Since the beginning of agriculture, the practice to remove all the vegetation from the soil and plowing has been considered necessary and the only way to do. But this way depletes the earth of fertility and creates the well-known problems of erosion, run-off and leaching.

In Japan, Masanobu Fukuoka, a microbiologist and farmer started in the 30's a new way of crop production. What he begun is revolutionary, since he succeeded to practice an agriculture where, not only the plough was put aside but also the change to maintain the soil covered with permanent living mulch while growing crops. He named this type of agriculture Natural; as it uses the dynamic of the law of synergy to maintain the fertility of the soil. Since mining the soil is not longer done, compensating the losses of fertility with compost, manure, or any other type of fertilizer no longer is necessary.

In agriculture plants are accused of exporting fertilising elements from the soil, but how is it possible that if in Nature plants create the soil, in agriculture they destroy it? Aren't we accusing the plants to be responsible for something that the real cause is the way we manage the soil for the crop production? A plant is made of 75% water- of the 25% dry matter left: 20% is made out of carbon (light from the sun) and gases; ONLY 5% OF THE TOTAL MASS OF THE PLANT NUTRITION COME FROM THE SOIL- and of this 5%; 2.5 is nitrogen- this nutrient can be obtained FREE from the atmosphere in a continuous symbiotic way (by associating the crop with nitrogen fixing plants); the remaining 2.5% are indeed minerals and trace elements that the plants take from the earth, dissolved from the parent rock. Our planet is a mass of minerals covered by a thin layer of "soil" - soil is the living-dead remnants of the decayed life of plants, animals (micro & macro) and fungi... so before we'll run out of minerals we will run out of Sun.

Fukuoka has proved that agriculture, calculated crops, can be practised respecting the dynamic of the living, "wild" soil organism. Natural agriculture, using the law of synergy, refutes the 1st Law of agronomical belief, stating that if so many elements are in a plant, in the crop, the same quantity should be put back in the soil. This belief does not take into account the capacity for plants to synthesize and transmute elements for their nutrition. Plant organisms on land and in water, form the base of the energy pyramid and support almost all forms of life, they certainly develop and maintain the organic material and the community of life in the soil.

Microbial interactions in soil play a key role in the biological control of plant diseases, the turnover of organic matter, and the recycling of essential plant nutrients. Plants stimulate microbial activity in soil by supplying chemical energy in the form of root exudates and litter; thus, an intimate relationship exists between the plants and soil microbes. Unfortunately, in the conventional methods used in agriculture this relationship is impaired, resulting in problems of nutrient supply to the plant and increase in the incidence of disease.

The latest research indicates that during the life of a plant up to 25% of the chemical energy in the form of carbon compounds that is manufactured in the leaves is lost by the plant into the soil directly adjacent to the root, this material is lost either as roots exudates or as dead, sloughed plant cells. How does this loss of carbon in the soil benefit the plant? Most importantly, these compounds are energy sources for the soil micro-organisms which proliferate in the rhizosphere, (the soil zone directly adjacent to the plant root), these micro-organisms multiply so rapidly that they deplete the soil of oxygen at numerous microsites in the rhizosphere, thus, oxygen-free anaerobic microsites are formed, these microsites plays an important role in ensuring the health and vigour of plants. Ethylene, a simple gaseous compound, is produced in these anaerobic microsites. This ethylene is a critical regulator of the activity of soil micro-organisms and, as such, affects the rate of turnover of organic matter, the recycling of plant nutrients and the incidence of soil-borne plant diseases.

Ethylene does not act by killing soil micro-organisms, but simply by temporarily inactivating them, concentrations of ethylene in the soil atmosphere rarely exceed 1 to 2 parts per million. Soil ethylene is produced in what is called the OXYGEN-ETHYLENE CYCLE. Initially, the soil micro-organisms proliferate on the plant root exudates and deplete the soil of oxygen at microsites. Ethylene is then produced in these spaces and diffuses out, inactivating without killing the soil microorganisms. When this happens the demand for oxygen diminishes and oxygen diffuses back into the microsites, this stops or greatly reduces ethylene production, which enables the soil micro-organisms to recommence activity. Favourable conditions are then recreated for ethylene production and the cycle is continuously repeated. In undisturbed soils, such as found under forests, ethylene can be constantly detected in the soil, indicating that the oxygen-ethylene cycle is active. Conversely, in agricultural soils, ethylene concentrations are extremely low or non-existent. This is to be expected if ethylene plays an important role in regulating microbial activity in the soil. When natural ecosystems are disturbed for agricultural or forestry usage there
is an alarming decline in the amount of soil organic matter, deficiencies of plant nutrients become commonplace and the incidence of plant diseases increases dramatically.

It is now known that one of the major reasons why disturbed, agricultural soils fail to produce ethylene is because plowing cause a change in the form of nitrogen in soil. In undisturbed soils, virtually all the nitrogen present is in the ammonium form with just a trace of nitrate nitrogen present. When these ecosystems are disturbed for agriculture uses most of the soil nitrogen occurs in the nitrate form. The change in form of nitrogen occurs because the disturbance of the soil by plowing stimulates activity of a specific group of bacteria that convert ammonium nitrogen to nitrate nitrogen. Plants and microorganisms can use either form of nitrogen but ethylene production in soil is inhibited whenever the nitrate form is present at more than trace amounts. Nitrate nitrogen stops ethylene production because it interferes with the formation of the anaerobic microsites. Ammonium nitrogen has no such inhibitory effect on ethylene production.

When all the oxygen is consumed in the microsites a series of complete chemical changes then take place. One of them is that iron goes from the oxidised or ferric form to the reduced or ferrous form. Iron is one of the major constituents of soil, making up somewhere between 2 and 12% of its weight. In naturally aerated soil virtually all the iron exists as minute crystals of iron oxide and in this oxidised or ferric form is immobile in soil. If oxygen is completely consumed in microsites, and reducing conditions exist, these minute crystals break down and iron is then transformed into the highly mobile ferrous or reduced form: ethylene production occurs in soil only when iron is in the reduced or ferrous form.

How does ferrous iron trigger the release of soil ethylene? This form of iron reacts with a precursor of ethylene that is already present in the soil and a reaction occurs that results in the release of ethylene, this precursor originates from plants and, more importantly, it accumulates to appreciable amounts only in old, senescent plant leaves. When these old leaves fall to the ground and decompose, the precursor accumulates in the soil, then, when conditions become favourable for mobilisation of ferrous iron, ethylene is produced.

It should not be too surprising that the ethylene precursor accumulates only in old, dead plant leaves. After all, in natural communities of plants, old dead leaves comprise the bulk of the litter that falls on the soil. Also, it is equally clear that in an agricultural situation most of the old plants leaves are removed either during harvest or by grazing or by burning crop residues, thus, agricultural soils are usually deficient in precursors.

