressing special problems in the region.

An input seen as 'natural' to use for organic agriculture in one place, as there is abundance of that resource in that place, may not be allowed at all or is restricted in another area, e.g., the use of guano or peat. Requirements for inputs like organic seeds need to consider the availability of varieties adapted to the local conditions. Erosion control and water management are other examples where different regulations are necessary in different areas. The need for local adaptation is greater in livestock production, where conditions (and traditions) differ more than in crop production. However, instead of numerous local or national standards, **a regional standard can be a good option**. The **EU regulation is one such example; the East African organic standard is another**. The benefits of a regional standard compared to a national one are mainly that they **facilitate regional trade** and give **more negotiating power in international standard-setting forums** such as IFOAM and *Codex Alimentarius*.

7.2.1. East African organic product standard

First out was East Africa with the East African Organic Product Standard (EAOPS). The East African Organic Products Standard (EAOPS) is written for organic production in East Africa and adapted to conditions in East Africa. The purpose is to have **a single organic standard for organic agricultural production under East African conditions**. It is adopted by the East African Community as an East African standard, which means it is publicly recognized in **Burundi, Kenya, Rwanda, Tanzania and Uganda**.



Organic farm in Uganda

This East African Organic Products Standard is based on organic standards currently in place in the region as well as the IFOAM Basic Standards and the *Codex Alimentarius* Guidelines for production, processing, labelling and marketing of organically produced

foods. The standard covers plant production, animal husbandry, bee-keeping, wild production, handling and processing.

❑ How can it be used?

The East African Organic Products Standard is a **voluntary standard** and can be used for **self-assessment** by producers, **declarations of conformity** in the marketplace and **certification** by certification bodies.

❑ Achievements

The EAOPS has provided the organic sector in East Africa with a common platform for trade and for international negotiations and recognition. Further, a working regional collaboration has developed on the governmental level, in the form of the East African Community, and between the national organic agriculture movements around market development and the management of the East African Organic Mark.

The standard also formulates standpoints, which can be used in international negotiations on standards. Furthermore, it can be a basis for equivalence agreements with other countries and regions.

The experiences in East Africa can provide interesting learning points for other parts of the world. The **whole process has been development-oriented**. The standard and the mark are mainly seen as market-development activities to further develop the organic sector. **Key words** have been **facilitation, not control; and inclusion, not exclusion**. The consultations about the standards were extensive at all stages of the process, which made the final products both better and more acceptable to all.

❑ Label

Linked to the EAOPS is the East African Organic Mark. **The mark is owned by the national Organic Movements in Kenya, Tanzania and Uganda (KOAN, TOAM and NOGAMU).**

The East African Organic Mark can be **used by all certified to the EAOPS both in third party certified systems and PGS systems**. Also products certified to other recognized standards as the EU-regulation, the NOP and JAS and organic products imported to East African countries can carry the East African Organic Mark.



❑ Use of the EAOPS

The EAOPS is used to some extent in Kenya, Tanzania and Uganda, but less or not at all in Burundi and Rwanda. The East African Organic Mark is used mainly in Kenya. The GOMA (Global Organic Market Access) project is engaged in efforts to get the EAOPS recognized in the European Union.

❑ How was the East African Organic Production Standard developed?

The East African Organic Production Standard was developed in a strong public private partnership with involvement and support from UNEP, UNCTAD and IFOAM.

➤ **Drafting and consultations**

The first draft was based on local and international organic standards. It was then further developed through the consultation process.

The **standard consultation process** was comprehensive and **participatory**. Two national consultation meetings were organized in each country. In addition, the standard was consulted at two regional meetings. There were also personal meetings held with ministries of agriculture, national bureaus of standards and the East African Community.

The draft standards were also sent out to a mailing list of around 800 persons. The National Organic Movements of Kenya (KOAN), Tanzania (TOAM) and Uganda (NOGAMU) and others distributed the draft even further.

➤ **Testing and comparisons of the standard**

The EAOPS was **tested in the field** by a group of organic inspectors in Uganda. The outcome was that the standard functions well but there were several proposals for improvement and recommendations to take away a few standards.



Organic inspection

The EAOPS was also compared with the IFOAM Basic Standards and the *Codex Alimentarius* organic Guidelines. Most of the EAOPS was found to be in full compliance with these standards. For some issues, the extent to which the EAOPS complies is a question of interpretation. For a few standards (e.g., the conversion period), the EAOPS doesn't comply with the compared standards.

➤ **Final adoption**

In April 2007 the EAOPS⁷ was adopted by the East African Community the East African Standard (EAS) 456. Through the adoption by the EAC it automatically becomes the **official standard for the partner States**, and **existing public national standards are withdrawn**.

⁷ See unctad.org/en/pages/Home.aspx.

7.2.2. Pacific Organic Standard

□ Overview

The Pacific Organic Standard is written for organic production in the **Pacific Island countries and territories**. The Pacific Organic Standard is expected to serve as a basis for raising the profile of organic agriculture among farmers and consumers, strengthening organic production capacity in the region, and promoting further development of local, regional and international markets for Pacific organic agriculture products.

The standard has been **endorsed by the Conference of Pacific Ministers of Agriculture and Fisheries**. The standard now provides a platform for further regional policy development around organics.

The provisions of the Pacific Organic Standard take into account both local agricultural traditions and two global organic standards, IFOAM Basic Standards and *Codex Alimentarius*. Areas covered are crop production, animal husbandry, aquaculture production, processing and handling, social justice and textile processing. The Pacific Organic Standard also covers mitigation of climate change, an area which few other standards cover.

The Pacific Organic Standard has been written in a way to make it easy for the reader and user to access and understand. The standard is formulated in general principles and standards. The standard is nicely illustrated with pictures giving the reader the flavor of organic production in the Pacific.



