

Before starting

The following sheets provide methods and technical instructions in order to perform high productivity of the vegetable garden.

The authors of these sheets do not possess the absolute truth, therefore the information provided has to be taken with discernment, be criticized, modified and adapted to every situation.

As the authors could only study a restricted number of topics and therefore create restricted number of sheets, namely on the vegetable garden, they encourage warmly the readers and users of these sheets to enlarge this collection by adding new leaflets to it.

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Reproducing vegetables, tuber and spices (1)

For some vegetables it is easy to re-use the seeds, for others it is more complicated. It is also known that certain family of vegetable could cross with each other causing alteration in the next generation by re-using the seeds. By collecting the seeds of hybrid cultivars (often named F1) unproductive plants will emerge from the seed, so it is not recommended to re-use these seeds. **Use always nice and healthy fruits from productive plant.**

Seeds which are easy to collect

Okra → Let some okra pods dry on the plant, harvest the pods when they turn color and begin to crack. Separate the seed and make them dry

Any type of bean → Let the pods dry on the plant, harvest them, separate the seeds and let them dry in the house.

Eggplant → Harvest a ripe eggplant (yellow or black depending on the type), let it stand at home 6 days and then separate the seed from the pulp, rub the seed between your hands in water to wash them. Dry them after washing.

Squash / Zucchini / Melon → Use a ripe squash/zucchini/melon, separate the seed from the flesh and make them dry at home.

Sweet potato → Cut vines on living plants, cut some small parts where new roots are coming and plant them

Yam → Use saved small tubers or cut part (fist size) of a big tuber showing small sprouts. Plant them

Chili / Pepe / Peperoni → If possible, let the vegetable ripe on the plant, harvest it, let it dry a little at home, separate the seeds and let them dry in the house. Another possibility is to harvest the fruits green and to make them ripe at home. Then follow the same steps as before.

Garlic → Use one clove of garlic and plant it. Garlic is a 2 seasons crop.

Ginger → Break sprouting ginger roots in part of the size of your thumb and plant them

Basil / Coriander / Parsley / Marjoram / Dill / Ganja → Let part of the plant/some plants flower. After flowering, check for seeds appearance. Let part of the plant carrying seed dry. When it is dry, collect the organ containing the seeds and make them dry at home. If the plant is not drying out on the field, cut the seed organs and make them dry at home. When these are dry, rub them softly with your finger in a ceramic grinder to collect the seeds.

Seeds which are middle hard to collect

Tomatoes → Take a ripe tomato, extract the seed and the pulp of the tomato. Put the seeds and the pulp in 3 cm of water in a PET bottle. Let the seeds rot inside for 2 days. After that, sieve the seeds and rub the seeds in a towel to remove the pulp attached to it. Then dry them.

Cucumber → Take a hard cucumber. Let it stay at home until it color turn slightly yellow. Then proceed similarly as for the tomatoes.

Radish → Let 10 radishes on the field. After some time, a huge branch will spread from each radish and will flower (This is not always the case, be patient). After flowering, when the branches turn brownish, cut it and dry it at home. When they are dried, shake the branches in a bucket to harvest the seeds

Reproducing vegetables, tuber and spices (2)

Seeds which hare very hard to collect

These plants require change of sunlight period in order to flower. Thus it is even not sure that these crops will flower in Ghana

Spinach: Do not harvest few plants and let them make flowering branches (this could take some time). Wait that seeds are formed on that branches. When the seeds become brownish and the branches begin to dry, cut tem and dry them at home. When they are dried, shake the branches in a bucket to harvest the seeds.

Carrots / Beetroots → Carrots/Beetroots need a seasonal break to flower. At harvesting time, spare some carrots/beetroots or buy some at the market. Bury them for some weeks in slightly humid sand. Watch regularly the buried carrots/beetroots that they not rot. After a while, the carrots/beetroots will begin to sprout. At this time, plant them in soil and let them flower. When the flowers come, process as explained above for the cabbage family.

Salad → Let some salads on the field to flower. After some time, a huge branch will spread from the middle of the salad and flower. After flowering, when the branches turn brownish, cut them and dry them at home. When they are dried, shake the branches in a bucket to harvest the seeds. The seeds are very small.

Onion → Store nice and healthy onions. Let them dry well in the house. Plant them again and let them flower. Let the flowering stems dry then cut and dry them at home. Shake the branches in a bucket to harvest the seeds.

Celery → During growing time, select 3-4 plants to keep for seed production. Let them grow powerfully and when they reached a good height, dig them out, cut the leaves out and place the root in slightly humid sand for a month. After this time, plant them in soil and let them flower. When the flower comes, process as explained above for the cabbage family

Raise the seeds in the nursery

Making a nursery

A nursery is a place where we sow some seeds to make seedlings. The nursery should shade the soil, protect the seedlings against wildlife and insects and provide good conditions (nutrient, water and temperature) for the early stage of the plants.

In order to make a good nursery, you should find a place protected from wind with a well drained soil (for that, sandy soil are good). The following step will guide you to the establishment of a long living nursery.