A major limitation to plant growth in agricultural soils is an inadequate supply of essential plant nutrients, this occurs even though there are adequate reserves of these nutrients in soil, but they are held in highly insoluble forms.

Formation of anaerobic microsites in the rhizosphere of plants, which is of such paramount importance to ethylene production, can play a critical role in the mobilisation and thus supply rate of these essential nutrients to plants.

This mechanism revolves around the importance of iron in soil. Under normal, natural conditions in soil, most of the iron occurs as minute crystals of iron oxide, these crystals have a large surface area and are highly charged, as a result, plant nutrients such as phosphate, sulphate and trace elements are tightly bound to the surfaces of these crystals. In this form they are virtually unavailable to plants. If however, in an undisturbed soil, anaerobic microsites develop, these crystals breakdown and the bound nutrients are released for uptake by the plant.

At the same time, high concentrations of ferrous (reduced and mobile form) iron are released into the soil solution in the microsite. The other essential plant nutrients, including calcium, potassium, magnesium and ammonium, are held on the surfaces of clay and organic matter. When concentrations of ferrous iron increase, these nutrients are displaced by ferrous iron where they are made available for uptake by plant roots.

Since anaerobic microsites are most likely to form in the rhizosphere of plants, the nutrients are mobilised exactly where they are required by the plant. An additional advantage of this mechanism is that if the released nutrients are not utilised by plant roots they cannot be leached in the soil: as soon as they migrate to the edge of the anaerobic microsite, reoxidation of the iron occurs with recrystallization of iron oxide. These crystals then rebind the nutrients and prevent their loss by leaching. The soil conditions necessary for this mechanism to operate are identical with those required for ethylene production.
IN AGRICULTURAL SOILS, WHERE PLOWING IMPAIRS ETHYLENE PRODUCTION, THIS MECHANISM OF NUTRIENT MOBILISATION IS ALSO INHIBITED.

Successful management of soils, will demand changes to some of the traditional, established practices in agriculture, like tilling, aimed at increasing aeration and oxidation states of soil, which give short-term increases in plant growth but rapidly create long term problems of nutrient depletion and increased plant disease incidence.

Techniques of no tilling can ensure that plants are growing continually, keeping the soil covered increases the amount of organic matter that is returned to the soil. It is best to use mature plants as a source of organic amendments, and as green manures, allowing the residues to stay in the soil surface, as a mulch, rather than incorporate them into the soil.

Cartesian science has a hard time accepting and understanding the holistic dynamic of living organisms, this cultural limitation should not have the power to prevent society from finding sustainable ways to produce food without destruction.

In synergistic agriculture (syn.ag) we create the conditions in soil that soil needs to maintain its own healthy life, and fertility. We imitate the way soil feeds itself, keeps itself alive... by doing this, we stop totally the way traditional agriculture as well as the "modern" one does to obtain yields.

Changing habits is never easy and if the habit to change is constantly reinforced by tradition, by extension agents, agronomical schools...by the whole of culture, it becomes even harder. It takes a deep and strong conviction for the need to change, so as to go against the current and become a pioneer for an agriculture of the future, when soil, petrol and fertilizers won't be as abundant as today. Animal manures and compost are hard to have in many places of the world, thus, to know how to produce food using the self-fertility of the soil can make all the difference between life and death.

We need to start now practising this new agriculture in small experimental plots; so as to be in the position to advise farmers in all types of climatic and soil conditions how to succeed their crops in a genuinely sustainable way. This ongoing research is just beginning in various places in the world. We are the members for the critical mass group necessary for the quantum leap...that could help humanity meet the coming challenge of feeding an exponentially demographic explosion, while loosing soils exponentially as well.

Since healthy, fertile soils, are always covered with a profusion of diverse plants, it follows that soil needs to be maintained covered and occupied by plants while growing crops. If we avoid the problems that mining the soil produces: loss of organic matter by precipitating its combustion when air is forced into the soil by tilling, erosion, run-off and leaching, the residues left after harvest will be superior to the 2.5% of elements the crop takes from the soil.

By avoiding the destruction of the soil that happens with "normal" practices we also avoid the need to compensate this losses: so the work of making compost, finding manure and/or any other type of fertiliser, besides treatments for diseases, etc. won't be any longer necessary.

With this agriculture we organise our fields, gardens, in such a way where symbiosis among plants, bacteria, fungi and other elements creates a synergistic dynamic that perpetually goes on giving yields using the potential for self-fertility of soil.

THE FOUR PRINCIPLES OF SYNERGISTIC AGRICULTURE

1) Continuous fertilization of the soil by a permanent organic cover.
2) Growing the annual crops with the association of complementary crops, integrating nitrogen fixing trees.
3) No plowing, or any other type of disturbing soil, the soil "works" itself.
4) The soil aerates itself, as long as we don't provoke compaction.

1st PRINCIPLE:
Depending where one is, the choice of crops and living cover will be different, but the system will be the same. For field crops, in a brittle environment like Botswana, we would prepare the field by establishing a permanent living cover of low height, maximum soil coverage, perennial nitrogen fixing plant, drought resistant and keeping alive during the dry season, like the Ethiopian clover, Trifolium cryptopodium or the southern African plants: Desmodium triflorum and Indigofera spicata.

To start, sow the living cover all over the field, this may require using the plough...the last time soil is to be disturbed. If the field has too many "weeds", have first a crop of sunhemp or a bunch of pigs to clean it. Once the living cover is established the crops will be sowed and harvested without disrupting the soil by tilling, etc.
2nd PRINCIPLE
Not growing monocultures means having simultaneously in the field more than one crop. If maize is going to be the main crop, we will sow it at a bigger distance than it is customary so as to allow light to reach the living cover. We want the living cover to thrive so as to protect the soil from cracking, and/or being compacted, besides releasing ammonia nitrogen to the crops. We can put the maize at one meter in the line and the rows at lm50 apart. Beans can be put in the same line than the maize, at 30cm and alternating maize plants. In the spaces left as passages between crop bands, a line of squash, or melons, can be planted. Nitrogen fixing trees like Sesbania, Tagasaste or Leucaena (maintaining them coppiced) are planted all around the field, in the hedge, at about 5m from each other, (drawing n.1&2)
EXHIBIT OF 1 ACRE FIELD COVERED WITH A LIVING COVER

CROPS: MAIZE, with intercropping of squash (or melons, etc.) & beans: set at 30cm from the maize & alternating plants. Sunhemp, as extra fertilizer in the vicinity of the line with the squash. The sunhemp is allowed to go to seed, cutting it only afterwards & leaving it in place as mulch, as it will reseed itself thickly & it will be necessary to remove some of it the following year.

The hedge is 1 meter wide (or more) & ideally surrounds the 1 acre (or 500m2) field. One Nitrogen Fixing tree is put every 5 meters, in between the trees, different types of bushes, favorising those giving lots of mulch & multifunctional.