Pacific Organic Producers

The aims of the Pacific Organic Standard are:

- to **ensure** that **sustainable production** systems are developed and maintained;
- to **protect consumers** against deception and fraud in the marketplace and against unsubstantiated claims;
- to **protect producers** of organic produce against misrepresentation of other agricultural produce as organic;
- to **ensure that all stages** of production, processing, storage, transport and marketing are **subject to inspection and comply with this standard**;
- to **assist in informing consumers** about the character of organic production in the Pacific.

The Pacific Organic Standard can be **used for self-assessment** by producers, **declarations of conformity** in the marketplace, **certification** by certification bodies in the region and **Participatory Guarantee systems**. It is a voluntary standard.

The standard is a platform for the common label for organic products in the Pacific region and for developing consumer trust. The standard also formulates standpoints which can be used in international negotiations on standards. Furthermore, it **can be a basis for equivalence agreements with other countries** and regions.

Label

Operators certified to the Pacific Organic Standard can use the **Pacific Organic and Ethical Trade Community (POETCom)** Name and Label on their products. Participatory Guarantee Schemes using the Pacific Organic Standard can use a special PGS version of the POETCom label. The labels can be used both on certified and in-conversion products.



Use of the Pacific Organic Standard

The standard is so far used for one PGS project.

Process to develop the standard

The Pacific Organic Standard **was developed** under a **project financed by the International Fund for Agricultural Development (IFAD)** and **implemented by the International Federation of Organic Agriculture Movements (IFOAM)** in cooperation with the **Secretariat of the Pacific Community (SPC)** and the **Regional Organic Task Force (ROTF)**. Secretariat of the Pacific Community, SPC consists of the following members: American Samoa, Australia, Cook Islands, Federated States of Micronesia, Fiji Islands, France, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, New Zealand, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, United States of America, Vanuatu and Wallis and Futuna.

In the development of the standard **the Regional Organic Task Force** has been a highly **important and successful public-private sector partnership**. Members of the Task Force have been representatives of national organic movements, government bodies, organic businesses and regional NGOs. Input from national organic associations, governments and the private sector have ensured that regional stakeholders can truly claim ownership of the Pacific Organic Standard.

➤ **Drafting and consultation**

The development of the Pacific Organic Standard has included an intensive regional consultation process. There have also been comparisons with international organic standards to analyze which differences there are to these.

In 2006, the activities related to this objective consisted mainly of '**network building**'; identifying and sensitizing the stakeholders on the importance of having a Pacific Organic Regional Standard. The work consisted in **spreading information and providing the tools** to understand the main technical aspects related to this subject.

In 2007, the process of **developing the standards started** and a **Regional Organic Task Force was established**. It consisted of organic experts selected by each participating country, to serve as the technical body for regional organic development and specifically, the development of the regional organic standards.

The inaugural ROTF meeting was held in November 2007. It decided on the objective of the regional organic standard in a participatory way as well as the methodology and process for the development of the standard. Based on the results of this meeting, the first draft of the standard was developed. It was circulated for a first consultation among members of the ROTF, and SPC in January 2008. The second draft incorporated these contributions, especially some specific information on traditional agricultural practices still relevant today.

The draft standard was presented to and discussed by the ROTF at its second meeting in March 2008. Inputs from this discussion fed into the third draft of the standards, which was circulated more widely; including certification agencies active in the region, the interested public, the IFOAM membership and regional governments in the consultation process. The resulting fourth draft was examined and further amended at the third ROTF meeting in May 2008. The final version of the Pacific Organic Standard was completed in June 2008, and presented and endorsed at the Pacific High Level Organics Group meeting in Niue.

➤ **Official launch**

The first Pacific Organic Standard⁸ was officially launched by the Chair of the **Pacific High Level Organics Group (PHLOG)** and Prime Minister of Samoa, at the Ministers' of Agriculture and Forestry Conference in Apia Samoa in September 2008. There were also meetings and discussions with a range of key stakeholders on the future of Organic Agriculture in the region; e.g. how the Pacific Organic Standard will be housed and updated and how certification would work with the standard.

☐ **Further development**

In 2009 the Regional Organic Task Force (ROTF) began its evolution into the Pacific Organic and Ethical Trade Community (POETCom) which is responsible for implementing the Regional Action Plan and serve as the peak body for the organic and fair trade movements in the region. POETCom which will remain housed in the Secretariat of the Pacific Community is currently in the process of developing its governance and management structure. The Pacific High Level Organics Group (PHLOG) consists of

⁸ The Pacific Organic Standard can be found on www.ifoam.bio/sites/default/files/page/files/pacific_organic_standard.pdf.

Pacific leaders who have shown a commitment to organics development in the region and provide high level political support and advocacy.⁹

7.2.3. Other regional standards

The **Central American countries** (Guatemala, Honduras, El Salvador, Nicaragua, Panama and Costa Rica), **together with Dominican Republic**, are driving a process to develop a harmonized **regional regulation on organic agriculture in the American Continent**. The system includes standards for organic production and processing, requirements for conducting organic certification, import requirement, and a system for supervision of the regulation by the governments.

In East, South-East and South Asia, **the Asia Regional Organic Standards (AROS)** is under development. Twelve Asian countries are involved, including China, Thailand, India, Malaysia, Indonesia and the Philippines. The purpose is to provide a platform for recognition of imports to participating countries. The countries involved are developing a regional standard which also can act as a baseline for mutual recognition. This standard could, however, also be used for direct certification in countries without mandatory organic regulation or as a basis for the development of new standards.¹⁰

⁹ See www.organic-world.net/index.html.

¹⁰ *Ibid.*



7.3. Private standards

The Soil Association in the UK published the **first private organic standards in 1967**. These were more a set of guiding principles rather than the detailed production and processing standards prevalent today. There were also others which in the 1970s published own standards.

The **private standards** that were developed in Europe and the US were **driven by the need of organic farmers in the region to have a common definition of organic**. This was both to provide assurance to the growing consumer sector and to prevent fraudulent claims and unfair competition. Farmers' associations published all of the earliest organic standards.