A row of vetiver on the outside of the hedge following the contour (on slope grounds) & at the lower side of the field. Sunhemp & aromatic/ medicinal/insecticidal plants in the inside.
Marigolds, Nasturtiums, Calendulas, Castor beans, Crotolaria, Garlic, Lemon grass. Tansy, Lavender, Basil, etc. are put in the edge/hedge line of trees, the more insecticidal plants, the better, these plants by their presence not only are they beneficial to the crops by protecting them of nematodes and other pests, you also have them handy for using them in the kitchen or for preparations as insecticides to use in the crops if necessary.

Sowing in a field with clover: if the clover has grown a bit tall: pass a lawnmower (or any other system to cut down vegetation), before sowing the crops. If the field is big you can use the tractor: opening a line by disking and drill- or utilize a circular sowing implement, that lets the seed out at the convenient distance. If sowing by hand: push down the seeds through the clover into the soil: staying in the line. With this system we can broadcast seeds, but very thin so as not to eliminate the clover by lack of light, mulch should be put after sowing so as to cover the seeds.

3rd PRINCIPLE
The soil works itself : in a non-traumatized soil, constantly the action of its inhabitants go on creating a structure in which air pockets are maintained, decaying roots leave passages where bacteria and other microscopic fauna colonize them as well as facilitating the circulation of the earth worms and/or ants: their presence increasing the quantity of organic matter within the soil, and other substances like calcium, etc. Decaying matter in the soil is essential to keep it fertile-the way it happens in nature is : the soil digest all that falls to its surface and all that dies inside. When we open the soil to bring in compost, manure, green manure or any other fertilizer, we disrupt the whole equilibrium that exist in this complex organism and although what we put, the crops utilize it, the soil itself suffers from this, not only by the violent death of its inhabitants bum out by excess of oxygen as they get exposed to the air, but as well, by an "indigestion" of what has been force-fed, diseases in plants are the manifestation of this doing.

4th PRINCIPLE
Avoiding compaction is perhaps the condition most difficult to observe with this agriculture... the habit of carelessly compacting soil when harvesting or when doing any other activity during the growing season is part of the traditional way, as plowing before sowing will again bring air to the soil (and paying a high ecological price for it). But since we don't want to disrupt the soil anymore, we have to be very careful how the harvest is going to be done, or any other work in those fields. If we use animals to do the sowing, we will only work in the field if the ground is not too wet, the same applies for any other activity. Avoid putting weight to the soil when it is wet. If you compact your field, if you push the air out from the soil structure, plants won't be able to grow, the microflora and microfauna not having the microsites in which to live and grow, will die.

Soil bacteria and all the other dwellers in the soil are our partners in keeping the soil fertile, think about their needs, don't forget they are there even if their size makes them invisible...their presence is manifested by the well being of the plants, of the growing crops, the whole health of the soil.

By avoiding compaction we avoid a lot of work and a lot destruction, and at the same time we make it possible for the soil to have the oxygen-ethylene cycle, to have it's own breathing rhythm.

Continuing with the example of the maize crop/When harvest time comes, cut all the crops above the ground. DON'T PULL THEM ! The soil needs dying roots. By allowing all the roots to decompose in the soil, great quantities of organic matter, of biomass, are going to enrich the soil, besides the generous amount of (ammonium) nitrogen that the roots from the legume plants will leave in the soil. The clover should be left alone. If in some places the clover is lacking put some more seeds there at the beginning of the rainy season, without turning the soil, just press the seeds down on the ground.

In a maize/bean/cucurbit crop dispose some of the stubble from the maize at random as a mulch over the field. The aerial parts of the bean plants and squashes/melons should also be left on the field as mulch, while all the roots are left undisturbed within the soil. The following year without changing bands, the sowing gets moved so that the maize is put in the spaces that were in between the lines the year before. The squash/melons are left in the same line but are set in the middle, between the stumps of the year before crop.

This way, after the 5th year, we will continue alternating the places of the crops returning to the original places. And if you want to change completely the type of crops in that field: no problem just set the distances for the new crops, always thinking about the need for light of the living cover, and the need of the soil for diversity of plants, for diversity of roots.

We leave 1.50m of space between the crop bands as to allow the passing of machines or the circulating when weeding or harvesting or for any other need to go to the field. In these spaces we can put as well a


diversity of herbs, these spaces are not lost: although crop yield won't be obtained directly in them, by being there the quality and quantity of the crop increases and in a long term production, protects the yield spaces from the compaction of machines, animals and humans while carrying on their work, their presence is to be understood as part of the general production.

The field remains "cultivated" with this type of rotation year after year without ever exhausting the fertility of the soil and even increasing its quality. This applies to any soil of farming quality, if you want to do agriculture in a soil that is already depleted or somewhere where salting or laterisation of soil has begun, before reaching the phase of permanent field production, work to regenerate the soil will have to be done. This could imply a succession of green manures (that would be cut and left on top of the soil) like sunhemp. In acidic soils : Lupinus mutabilis-tarwi, or in salty soils, atriplex. But for each situation a careful study is needed so as to put the succession of species that would correspond to that site for a faster recovery.

For water harvesting slopes we may organise the field (before sowing the clover) with earth bunds or simply by planting vetiver on contour lines. The 1st line of the crop should always be at a minimum distance of 1.50m from the vetiver row-Arachis piritoii-a forage legume can be put parallel to the vetiver row. Vetiver roots are very deep and vertical-no other grass has this particularity: so if you don't have vetiver keep looking for it but please don't replace vetiver with any other type of grass in the grain field, even if the others may be better as fodder. We want to optimise the production of the crop, not of the fodder needs. (Fodder grasses can be put on hedges far out from the roots of the crops). IMPORTANT: Vetiver should always be eestablished from cuttings and never from plants that go to seed. Don't ever use seeds to implant vetiver.

Finding the low height, nitrogen fixing living cover that best corresponds to your soil and climatic conditions is a work that we all have to do and hopefully a work that we will share among us all, so that sooner than later, we can be in the position to recommend farmers which permanent living cover they can use and even make the seeds accessible to them.

For a living cover in a brittle environment, we are looking for plants having these characteristics:
Perennial
Nitrogen fixer
Drought resistant
Covers well the soil(even during the dry season)
Maximum height-30cm tall.
Among the plants that have come to my attention and that we can begin trials with are:
Trifolium cryptopodium
Trifolium berchellium, var johnstonii
Trifolium tembense
Trifolium semipilosum

And for getting the following seeds :
Arachis pintoii
Indigofera prostrata hytidocarpa
Indigofera daleoides
Indigofera spicata
Indigofera endecaphylla
Indigofera parisflora
Cassia biensis
Crotolaria sphacrocarpa : wild legume self seeding annual
Desmodium triflorum.

Of course the ideal plant is one that would be spontaneous to your area.... one that you discover in the wild, that you harvest the seeds and use in your fields... But if such a plant is not in your region then bring one in that will help you grow food without destroying your fields, your planet.
STARTING A FARM ON A WILD PLACE
In the case that one is to start doing agriculture in a piece of land that never before has been utilized, before clearing all the existing vegetation, bushes, trees, etc. take into consideration the benefits of leaving as many trees & bushes as possible while creating your field. Acacias are nitrogen fixers, you may need to remove some of the branches & make it easier the moving around as well as removing some excessive shade, but leaving the tree will be beneficial to the health of the soil and therefore to the crops.

If work is to be done with a tractor, choose one that won't be too big, too heavy; big engines are needed if plowing has to be done, but with a no-till agriculture, except for the initial plowing to get the system started there won't be any further need for a powerful engine. A small machine will do just fine. An ideal size for a field surrounded by a living windbreak hedge is of 1 acre maximum. The field becomes a "clearing", and although annual crops root's aren't very deep, the presence in the hedge of a diverse perennial vegetation with deep roots will act as agents lifting up mineral and trace elements to the surface layers of the soil, to the general benefit of the crops.

Trace minerals, although only needed in very small quantities are essential to the well being of plants and animals, including us.

The hedges also work as water traps, establishing an effective water cycle that, combined with the permanent coverage of soil with the living covers in the fields, makes it possible to grow annual crops without producing the usual negative effects of erosion, run-off and leaching in the fields. Rain water will be able to soak deep in the ground with each succeeding rain, the water flowing through particles already holding water and penetrating even deeper in the soil to depths in which the excess can trickle through larger decomposing rock fragments to join underground supplies. The accumulated, almost optimal moisture in the underground will allowed the plants to go on growing until temperatures will fall, the following year, the soil will have conserved enough moisture and when the weather warms up, the plants can have an earlier start while the rains are still to come some weeks later.

Although the wider spacing in syn.ag. may seem to reduce the total yield per Ha. at the long run, long term, it actually increases the benefits. Weeds are controlled by keeping the soil permanently covered with the living cover..."weeds" are the pioneer plants trying to protect the soil from the abuse of forcing it to be naked. If we respect the need of soil to be occupied by plants then, these strong, regenerative plant pioneers won't be any longer having a function. So work is reduced as well as yields losses caused by weed competition, and if the rains are scarce by distancing the crop plants more moisture will be at their disposal. The amount of water that the living cover utilizes being inferior to the quantity lost by the evaporation through the cracks in a naked soil.

During the first 3 years, weeding (by hand and selectively) "weeds" growing in the crops and living cover may be necessary, but this weeding will go on decreasing till it won't be any longer necessary in a "mature" field. This is an evolutive system reaching and with our monitoring, maintaining, the optimal climax stage, beneficial to the field.
EXAMPLES FOR THE MANAGEMENT OF A DIVERSITY OF CROPS

POTATOES, PEANUTS, ETC.

Whenever we have crops produced underground the soil is going to suffer. Therefore we have to organize the field in such a way that a "healing" rotation will always be applied that allows the soil to regenerate itself from one crop to the next.

The whole field will be kept covered with the living cover, bands 3 meter wide kept apart by lm50 passages are marked. The root crop is planted in the bands at a bigger distance that it is customary and alternating bands, the bean crop is sowed with annual sesbania and/or sunhemp as a living support, regenerative and nitrogen fixing multipurpose plants. This crop will add biomass and fertility to the soil, developing and maintaining organic material and the soil life community. The residue from all these plants is left as mulch, and in between the bands the living cover keeps the soil on the passages protected for all the circulating, this way compaction is kept always in the same places, off the growing bands.

The following year the root crop is put in these bands where the soil will be having the living cover plus the mulch.

Other types of root crops, like carrots, radishes, beets, etc. that are sowed instead of planted, require a soil without the living cover, we will see how to grow them next.

We can consider the soil as being an animal having the same nutritional needs than cows, horses, goats, etc. which means to keep your soil fed you cannot give the crop leftovers to other animals. There is also another disadvantage to have animals grazing in the fields after the harvest, they compact the soil. If your field produces more biomass than is needed for mulch, you can harvest it as forage to be fed to the animals elsewhere.

THE CROP FIELDS ARE ZERO GRAZING PLACES

And it is maybe necessary to fence them or establish an efficient thorn hedge all around the fields, ensuring that not wandering animals will get in. (see drawing n.3)
SWEET POTATOES
We can grow this crop in a permanent field without field rotation: just by moving the planting space 25/50 cm. from the previous year. Small, nitrogen fixing (and drought resistant) trees are set in the bands as support for the crop, this way the vegetation is kept off the ground allowing light to reach the soil to the benefit of the living cover, (drawing n.4)
CARROTS OR ANY OTHER ROOT CROP NEEDING DIRECT SOWING

The only crops that are almost impossible to succeed in a soil occupied with a living cover are from plants having small seeds needing direct sowing. For this type of crops we won't put the living cover in the soil, instead, we will cover it with an organic mulch, and as with many other type of crops, maintain a rotation with an equal number of bands having legumes.

For root crops, as they benefit from a loose, crumbly soil structure, it is a good strategy to organize the fields with raised beds, this way compaction can be prevented and although at harvest time the soil will be disrupted, by not adding compaction to this, soil destruction is minimised. The less we destroy, the less we have to compensate.

We organize the field with raised beds lm20 wide or if working with a tractor, whatever distance between the wheels your tractor has. The passages in between the beds around 50 cm wide (or more if working with machines or animals). Whatever the width, this passages are covered with living cover and the beds with biodegradable mulches. This mulch is only removed in the lines where sowing takes place, what is removed gets pushed off in between the sowing lines, this way the soil is not left naked over a big surface. Onions can be transplanted through the mulch, in a zigzag fashion, at the centre space between the line of carrots (see drawing n.5).

![Diagram of planting layout](image-url)

In the beds or bands where the beans are, also mulch should cover them totally (but not too thick, to let the living cover come through). The beans and annual sesbania sowed in pockets 50 cm. from each other in the line and in a zigzag way, starting at 25 cm. on the next row.

Around the beds in this area it is advised to put plants beneficial to the root crop like: Marigolds, Calendulas, Pyrethrum, Cosmos, Chrysanthemums, Sunhemp, Wormwood, etc. These plants can be intermixed as well with the crop, after they mature and go to seed, they can be cut and their biomass used as protective mulch. Whenever those beds have a root crop, the sowing is done by jumping over these plants: don't pull them out, if they become invasive, transplant the seedlings to the edge of hedges or any other space in or around the fields.