Along with publishing standards the associations then set about **verify compliance with those standards**. The **result was** that **certification bodies** that were established during the 1970s and 1980s also published **their own standards**. These standards provided an identity to the farmers' association and helped to ensure the loyalty of the farmer. The first IFOAM Basic Standards was published 1980 and based on these private standards.

The **result** of this heritage is that there are a **great many private organic standards** for production and certification around the globe. The Organic Certification Directory published by the newsletter *The Organic Standard* identified **549 bodies offering organic certification**.

While this plethora of standards has created some difficulties with respect to mutual recognition and trade, there have also been some advantages. As the **standards are being set in the specific region in which the certification body operates**, they tend to be **more appropriate for the local ecosystems and local culture** than standards set distantly. It has also resulted in the vigorous development of organic standards. Standards set **within a small organization can react more easily** to new developments or new input products being placed on the market.

A result of this dynamism is that **private organic standards have been developed for activities generally not covered in regulations**. These include textile processing, aquaculture, restaurants, cosmetics and others. Regulations by their nature are more inclined to exclude these activities and adopt a more narrow scope.

The **private standards determined the content of the IFOAM Basic Standards**, which in turn have had a major influence on the EU Regulation 834/2007, which itself has influenced the content of most other organic regulations and the *Codex Alimentarius* Guidelines. **Historically, organic standards can therefore be viewed as having been developed from the bottom up rather than being imposed from above**.

The large number of organic standards should not be taken to mean that there are necessarily large differences between these standards. The IFOAM Basic Standards and the EU Regulation 834/2007 have instructed the content of private organic standards

around the world. Differences tend to relate more to which sections of the standards are given most emphasis. For example in countries where organically reared livestock is in its infancy the private livestock standards are likely to be more basic than in regions where livestock plays a more important role. Differences also reflect the local consumer expectations.

There has been some effort within the private sector to move away from the 'certifier own standard' model and instead to develop jointly used standards. An example is the Accredited Certification Bodies' Equivalent European Union Organic Production & Processing Standard for Third Countries. It is a standard used by 15 certification bodies which are accepted by the EU to work in equivalence with the EU regulations.

Another trend is that **private certification bodies set up standards in areas which are outside the traditional organic sector** but areas where it is a high consumer demand for the area to be fulfilled by organic production. The most important example is **certification of social fair production requirements**, two certification bodies which have done so is Ecocert and Institute for Marketecology (IMO). The development of these standards can also be seen as a reaction to that the Fairtrade Labelling Organization is very restrictive with allowing other certification bodies than FLO-Cert to handle inspection to their standards. The Fairtrade standards also have limitations on which type of organizations that can be certified. The international organic certification bodies would like to be able to provide all kind of certification to their clients and they would like to provide social fair certification to all type of customers like out grower schemes and plantations.

7.3.1. Naturland

Naturland¹¹ is a German farmers' association with 53,000 members all over the world. The organization was founded in 1982. Naturland is recognized as a non-profit-making organization and the standards and logo are well known in the **German market**. The **inspection to the standards is done by independent inspection bodies** while the **certification decision to the Naturland standards is taken by Naturland itself**.



The Naturland standard covers:

- Production
- Beekeeping
- Aquaculture
- Forest management
- Sustainable capture fishery
- Processing
- Textiles
- Cosmetic products
- Naturland standards on social responsibility
- Naturland Fair Trade Standards

¹¹ See www.naturland.de.

7.3.2. Soil Association

The Soil Association¹² was founded 1946 and have since then worked with standards, certification and promotion of organic agriculture. Today the **activities of information** and promotion are well divided from the **certification activities**. The logo of the Soil Association is well known and has a strong position in **the market in the United Kingdom** where the organization is based.



The standards which is one of the spearhead standards in the organic sector today covers:

- Farming and growing
- Food and drink
- Health and beauty
- Textiles
- Hides, leathers and skins
- Ethical trade
- Aquaculture
- Abattoirs and slaughtering
- Livestock markets
- Exceptional permissions
- Equivalence

7.3.3. Bio Suisse

Bio Suisse¹³ is an association of Swiss organic farmers which have set up standards for organic production, The Bio Suisse logo 'the Bud' is the **most important logo for organic products in Switzerland**.



International producers, processors and traders **can formally not be 'certified'** in their own name according to Bio Suisse, but they can **be Bio Suisse approved**. All operations in the production chain must be Bio Suisse approved to sell products carrying the logo in Switzerland. It is only an importer in Switzerland certified by Bio Suisse which can apply for Bio Suisse approval of international suppliers, international operators cannot apply in their own name to Bio Suisse, but must find a Swiss importer.

Priority is given to imports from the nearest production regions or countries. Import of fresh produce from overseas may only take place when it cannot be produced in European countries for climatic reasons. **Bio Suisse products may not be exported by airplane.**

¹² See www.soilassociation.org.

¹³ See www.bio-suisse.ch/en/home.php.

7.3.4. KRAV

KRAV¹⁴ is a Swedish organization with standards and a logo which is **well known in Sweden**. The **standards are stricter than the European legislation in a number of areas**. For imported products it has to be verified that the production is fulfilling the stricter requirements by a certification body or by an additional certification.



¹⁴ See www.krav.se/english.



7.4. Other social and environmental standards and certification systems

7.4.1. Rainforest Alliance



The Rainforest Alliance¹⁵ standards are **developed** in cooperation between the **members of the Sustainable Agriculture Network, SAN**. It is a network of environmental non- governmental organizations based in Central and Latin America. The goal of SAN is to improve environmental and social conditions in tropical agriculture through certification of agriculture.

One of the major targets is to **stop exploitation of tropical forest for conversion to farming land**.