To live the soil needs roots within it as plants aboveground need the Sun! The more roots live and die in the earth the healthier and more fertile will be the soil. Just leave below what grew under and above
what was there. DON'T FORCE FEED THE SOIL! For energy to flow, the process of life and decay must go on constantly. A good mineral cycle cannot function in an stressed or dead soil; to function correctly it needs a biologically active living soil with good "natural" aeration and energy to sustain an abundance of organisms, which are in continuous contact and interaction with filtered atmospheric gasses while creating their own atmosphere.

OTHER TYPES OF CROPS

CABBAGES: if the main production is cabbages, as they take a long time to be harvested from the moment of planting, we can intercrop with a fast growing plant, like lettuces, and an erect one like onions, garlic or leeks that also act as a protective crop on a soil covered with living cover, the cabbages are planted at 1m distance in all directions. Between the cabbages we put the onions, or leeks or garlic every 30cm in the lines where the cabbages are planted and in the inside square that this forms we will have 4 rows in which we put the leaks and lettuces alternating them at 20cm from each other, (see drawing no.6).

Because cabbages can be attacked by a number of "pests" it is good strategy to grow them in a 3 crop rotation that insures that it will be 7 years before the cabbages will return to the same band of soil.
BEAN CROP
To maintain the fertility of the soil without having to make compost, find manure, etc. We will accompany the main crop with an equal surface in the field of beans. Any kind or many different kinds can be grown: each band of 3m x the length of the field can have a different variety. We can also put annual sesbania & crotolaria as enrichers of the soil plus helping the beans to stay erect. As the living cover covers the whole surface, it is better to keep the beans up, so that light reaches the soil and keeps the clover alive. We should not put more than few beans together in pockets. If the variety is a vigorous one, with big plants and lots of foliage, we will space them more, only setting pockets every meter with 1 pocket in the centre of the square.
At harvest time—the lettuces are cut and we do the same with the cabbages allowing the roots to decompose in the soil, the onions, garlic or leeks, of course get pulled out. If possible this should be done in such a way that not much earth will be taken with the roots of these plants: Removing them when the soil is dry and shaking the earth off the roots as we collect them. Any part of the plant that is going to be discarded as the crop is prepared to go to the market, should be put back as mulch, over the soil where it grew.

For the crop of beans: after harvesting the beans (and the seeds of the annual sesbania and sunhemp) slash the vegetation down and let it cover the band as a mulch, if the biomass produced is enormous, some of it can be put in any of the other bands having had the cabbages (or whatever the neighbouring crop was). (see drawings n.8 & 9)
During the dry season the soil will remain protected by all this organic residues plus the living cover, by the time it will be again time to sow the next crop, much of all this will be gone (specially if termites are round) but the underground will still be supplied with lots of decaying roots. Nourishing the soil communities and insuring good crumb structure for a new, healthy crop to be produced. If the stems from the harvested plants are still present, don't try to remove them. Just plant or sow your crop next to them, the roots of the new crop will take advantage of the canals left in the soil by the previous roots and will colonize the underground even more efficiently than the precedent crop. For the soil organisms, life and death is so closely related that there is no way to set them apart without disrupting the equilibrium of this complex organism.

PARSLEY
In permanent beds with chives and climbing beans, intercropped with permanent beds of tomatoes, to avoid having a big surface with a monoculture.

The parsley beds are separated from each other by permanent beds of tomatoes with garlic and bush beans, like soya, mung, etc. Flowers like Marigolds, Calendulas and others should also be part of the vegetation in these bands, their presence protective to the crop.

Parsley is a biennial plant, it goes to seed on the 2nd year of growth, so we are going to manage this crop taking this into account, taking advantage of this characteristic.

YEAR 1: Out of all the beds reserved for parsley we are only sowing half of them. Mulch is not put in this beds or living cover. The seeds are mixed with sand (1 to 2) and scattered over the whole surface of the beds. If the beds have been prepared ahead of time, mulch should be covering them till sowing time when the mulch is to be removed: parsley seeds are small and mulch would impair germination. At the edges, we install climbing beans in pockets, 2 meter apart from each other. These beans can be trellised over the parsley beds, and provide shade (besides nitrogen) to this crop benefitting from coolness. The beans can be perennial; if they are annual the sowing place can be changed but always in the border of the bed.

Parsley will be getting into production by summer and if it can be watered, it will go on giving yields all through the dry season till the following spring when it will flower.

The other half of the beds reserved for parsley to be sowed the 2nd year, can be occupied the 1st year with any annual bean crop that we choose. If the soil is poor and/or covered with "weeds", we can install a green manure crop of sunhemp.

YEAR 2: While the beds having Year 1 parsley goes to flowering, the ones having the green manure are being prepared for sowing.

The sunhemp green manure should have been slashed at the time the plants were flowering, in any case, before seeds would mature so as to prevent reseeding, and left over the soil as mulch. This mulch gets pushed aside and without tilling, just raking the surface, we sow parsley in these beds as we did the others the year before, the seeds are pressed down and covered just a little.

By summer time, these beds will be in production while Year 1 ones will be settling to seed. At the end of summer, or as soon as the seeds are "ripe": we can reseed the same beds with their own seeds.

To do this: cut the seed heads and shake them over the beds. There will be many more seeds in the old plants that you will need for reseeding, this can be harvested and commercialise them as seeds for sowing or for sprouting as food.

All the old plants are to be cut as low as possible, and left as mulch over the beds. If they get watered, the seeds will sprout very quickly and by winter those beds will again get into production. If they don't get watered and the dry season is under way, they will only sprout the following year, with the rains.

YEAR 3: Production will be in the Year 1 beds, while Year 2 beds will be going to seed.

So, from Year 1, there always will be one half of the beds (for parsley) in production while the other half is going to seed, with overlapping of yields at some times.

Parsley is a crop difficult to sow, but when one allowed self-sowing in its own mulch, the plant thrives, and not only do we economise all the time and effort of again and again preparing the ground for the crop, with this system the seeds are obtained for free and they can even bring some extra cash from selling the surplus.

There are different types of parsley, you can establish them in different beds, just make sure you are not sowing hybrids the 1st time!
In company with the parsley, at the edge of the beds, chives in a zig-zag way can be put: 40cm apart in the line. This plant is a perennial, its presence works as a repellent to potential parasites to parsley. Chives can be dried and sold as a culinary herb.

Since these beds are permanent, we can install permanent trellises for the climbing beans. Arcs can be made out of construction iron rods (rebar), or out of bamboo. In any case, the foliage should be guided so that plants won't cover the ground, we want them to stay off the parsley and high up giving shade.