In the standards three main topics are covered, **biodiversity, social conditions and secure handling of chemical pesticides**. The Rainforest Alliance certification is not a certification of organic production but the standards for agricultural production is strongly influenced by GAP, good agriculture practice requirements. The protection of rainforest from being cut down is central. There is a list of banned pesticides and elaborate standards on handling of chemicals. Rainforest Alliance started to certify coffee and bananas but today the standard and **certification system covers almost all crops**. The certification to the standards is made by independent certification bodies.

7.4.2. Fairtrade

The Fairtrade Labelling Organization¹⁶ (FLO) is an international labelling of fair-traded products.

FLO is focusing on **trade issues, smallholder farmers and labor on farms and factories** should have a fair payment and fair conditions. Coffee was the first product to be certified but is today expanded to all kind of food products. For some crops like coffee and cocoa it is still required that it can only be produced by small holders organized in cooperatives while for many other crops can be produced by plantations. A third way of organization accepted for some crops in some countries is out grower schemes. So far none of the countries included is an ACP Member State.



The standards cover production, processing and sales of production. **The standards are based on the International Labor Organization (ILO) conventions** on social and financial conditions as wages, work time, discrimination, health and work security. Other

¹⁵ See www.rainforest-alliance.org.

¹⁶ See www.fairtrade.net.

areas included are child labor, the right to organize and to form labor unions. The FLO standards **also cover environmental conditions** and regulate but do not prohibit the use of chemical pesticides. **Minimum price** for a certain crop is also part of the standard and set in relation to the world market price and the costs of production for a certain crop.

FLO-Cert is an independent certification body which is doing a majority of Fairtrade certification, some Fairtrade certification is also done by certification bodies doing organic certification.

7.4.3. IMO, Fair for life

Institute for Marketecology¹⁷ (IMO) is one of the major certification bodies for organic production. IMO is based in Switzerland but have a range of offices around the world. IMO is certifying to the major legislations and standards but have also set up a **fair-trade standard, Fair for life, which is open both for organic and other operators.**



Fair for life is a third party certification programme for social accountability and fair trade in agricultural, manufacturing and trading operations. The standard **also includes detailed environmental criteria.** The system is designed **for both food and non-food commodities** (cosmetics, textiles etc.) and linked to the standard is a Fair for life logo.

7.4.4. Ecocert

Ecocert¹⁸ is another major certification bodies which work on the international market and is based in France. Ecocert is mainly certifying to the EU regulation and is also doing certification to the National Organic Program in the US and the Japanese organic regulation. Ecocert has developed **one own standard Ecocert Fair Trade** which applies to food, cosmetics and textiles. Linked to the standards is an Ecocert Fair Trade label. Ecocert has also developed a standard for certification of organic cosmetics.



¹⁷ See www.fairforlife.net.

¹⁸ See www.ecocert.com.



7.5. Certification

7.5.1. What is certification?

Certification is a system by which the conformity of products, services, etc. to a standard is determined and confirmed.

This confirmation can be done in the following way:

The first party	the supplier (producer)
The second party	the customer (buyer)
A third party	an independent body

Certification in organic agriculture generally refers to third-party certification. The independent body in this case is expected to be neutral or have a balance of interests (as opposed to a body controlled by one of any interested parties).

Certification of organic agriculture includes **the certification of products and certification of quality systems.** Primarily it is certification of a production system or method including the products thereof.

It is the **producer** which is responsible for that a **production is fulfilling the organic standards and procedures** while **the inspector** and certification body **verifies that it is so.**

Certification is a market instrument

Certification is a market instrument which **allows producers to reach a certain organic market and often sell the products with a higher price** compared to conventional production. The need for organic production arises when there is a distance between producer and consumer so that they are not in direct contact knowing what the other party is doing. The distance therefore doesn't have to be a huge geographic distance but often is in international trade. It can be said that **certification creates or enhances trust between parties.**

7.5.2. Components of a certification system

Who should get certified

All parties which take ownership of the product should get included in the certification system, it can be farmers, co-operative, processors, wholesalers and importers.

Standards

There is a need of a standard or a regulation as a base for the certification and which describes what has to be done or not.

❑ Certification requirements

The certification body often has a set of requirements on practical procedures which have to be fulfilled by the producer. It can for example be more detailed requirements for documentation which is not covered in the standards, what will happen if invoices are not paid, and how a complaint by the producer is handled.

❑ Contracts

There has to be a contract between the producer and the certification body **regulating the business relation between the two parties**. The contract often regulates the right to information, confidentiality, fees etc.

❑ Documentation

The production has to be **described in detail including farm inputs, sowing seeds, transplants etc., maps of the land used, production lines, recipes** etc. The requirements also include records of farming and processing activities.

❑ Inspection

The inspector makes an inspection visit **going through documentation and activities on the ground**. A visit can take from a few hours to several days depending on the size and complexity of the business inspected. Especially **grower groups with internal control system take a considerable time for inspection**. At the end of an inspection it is common that the inspector has an exit interview presenting the major findings of the inspection also giving the possibility for the producer to give inputs and explanations.



❑ Testing

The organic quality cannot be verified through product testing. **In some cases, product testing can be used to detect non-conformity**. In most certification schemes testing is included to a smaller or greater extent. It can be testing of soil or plants, testing of inputs for growing or testing of finalized products. The standards, contract or certification requirement should cover which party (certification body or producer) is responsible for covering the cost of analyses.

❑ Inspection report

After the inspection visit a certification report is formulated. The inspection reports can look differently depending on certification body. In some systems, for example the EU, the producer should confirm that the findings in the inspection report are fair. This is sometimes done through signing the full report and more often through signing a shorter report already at the visit.

❑ Certification decision

The certification body takes a decision with the inspection report as the base. Sometimes there are unclear issues which have to be sorted out before the decision. The certification decision can be a positive or a negative decision. Sometimes part of the production can

be certified but not other parts. **Common is that the certification decision comes with a range of conditions that has to be handled by the producer to a certain timescale.**

Appeals and complaints

A producer **can always appeal a certification decision which seems to be incorrect.** Complaints can be done both by producers about handling of the certification body and by others which want to make more general complaint of the certification system.

Payment of certification fees

The payment for certification is arranged in different way by different certification bodies. The fee system varies with fees for farms, hours, travel, certification decisions, issuing of certain documents, handling of problematic issues, checking of inputs, checking of recipes. Some certification bodies have a flat fee per farm or a flat fee per product. Common is that at least part of the costs are paid beforehand and that a final invoice is paid after the certification decision.

Certificate

The certificate is a document which shows that the producer and the production is certified and is used to show the buyer the proof that a certain production can be bought as certified organic



Logo

Many regulations and private standards have a logo linked to system. The logo is the main way to communicate that a product is organic to the consumer.

Information

A certification body or a standards and logo owner makes information about the logo to make it well-known among consumers.

Confidentiality

The certification body is obliged **to keep facts like production methods, production costs, incomes from sales, buyers of products, sellers of inputs and recipes confidential.** Certified products, name and location of the producer are official information but can be kept unofficial before a product is released on the market.

For a deeper study and understanding of certification of organic production *Building trust in organics* is recommended.¹⁹

7.5.3. Certification for the export market

When planning for sales of organic production it is important to know where the products will be sold. There are different requirements for the European market, the US market and the Japanese market, as some examples. For some markets there are well-

¹⁹ See www.ifoam.bio/sites/default/files/page/files/buildingtrust_2007_0.pdf.

known private organic logos which might have additional requirements for recertification. Consumers might also have additional requirements as well as supermarkets. This together shows that a genuine **market knowledge is needed when going to choose standard and certification to work with.**

The legislations for the three above mentioned markets are different and might even be contradictory. Anyhow it might be possible to get certification for all three markets but the costs for paperwork and own administration will raise and the certification costs will also be higher for such a solution. The conclusion is that it normally not is a feasible solution especially not from the start.

The publication *The Organic Standard*²⁰ is every year compiling the Organic Certification Directory which lists all certification bodies in the world active in certification of organic production and for which markets these certification bodies are accepted.

In the 2011 Certification Directory, the following certification bodies are listed for acceptance in the EU, US, Japan and Canada.

Certification body	Country based in
Overseas Merchandise Inspection Co., Ltd. (OMIC)	Japan
Ecocert SA (International Department)	France
CERES - Certification of Environmental Standards GmbH	Germany
BCS Öko-Garantie GmbH	Germany
<i>Instituto per la certificazione Etica e Ambientale (ICEA)</i>	Italy
Bioagricert S.R.L.	Italy
CCPB ltd	Italy
Control Union Certifications B.V.	Netherlands
Institute for Marketecology (IMO)	Switzerland
Argencert S.R.L.	Argentina
LETIS S.A.	Argentina
Food Safety S.A.	Argentina
Pro-Cert Organic Systems Ltd (Pro-Cert)	Canada
OCIA International, Inc. Organic Crop Improvement Association	USA
Oregon Tilth, Inc. (OCTO)	USA
Organic Certifiers Inc.	USA
Quality Assurance International (QAI)	USA

²⁰ See www.organicstandard.com.



OneCert	USA
Washington State Department of Agriculture (WSDA)	USA
Global Organic Alliance Inc.	USA
NASAA Certified Organic	Australia
Australian Certified Organic Pty Ltd (ACO)	Australia
Organic Food Chain Pty Ltd (OFC)	Australia
BioGro New Zealand Ltd	New Zealand
AsureQuality	New Zealand

There are also several other certification bodies which are accepted in one or two of the markets. At both the US²¹ and the EU²² Web pages there are lists of accepted certification bodies. The sector with which country is accepting which country's organic certification, which certification bodies are accepted by a certain country or region is changing so it is important to search for current information.

Experiences from certified producers

A study was done asking a number of **export companies in Uganda and Tanzania** about their **experiences to become certified for organic production**. All companies had been involved in the EPOPA project (Export Promotion of Organic Products from Africa) which identified producers in East Africa which had or set up production of organic export. All of the companies had been through conversion and certification of their organic production relatively recently.

Several of the exporters stated that it took quite long time to understand the steps and the flow of the certification body. One of them stated that at start it was chaos but after some years certification was manageable and understandable. All also felt that **at start the costs of certification was almost unbearable** but **later** in the process when organic export was successful, **costs were still high but much more bearable** and needed to reach the export market.

Almost all interviewed exporters **used a consultant to handle the certification** and especially the internal control systems for group certification or they want to recruit a consultant. Many of the exporters were asking for experienced inspectors, based in the country with local knowledge, new inspectors very often gives problems. The exporters also had understood how **important it was to train farmers** (certified in groups) and **farm personnel**.

²¹ See www.ams.usda.gov/AMSV1.0/nop.

²² See ec.europa.eu/agriculture/ofis_public.

7.5.4. Individual and group certification

The normal case in certification is that each individual farm gets certified in its own rights. **One farm, one inspector, one certification is the standard.** When organic farming certification was expanded to developing countries with many smallholder farmers the certification system had to change. The cost of inspection and certification was quite often higher than the value of the whole organic harvest, especially when foreign inspectors were flown in from Europe or the USA.

To solve this problem a system was developed **grower group certification or internal control systems (ICS).**

ICS is set up so that the certification body is **delegating the inspection** of each individual smallholder farmer **to the main producer or a co-operative.** The smallholder farmers are organized in a group which is either organized by a producer in an out grower scheme or in a co-operative. For **each smallholder** farmer there should be a **contract, documentation of the production, a map and training when necessary.** **Inspection visit** are done by a **field officer/internal inspector.** All this is arranged and done by the producer or co-operative. The role of the certification body is to evaluate the system for internal inspections to see that the system works well and is detecting non-conformities. The certification body also makes some visits to the smallholder farmers, but the intention with these visits are to check that system with the producers or co-operatives system works safely.