The other beds intercropped with tomatoes, have as well a permanent production of annual plants. We put the tomatoes at 60cm from each other in zigzag also with poles so that the tomatoes stay off the ground and are easy to pick, in a mulch covered bed or with living cover all over it. Garlic is interplanted at the edges in a zigzag manner and the bush beans in between spaces of the tomato plants, the Calendulas, Marigolds and whatever other flowers: in the very centre of the bed. At the end of the tomato season, all the plants including the flowers are cut, not pulled leaving all the root parts in the ground and the above ground parts as mulch all over the beds. (see drawing n.10)
At the next rainy season, if you notice many flower seedlings you can wait till they are big enough to transplant them to any other field or edge of hedge. The tomatoes the 2nd year get planted in the same bed where the beans used to be and the beans where the tomatoes were... year after year. Weeds may be present during the first 3 years of establishing the beds but this is an evolving system so as the years pass, the weeding decreases till there is only the plants that we have chosen with perhaps, some volunteers compatible with the crops.

**COTTON CROP:**
Intercropping with bush beans in a field with permanent ridges & living cover. To get the field ready we start with a green manure crop of sunhemp (Crotolaria ochroleuca) this plant not only will enrich the fertility of the soil but it will suppress the weeds and soil parasites, like nematodes, the sunhemp is left till the plant flowers at which point it is slashed leaving the soil undisturbed, so that the roots decompose within the soil, while the aerial biomass protects the ground as a surface compost-mulch, this is left all through the dry season. The following year as soon as the soil can be worked out with the hoe, the animals or the tractor, ridges are made in rows 1m apart-and as high as the soil and/or implement allows it. Immediately after or during this operation, the nitrogen fixing, low type of living cover plant is sowed over the whole surface of the field. The number of rows for the cotton crop and the bush bean crop have to be equal, since the following year we will change the places for the 2 crops, this way the cotton will be benefiting from the enriched soil left by the bean crop. (see drawing 11)
But other widths are just as possible. The spacing of the cotton plants: one every 50cm in the line and for the beans every 25cm in zigzag, we only use the bush type ones, as we don't want this crop to cover excessively the soil, killing the living cover. The constant presence of the low height plant maintains the ridges and passages protected and fertilised, this continuity is more beneficial to the system than: On and Offs- of rows of organic matter from big bean plants but the soil in the bands where the cotton was left unprotected and unfertilised after the cotton harvest.

Among the many choices for bush beans we can put soya beans, or mung beans etc. We can even put each year a different type. Or put different types on different bands. If the spacing of 1 seed each 25cm is too close together for some varieties a less crowded sowing can be done but always on top of the ridge, leaving the space between the ridges as a passage for walking or having the animals/machines circulating. This way, although that soil will get a bit compacted the ridges will remain with a good, loose, crumby soil structure.

At harvest time, leave all the plant left over after harvest, slashed, as mulch, covering the ridges. Same thing for the bean plants. The following year, the cotton is sowed in the ridges covered with the bean mulch and the beans on the ridges where the cotton plants where, if the living cover is missing in places, reseed these spots, by just broadcasting the seeds over the naked spots and pressing down the seeds. If after some years the ridges flatten, they may need again to be reshaped, or by then, the soil structure may be so crumbly that ridges won't be any longer necessary.

Organic cotton grown in a holistic way is in great demand by consumers aware of the health problems that people and the planet suffer from chemical, conventional agriculture. Organic cotton can be commercialised through the international network of organic agriculture, paying a higher price for the crop.

In the hedge surrounding the cotton field, install as well a great diversity of insecticidal plants, as in the hedge for root crops.

THE VEGETABLE GARDEN

In the home garden we can grow food in a very intensive way. The size and the type of beds that we choose have to be decided before doing anything.

For a zero tilling garden, raised beds or sunken beds are a must. If we are in heavy clay soils, it is better to install raised beds, protecting the sides with stones or any other way that will prevent the excessive drying out of the raised bed soil. For sandy soils, sunken beds are more appropriate, and the big labour to set them up pays back in the long run. In either case, the initial work is the same.

In sloping ground, marking the contour lines and setting the beds parallel to the contour.

The shape... it is up to you to decide but remember harvest time, I visited once a big garden, a big spiral, to get to the centre one had to walk around and around...helpers at the garden were taking short cuts, stepping anywhere and everywhere on the beds. So whatever shape you choose don't ever sacrifice the practical to the ornamental, reconciling both is the challenge.

With sunken beds it is hard enough to dig them as a rectangle, so any other shape would be adding extra pain to suffering...

Remember to leave at least 1 meter wide for the hedge all around the vegetable garden. If the space allows it, make it wider, the hedge protects the vegetables from the wind, increasing yields, moisture is prevented from evaporating, plants are not suffering from stress besides, all the mulch material that these spaces can provide.

Once the hedge surface is established, indicate with sticks where the beds are going to be put, they shouldn't be any narrower than 1 meter or wider than 1m20, the width of the paths at least 50cm, wider if you are using a tractor or animals.

Once you have all the garden space organised, take bands of 2 meter wide and as long as the garden; and remove the top soil. Depending on the quality of the soil, you can dig out 30cm or more down. Put all this soil to the side and begin digging where the beds will be, if they are going to be raised beds:

you only need to loosen up, open up the deep soil (adding up some compost if you have any) and putting back the top soil ONLY where the beds are going to be. The paths are left lowered to the less fertile, deep soil level, this helps to keep the paths without spontaneous plants growing, eliminating the ulterior work of weeding them. To prevent the drying of the sides of the raised beds, we either protect the sides with flat stones or we sow (only on the sides) a living cover, a legume plant of a very low height, like the ones used in the field crops, the paths can also be sowed with this plant. As the beds are finished cover them up with mulch.
If the beds are going to be sunken, then all the deep soil is to be taken out another 60cm further down. This soil is kept apart from the good, top soil. Once the trenches are open (if the beds are going to be long, we can proceed by 2 meters at a time) we put inside at the sides and bottom, recycled bags (synthetic weaved type) opened up, this will help preventing the quick passing of water to the sand. We relate to the trench as if it was a compost pit.... putting layers of mixed organic materials: at the very bottom, rough fibrous type like stems of sunflowers, or sorghum or maize or elephant grass etc. We can also get rid of cardboard, newspapers, old cotton clothes and/or woollen ones, after this: one layer of deep soil and if we have a compost toilet, the composted residues can also be added at this depth in the pit (or any other animal manure), on top of this layer, another layer of carbonaceous material, like straw, or stems of millet, etc. mixing layers of deep soil as the trench is being filled up. When you are about 30cm from the level of the path: put only compost and top soil, this way, you will be able to start using the beds immediately, without waiting for the heat to cool down from the composting going on before you start planting.

As the beds are made they get covered with mulch. And in the paths we spread whatever is left of the deep soil. If the beds are going to be watered, installing a drip system over the soil but under the mulch, will help to economise a lot of water, as there won't be any evaporation from a wet mulch, this economy will pay the expenses of buying the hose and save a lot of time, of work.

Once all the beds are done, regardless if they are raised or sunken, keeping them producing and in good health is maintained the same way.