ICS systems are commonly **used in many developing countries. Several thousands of farmers can be certified in one group.** Well-handled ICS systems gives a good security and maybe even a better security compared to the system with one farm one inspector, but it has to be remembered that ICS systems are a more complicated and therefore more difficult to handle.

Both **the EU** and the **US** has **processes to accept ICS systems,** both have guidance on how the systems should be handled. The ISEAL Alliance,²³ a global association for social and environmental standards has worked on a document describing requirements for certification of producer groups which can be of good help when setting up a farmer group.

7.5.5. Local market certification, local bodies, Participatory Guarantee System

❑ Local market development

Often when organic products are produced for export the total focus are on the export market and the possibilities to sell the products. But it should also be remembered that there **often is a local market as well for organic products.** In some countries like

²³ ISEAL, 2008: P035 ISEAL Common Requirement for the Certification of Producer Groups, Public Version 1, November 2008, available at: www.rainforest-alliance.org/business/agriculture/documents/iseal_req_group_cert.pdf.

Brazil, India or Thailand it is huge national organic market but also in many other countries there is a certain demand for organic products. The middle class have often a wish to buy products which are produced in an environmental way and without pesticides. Tourist hotels are another possible buyer of organic products. For an organic producer it can be possible **to sell products which are not sold for export**, second grade products or second crops **which also are produced organically**. All of these contribute to financial stability of the organic production. In several export projects the development have been that it has started off as for export only but as time passes distribution and sales channels locally are developed.

❑ Certification of organic production for local sales

For most organic products sold locally the main certification for international conditions will also be the appropriate certification for the products sold locally but sometimes other solutions might be better. If it for the export production is used on of the international certification bodies which might even fly in inspectors it might be better to **use a local certification body for production for the local market**. One example can be when fruit which was intended for export is processed for the local market. A local body which maybe don't have the approvals needed for export but which is locally recognized could be a closer and possibly cheaper solution. Another example is when a second crop can be sold on the local market it could be **certified through a local certifier or a Participatory Guarantee System**.

❑ Participatory Guarantee System (PGS)

Participatory Guarantee System²⁴ (PGS) is a system for quality assurance in the same way as third party certification; it is not a system for production. PGS systems are **involving many stakeholders as farmers and consumers** which are obvious stakeholders but also **environmental NGOs, consumer groups, advisers, local government agencies** and others.

PGS systems were initially set up as a reaction to the third party certification which focused on paper documentation and independent inspectors and organization. Many producers felt that the gap got too big and wanted a more inclusive process. Groups of farmers, consumers and others were formed with a system of inspection of each other in the group.

Both PGS and Third Party Certification systems are based on the **same Principles of Organic Agriculture** so standards for a PGS certified organic agriculture are generally the same as those in third party certified organic agriculture.

PGS systems are successfully used in several countries, mainly in Latin-American, but also Africa, Asia and the US. The system is **mainly used for local sales** but also in some places PGS certified products are accepted to be used together with third party certified products.

There are also differentiations of the PGS systems so that the system works well under many different production and assurance conditions.

²⁴ More can be found out about PGS systems on www.ifoam.bio/en/pgs-video-library.

7.5.6. Steps to certification

The process²⁵ from taking the first steps of planning for production and sales of organic production to when finally selling organic products is often winding and cumbersome. There are many components, knowledge of organic production and processing, equipment and facilities, organizing of smallholder farmers (if it is an ICS system), documentation, market contacts, transports and quality requirements for the sold product, just to mention some.

Example: Certification activities in one export project

1-3 July 2006

ICS training of the company staff. All staff (six men, one woman) involved in the ICS management attended the training session, which basically gave the background to ICS in general and thoroughly looked at the company's ICS manual, which had been developed. There was also a field exercise in which the internal inspection reports were used and discussed.

1-5 August 2006

Internal inspection was carried out after the first harvest. The outcome had good results and only small adjustments were made to the implemented ICS.

October 2006

Farmer training sessions. Six days of farmer training sessions were conducted in the field on introducing the concept of organic agriculture to the farmers and equipping the farmers with knowledge of organic cardamom and vanilla management. A total of 157 farmers attended, of which 121 farmers had already been contracted by the company for the organic project.

20 January 2007

Farmers' meeting. There were 255 farmers attending the meeting, which was conducted at the company estate where processing is taking place. A programme of organic-agriculture, a marketing update, and general information about the organic project were presented.

19 April 2007

ICS training of the company staff conducted again with staff involved in ICS management.

23-27 April 2007

External inspection carried out. This inspection showed that a group of farmers in one parish along the road were spraying one of the non-export crops, which led to the entire parish being suspended from the organic project. However, the organic certification for the rest of the project farmers and the estate was granted for the European Union on the 8 August 2007 and for the US market on 11 August 2007.

22 June 2007

Farmers' meeting. There were 280 farmers attending, the meeting which this time had

²⁵ In the study *Experiences with certification in EPOPA* (www.grolink.se/epopa/Publications/Experiences-of-Certification-in-EPOPA.pdf), an exporter's process to certification is described. The text has been slightly modified.

organic production, HIV/AIDS sensitization and a project update on the programme.

1 August 2007

Farmer sensitization on HIV/AIDS was conducted with good participation of over 70 farmers in the field.

26-31 October 2007

Fruit-drying training for the company processing staff (four) was carried out.

7.5.7. Advice for producers applying for certification

These advices to the operator are taken from *Experiences with Certification in EPOPA, October 2008*.

How to handle the certification

- Be very thorough in **understanding what is required to fulfil the requirements** for certification and what the signing of the contract with the certification body means.
- Build up and **maintain contact with inspectors and the certification body**. Don't be afraid to contact someone with a question even if he or she is far away in another country.
- Be **active at inspections**, exit interviews and handling certification decisions in communication with the certification body.
- **Use a consultant for support** in certification issues **if there is not enough capacity in the company** and qualified consultants are available.
- **Learn when different activities** regarding certification shall be done and what the possibilities are for adjusting the formal requirements to the realities on the ground.