If we start the garden with a very poor soil and we couldn't put compost, or composted manures, the 1st crops should be of plants not needing rich soils, like any type of beans and swiss chard, and the companion flowers : marigolds, calendulas and nasturtium.

As the soil in the beds gets to be "normal" for vegetable growing that is, rich in humus, you can then put all kinds of garden plants, since we want to maintain the production with the self-fertility of the soil and without force feeding it, we have to organize the plants in the beds in relation to what biomass they will be leaving after harvesting them, it is also a good strategy to avoid putting plants belonging to the same family exactly in the same place than they were at the previous crop, this is essential with the brassica family : the cabbages, and with the root crops where the soil was left without any roots.

The shape of the allium family plants: garlic, leaks and onions is very straight and narrow, which allows for putting them in many places intermixed with any other plants. Although it is reported that they may inhibit the nitrogen fixing capacity of bacteria associated with the legumes, in my experience I haven't noticed any negative effects, no matter how close they were to bean plants or peas, thus, the advantages of putting these plants all over, in my opinion, exceeds the whatever disadvantages they may incur.

Whenever you are putting plants or sowing in the beds, remember harvest time, organise their places in a way that harvesting will be easy. Many plants can be "milked", that is, you just pluck some leaves from them, usually the bigger external ones, or you cut them at a height that allows the whole plant to grow again, putting the plants close to the paths where it will be easy to "milk" them. This can be done with lettuces, some varieties are specifically appropriate for this type of harvesting, but even the regular kinds, respond well to this way of doing. Lettuces handled this way can give 2 or 3 crops before they bolt. When they do, let the plant go to flower, it will help attracting beneficial insects, and the shape of the lettuces will change, becoming tall and narrow, so in its vicinity you can transplant another lettuce.

By allowing spent plants to go to seed and reseed themselves a lot of work of starting plants in the nursery is eliminated, we can let the spontaneous seedlings grow where they are, or if that is not a good place like growing in the paths or to close together, they can then be transplanted as if started in the nursery.

Leeks can also be harvested several times by cutting them just at the level of the soil (under the mulch), by the 2nd year, (leeks are biennial) and, just before the plants would bolt and go to seed, you can harvest by pulling them, so as to finally eat the whole leek, but always leave selected plants to complete their growth cycle, thus seeds can be collected, this is essential in a sustainable garden : growing ones seeds.

If you end up with more flowers from leeks and onions that you need, these flowers are edible, just add them up to the salads, sauces or soups.

Cabbages can also be cut above the 2.4 bottom big leaves... they will regrow making several heads, and when they will go to seed, the stems are as delicious as asparagus... so letting plants to finish their life cycle is beneficial to the whole garden, not only by the insects that they attract but as well by the organic residues containing essential plant nutrients for recycling stimulating microbial activity in the soil, supplying ethylene precursor and restricting the rate of nitrification in soil. It is best to use mature plants as a source of organic amendments and return the residues to the soil surface.
In undisturbed soils, such as found under forests and grasslands, ethylene can be continually detected in the soil atmosphere, indicating that the Oxygen-Ethylene Cycle is operating efficiently. It is well established that in undisturbed ecosystems where there is a slow, balanced turnover of organic matter there is an efficient recycling of plant nutrients and soil borne plant diseases are unimportant. The ethylene precursor accumulates appreciably only in old, dead plant leaves... so let all your plants grow old in the garden, in the meantime you can go on sowing & transplanting new ones next to them, this way constantly the soil is kept occupied with plants of different ages while production is maintained non stop.

For synergy to happens, many elements must be present; the concept "resting the soil" by leaving it empty, is a human centred projection of how we rest, doing nothing...but the soil organism is a very different being, and the worst thing that we can do to it, is to clear all the vegetation leaving it empty: the more intensively the garden is managed, the better for the soil it will be, just as long as we respect the way the soil feeds itself.

To facilitate harvesting of produce, it is a good strategy not to scatter too much any particular crop. Even if you want to grow as many vegetables as possible, organize the beds for only 3 crops or 4 (besides permanent flowers and herbs) to be grown in each bed. (see drawing no. 12)
If you cannot water the vegetable garden you can only grow food during the rainy season, if it rains....but the soil in the garden has to be kept occupied with plants waiting for the next rains. Even if there wont be the intensive production that watering can give, the soil will remain fertile for whenever you can put again crops. In these gardens, always put some draught resistant leguminous plants like silver leaf (desmodium intortum, siratro); (macroptilium atropurpureum) cow peas; morama bean (Tyiosema esculentum); chick peas (cicer arietinum); cluster beans (cyc.mopsis tetragonoloba); pigeon pea (cajanus cajan): leaves of this tree are edible and stand frequent pruning giving lots of mulch material, cuttings should be done 75 cm from the ground to allow for quick regrowth.
FOOD FORESTS AND ORCHARDS

Forests, the home of trees, have very fertile soils, these soils are always covered, protected by litter: permanent mulch only getting disturbed by the occasional thumping or scratching done by animals, in these soils microorganisms thrive relating in an intensive dynamic way with fungi, roots and gasses.

The 1st thing to do if we want domesticated trees to be healthy and productive is to establish the same kind of soil, hosting the diverse and complex life community that "wild" forests soil have.

Fruits trees need a lot of nitrogen to bear quality fruit in sufficient quantities, this nitrogen has to be of the ammonium type (nitrate nitrogen may feed plants but has negative effects in soil and water table).

It has to be understood that nitrogen fixing plants, as long as they release nitrogen through their own living and dying process, will be giving ammonium nitrogen but if their biomass is incorporated, buried in the soil, there is going to be a reaction, precipitating a change and producing an excess of nitrate nitrogen. To avoid this is very easy: don't incorporate within the soil any green manure, imitate Nature: just leave it as decomposing litter, as mulch...choose nitrogen fixing plants that are perennials so as to avoid a massive, simultaneous death of roots in the soil.

In the orchards, we are going to manipulate the spontaneous vegetation and replace whatever grasses are growing there with a mixture of perennial nitrogen fixing plants intermixed with plants from other families,(excepting perennial grasses like the ones that are used in hedges).

If the soil is acidic, growing crucifers, like rape, colza, mustard, will be beneficial in modifying the pH of the soil towards alkaline (without adding lime that has negative effects in soil at the long term).

If the soil lacks organic matter, we can speed up the process of enriching it by growing a green manure of root crops. This roots are to be left to decompose within the soil, sugar or fodder beets, turnips, Japanese radishes (daikon), winter radishes are an example of plants that can be used for this purpose. The characteristics that we are looking for green manure nitrogen fixing plants are: roots should be occupying different soil horizons, including deep ones.

The aerial part very voluminous with quick regrowth and standing frequent cuttings, like:

- Pigeon pea, Cajanus cajan;
- Sunhemp, Crotolaria ochroleuca;
- Gliricidia sepium;
- Cluster beans, Cyamopsis tetragonoloba;
- Velvet beans;
- Calliandra calothyrsus;
- Annual sesbania, Sesbania bispinosa;
- Centrosema pubescens;
- Pueraria;
- Jackbean, Canavalia ensiformis;
- Swordbean, Canavalia gladiata;
- Lablab, Lablab purpureus;
- Morama bean, Tyiosema esculentum;
- Moth bean, Vigna aconitifolia;
- Rice bean, Vigna umbellata;
- Tarwi, Lupinus mutabilis (only in acidic soils);
- Tepary beans, Phaseolus acutifolius;
- Stylosanthes hamata; S. fruticosa; S. guianensis; S. humilis;
- Flemingia congesta;
- Desmodium rensonii; D. intortum; D. uncinatum;
- Silverleaf, Desmodium macrotyloma;
- Tephrosia vogelii;
- Calapo, Calopogonium mucunoides (high rainfall or watering);
- Glycine, Neonotonia wightii;
- Goats rue, Galega oriental is;
- Siratro, Macroptilium atropurpureum;
- Seca, Stylosanthes scabra;
- Crown vetch, Coronilla varia;
- Lespedeza bicolor; L. thunbergii;
Cassia sturtii;
Onobrychis sativa;
Trigonella foenum-graecum;
Vicia sativa;
"Serradelle", Ornithopus sativus;
Lotus corniculatus;
Etc.

Green manures are to be cut regularly, but once a year at the appropriate time, one has to stop to give time to the plants to complete their reproductive cycle: for perennials after flowering and going to seed their roots get nutrients; for annuals, to allow reseeding themselves and/or to collect their seeds at the end of their life.

After cutting the green manure, with the rake, all the biomass is distributed around the trees, paying attention not to touch the tree trunk with the mulch.

In sloping ground or drought sensitive areas it is convenient to design water collecting bunds around the trees or following the contour line of the field with a vetiver-swale system (without digging trenches). Aromatic plants, beehives and scratching chickens should be part of the permanent elements to keep the trees healthy and productive.

The trees should be placed very separated from each other if they have the same crown height. The more apart we put trees having the same shape and size the more light: carbon, will be reaching the foliar surface of the tree, without having to prune them. Trees can then develop their own true form, keep their leaves for an optimal photosynthesis function. Avoid the stress of the amputations known as "pruning", that become necessary to keep the trees from shading each other, growing deformed trying to reach to the light, when not enough space is given at planting time.

Pruning should be avoided as the stress and wounds provoked debilitate the tree and opens the door for infections, parasites and all kinds of problems. If the size of the tree is to be maintained low: don't wait for branches to go to wood to cut them; you can pinch off any new growth while still green if you know that it has to be removed. This type of handling the tree can cope with.

In between the great distances left between trees of similar volume, other smaller or taller trees, besides all kinds of other vegetation can be intermixed. But don't forget the need to manage the green manure cuts: and the bigger the surface to take care of, the more "in line" the different trees should be placed, maintenance work has to be made easy, not time consuming and exhausting to carry it out. We can have diversity and chaos while making it easy and financially viable. It is important to organise the food forest/orchard in such a way that reducing production and labour costs are a priority in the design.

THE HEDGE EFFECT
The more spaces that we can establish as windbreaks/living fences/hedges: the easier it will be for us the management of the crops growing in the fields.

If we are in a region when winds can be strong, it is a must to set windbreaks designed to protect the fields. When crops are exposed to desiccating winds, the stress that plants suffers takes a lot of energy from them, this is energy lost for the crop's yield. So, even if some space is "lost", in these forests-bands we gain in crop's quality and quantity as well as obtaining many products from them, besides the refuge that gives to predators and (small) wild life animals.

It is important to make the right selection of what plants and trees to place in these bands. The one most popular plant used in Southern Africa: Euphorbia tirucallii, although a good choice if only quick, strong growth is what is considered, it wouldn't be our choice as this plant cannot be used for mulch (the cuttings could regrow in the crops), and one of the priorities to consider when selecting plants, is their multifunction.

If the hedge is going to be as well a boundary for animals, the 1st. consideration when choosing the plants for this use will be vegetation with thorns to keep the animals in or out, and from this category, those plants that will have other functions, uses, as well: like firewood, wood for tool handles, roots not competing with neighbouring crops, bee fodder, medicinal uses, fodder for animals and mulch.

Among the choices for this type of vegetation we can put:
Erythrina abyssinica; Prickly pear;
Agave sesalana; Sisal;
Ziziphus mauritania Mucronata
Acacia karoo and many other acacias having thorns
Commiphora africana
Prosopis chilensis ameraria/P tomarugo/P africana
Trichantera argania spinosa
Trichantera gigaritea nacedero
Cassia spectabitis
Silerocarya birrea
Flemingia congesta
Balantites aegytiaca
Calliandra calophyrus
Centroesma pubexens
Leucaena leucocephala
Coreuxia edulis
Abiricidia sepium
Faidherbia albida

Acacia albida about 1 tree every 35m this tree is most helpful during droughts and dry seasons and Moringa oleifera, horse radish tree, Marango about 1 tree per hedge: its seeds can be used to clean drinking water and termites resistance plays like Melia azederoch, Azadiridita indica, Neem, Aloe granicola, Cassia siamea, Terminalia brownii.

For the inside hedges subdividing the field crops, the choice for the vegetation should be more towards plant giving a lot of quick biomass in short time, besides nitrogen fixing trees like sesbania sesan, and grandiflora etc. Pennisetum purpureum, Elephant grass: Panicum maximum, Guinea grass: Artplex canescens, Nummularia: Cynodon niemfiensis, Star grass: Eragrostis tremula, Bana grass: Vetiveria Zizanoises, vetiver: Anchopogon va-pier, guayanus grass: Pennisetum purpureum, Ricinus communis: castor oil plant. Drought resistant reeds; Desmodium rensonii and intortum Macrotyloma rhynchosia, silver leaf (siratro) Stylosanthes :guianensis/humilis/fruticosa/scabraca/harmata Mucuna pruriens ;Velvet beans Cyamopsis tetragonoloba=cluster beans: Crotolania ochroluca, sunhemp: Cajanus cajan, pigeon pea: Vigna unguiculata, cow pea: Sesbania bispinosa/grandiflora/sesban Shinus molle Tephrosia vogelii

FURTHER READING
The One Straw Revolution The Natural Way of Farming The Road back to Nature by Masanobu Fukuoka
An Agriculture Testament The Soil and Health by Sir Albert Howard
Biological Transmutations or any other book by C. L. Kervran
Grass productivity
Better grassland Sward
and/or any other book by Andre Voisin
Holistic Resource Management by Allan Savory
Secrets of the Living Soil by Dr. Alan Smith (article in the International PC. Journal n.39)
Permaculture ONE by David Holmgren & B. Mollison