Costs and handling of financial issues

- **Compare the offers** from different certification bodies. Realize that the cheapest offer maybe is not always the best. Ask others about their experiences with different certification bodies.
- Before signing the contract with the certification body, investigate in which fees there are, when they should be paid and what happens if they are not paid in time.
- Pay invoices on time. You don't pay the certification body for a positive certification decision, you pay for a service. Even if your production is not certified you will have to pay for inspection and certification.
- Count both time for the staff and the fees to the certification body as a cost include this sum as a cost for market access for organic products.

Staff

- **Assign senior staff to handle the certification.**

- **Consider training** more than one person in key-position to have a better back-up in the case one person is leaving the company.

❑ Documentation and computers

- **Keep documents and records** in good order and updated.
- Train personnel to be competent with computers and programmes.
- Use good virus programmes and have a system for backups.

❑ Internal Control Systems

- **The ICS** (Internal Control System for group certification) **documentation** has to be used and should not only be set up for the inspector and the certification body.
- Manage your field staff efficiently, field officers need a decent workload, regular payment and perhaps a bonus for good work.

❑ Certification decisions

- **Ask the inspector** and the certification body **when something is not clear** regarding the certification. Read through information sent from the certification body.
- **Request explanations** when an unclear certification decisions occurs, appeal decisions when needed.
- Always request the certification body to refer to a standards paragraph or other certification requirements when raising an issue.
- **Read the certification decision document**, handle certification requirements timely and don't wait until next inspection visit.

❑ Changes of certification body

If you want to switch certification body do it at the time of the certification year when the contract is expiring. Be clear that a change of certification body might be a cumbersome process. Fulfil the requirements needed to be able to leave a certification body (for example, pay the cost for certification).

❑ Timing of inspections

If the inspection visit is proposed to take place on a very inconvenient time, try to change the time but also remember that the inspection has to take place at least once a year. If the inspection visit is postponed it might be problems with expiring certificates, and without a certification certificate products cannot be sold.





Abbreviations and acronyms



Most used abbreviations and acronyms

ACP	African, Caribbean and Pacific (Group of ACP States that have signed a series of agreements with the EU, called the 'Cotonou Agreements')
AROS	Asia Regional Organic Standards
ATP	Adenosine-5'-triphosphate
Bt	<i>Bacillus thuringiensis</i>
C	Chemical symbol for carbon
CCAA	China Certification & Accreditation Association
CERES	Certification of Environmental Standards GmbH
CNAS	China National Accreditation Service for Conformity Assessment
CNCA	Certification and Accreditation Administration of the People's Republic of China
CO ₂	Chemical symbol for carbon dioxide
COROS	Common Objectives and Requirements of Organic Standards
DNA	Deoxyribonucleic acid
EAOPS	East African Organic Product Standard
EAS	the East African Standard

EC	European Commission
EEC	European Economic Community
EFI	Eco Functional Intensification
EPOPA	Export Promotion of Organic Products from Africa project
ETC group	Action Group on Erosion, Technology and Concentration
EU	European Union
FAO	Food and Agriculture Organisation: UN organisation that addresses food security problems in the world
FiBL	Research Institute of Organic Agriculture
FLO	Fairtrade Labelling Organizations International (FLO) is an association of 20 fairtrade labelling initiatives located in over 21 countries
GAP	Good Agricultural Practices
GLP	Good Laboratory Practices
GOMA	Global Organic Market Access project
GMO	Genetically Modified Organisms
HIV/aids	Human immunodeficiency virus
IBS	IFOAM Basic Standards for Organic Production and Processing
ICB	Independent (third-party) certification body (see TPC)

ICEA	Instituto per la certificazione Etica e Ambientale
ICIPE	International Centre of Insect Physiology and Ecology
ICS	Internal Control System
ICM	Integrated crop management or integrated production
IFAD	International Fund for Agricultural Development
IFOAM	International Federation of Organic Agriculture Movements
ILO	International Labour Organization
IMO	Institute for Marketecology
IOAS	International Organic Accreditation Service
ISD	Institute of Sustainable Development
JAS	Japanese Agricultural Standard
KOAN	Kenya Organic Agriculture Network
MAFF	Ministry of Agriculture, Forestry and Fisheries of Japan
N	Chemical symbol for nitrogen
NOGAMU	National Organic Agricultural Organization of Uganda
NOP	National Organic Program



NGO	Non-governmental Organisation
NZ	New Zealand
OA	Organic Agriculture
OECD	Organization for Economic Co-operation and Development
OFDC	Organic Food Development Center
OM	Organic matter
PGS	Participatory Guarantee System
PHLOG	Pacific High Level Organics Group
POETCom	Pacific Organic and Ethical Trade Community
RNA	Ribonucleic acid
ROTF	Regional Organic Task Force
SAN	Sustainable Agriculture Network
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SPC	Secretariat of the Pacific Community
TOAM	Tanzania Organic Agriculture Movement

UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNO	United Nations Organization
UPOV	International Union for the Protection of New Varieties of Plants
USD	United States dollar
USDA	United States Department of Agriculture
VAM	Vesiculum Arbuscular Mycorrhizal
VOC	Volatile Organic Compounds
WHO	World Health Organization
WTO	World Trade Organization





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Useful Websites



Useful Websites

AREFLH: areflh.org/index.php?lang=en

Africa Rice Center (WARDA): www.cgiar.org

Biodiversity International: www.biodiversityinternational.org

CITES: cites.org/eng

CIAT – International Center for Tropical Agriculture: gisweb.ciat.cgiar.org/sig/biological-mapping.htm

CIFOR – Center for International Forestry Research: www.cifor.cgiar.org

CIMMYT – International Maize and Wheat Improvement Center: www.cimmyt.org

CIP –International Potato Center: www.cipotato.org

Commission on intellectual property rights: www.iprcommission.org

CORPEN: www.developpement-durable.gouv.fr

COLEACP: coleacp.org/en

Convention on Biological Diversity (CBD): www.cbd.int

CTA: www.cta.int/en/

ECPGR: www.ecpgr.cgiar.org

EUFORGEN: www.euforgen.org

EU Law and Publications: publications.europa.eu

EUR-Lex: eur-lex.europa.eu

European Environment Agency: www.eea.europa.eu

European Parliament: www.europarl.europa.eu/?lg=en

FAO: www.fao.org, more specifically: www.fao.org/agriculture/crops/agp-home/en

ICIPE: www.icipe.org

ICARDA: www.icarda.cgiar.org

ICRISAT: www.icrisat.org

IFPRI: www.ifpri.org

IITA: www.iita.org

ILRI: www.ilri.cgiar.org

IWMI: www.iwmi.cgiar.org

Ministère de l'Environnement, de l'Énergie et de la Mer: www.developpement-durable.gouv.fr

PAN GERMANY: oisat.org

PHYTOPHAR: www.phytofar.be/fr/phy_pro.htm

PRPB: www.health.belgium.be

TOPPS: www.topps-life.org

TRAFFIC: www.traffic.org

UICN: www.iucn.org

UNEP: www.unep.org

UNESCO: en.unesco.org

UNIDO: www.unido.org

Water Footprint Network: waterfootprint.org/en

WIPO: www.wipo.int/portal/en/index.html

World Bank: www.worldbank.org

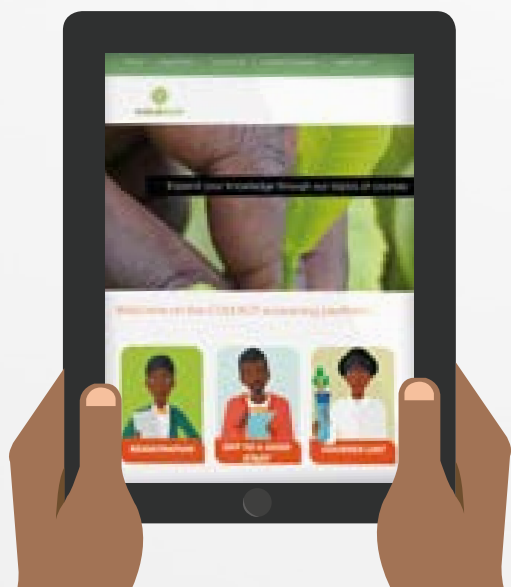
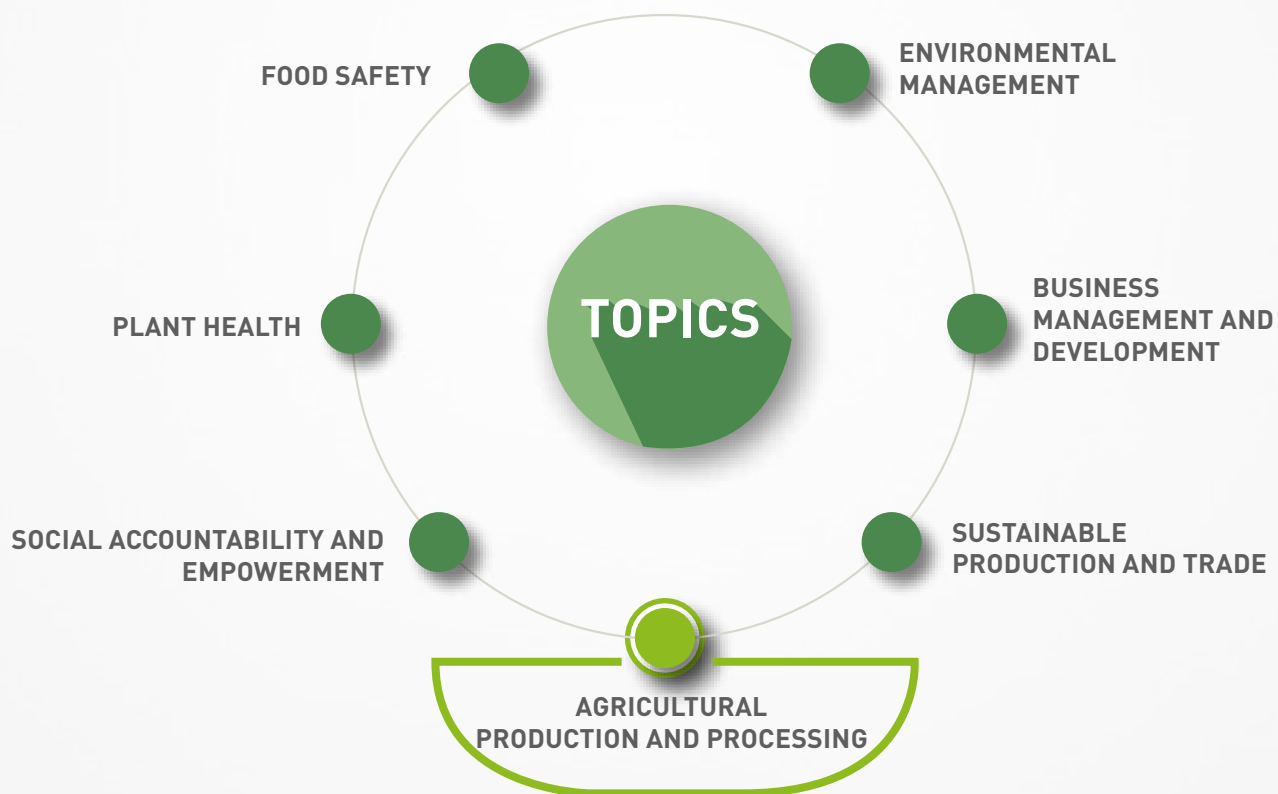
WorldFish Center : www.worldfishcenter.org



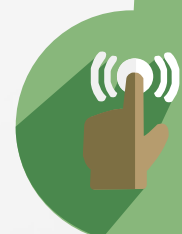
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