1. Define the area for the nursery with four sticks. 1 by 1 meter will give you the ability to produce around 50 seedling of big plants (cucumber, squash, zucchini, eggplant, cabbage) or around 150 seedlings of small plants (tomato, chili, beetroots, ...).
2. Loose the soil in the defined area with the appropriate tools (soso, hoe). Try not to mix the topsoil with the bottom soil. The soil should be thin without big aggregates.
3. Remove all stones and roots of the soil (use the rake if needed)
4. Incorporate organic residue (fine straw, palm chalk, saw dust) and organic fertilizer (compost, chicken or cow manure) with the appropriate tools (shovel, hoe, rake,...).
5. In order to avoid seedlings root disease and if the time allows it, wait 3-4 weeks that the fertilizer being dynamised in the soil.
6. Put wood sticks in the middle of the nursery to make a path. Never walk on the loosed soil !
7. Build a woody structure to support a roof of palm leaves
8. Close de sides of the nursery with many layers of fisherman net, burry the lower part in the soil. Cover the top with a roof of palm leaves.

Raising seedlings

NOT EVERY VEGETABLES NEED TO BE NURSED BEFORE PLANTING !

The following vegetable need to be nursed: Chili, peper, pepperoni, tomato, eggplant, any cabbage, celery, salad, onions from seeds, any tree.

The following vegetable could be nursed but could also be sown directly in rows: Cucumber, squash, melon, zucchini, beetroots, okra, basil, coriander, parsley and marjoram.

The following vegetable should not be nursed: Beans, spinach, carrots, sweet potato, yam, garlic, onion from small bulb, ginger, radish, dill and mulching beans.

In order to raise seedlings, small sowing lines have to be defined and identified with written mark (permanent marker on bamboo) with specie and variety. To raise seedlings, follow the following steps:

1. Draw a sowing line with your finger and put the written mark at the end of the line.
2. Sow vegetable seeds in the line. Each seed should be separated from each other with a distance of 5 times the size of the seed.
3. Cover the seeds with soil. The seed should be covered with a layer of soil of 2 times the size of the seed.
4. Proceed to another sowing row. Space between rows is 1 finger for small plant and 2 fingers for big plants Begin at step 1.
5. Finally, water the nursery carefully with small drop to avoid digging out the seeds.

Planting beds

A good and healthy soil is a prerequisite for a productive vegetable production. Soil will transport and retain water for the plant, free some nutriment for the plant and give air to the root for breathing. Soil in poor conditions will induce more diseases, reduce water and nutrient availability and its uptake. Thus, planting vegetables on planting beds where soil is enhanced is a necessity. Row cultivation will also allow irrigating the crops with drip tape.

Once the beds are made never step on them !

Prepare planting beds from raw soil

The following step will guide through the establishment of a planting bed.

1. Define the area for the planting bed with four sticks. The planting should be 80 cm width. The length should be at least 3 meter and maximum 15 meter long.
2. Loose the soil in the defined area with the appropriate tools (soso, hoe). Try not to mix the topsoil with the bottom soil. The soil should not be too thin and neither contains big aggregate.
3. Remove all stones and roots of the soil (use the rake if needed)
4. Mix to the soil 2 full shovels of organic residue per meter length (fine straw, palm chalk, saw dust) with the appropriate tools (shovel, hoe, rake,...).
5. Mix in soil 3 full shovels of organic fertilizer per meter length (compost, chicken or cow manure) with the appropriate tools (shovel, hoe, rake,...).
6. Level the planting bed.
7. Surround the planting bed with a colorful rope bind to stick at the edge of the beds.

A path of at least 40 cm width should be created between each planting bed.

Prepare planting beds from previous cultivated bed

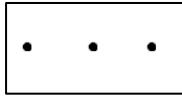
The following step will guide through the re-establishment of a already existing planting bed.

1. Weed the bed.
2. Check the soil structure. If the soil is loose, don't work on it. If the soil is hard with hard blocks, stone or roots, works on it.
3. If the soil is loose, skip this point. Loose the soil in the defined area with the appropriate tools (soso, hoe). Try not to mix the topsoil with the bottom soil. The soil should not be too thin and neither contains big aggregate.
4. If the soil is loose, skip this point. Remove all stones and roots of the soil (use the rake if needed)
5. Mix to the soil 2 full shovels of organic residue per meter length (fine straw, palm chalk, saw dust) with the appropriate tools (shovel, hoe, rake,...).
6. Mix in soil 2 full shovels of organic fertilizer per meter length (compost, chicken or cow manure) with the appropriate tools (shovel, hoe, rake,...).
7. Weed the edge of the bed and define it clearly (sticks, rope, stone, ...)

Plant seedling / sow seeds in the beds

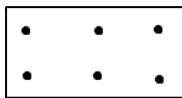
In order to set up straight lines of vegetables and allow a powerful irrigation and production, plant should be set as follow:

Beds of zucchini or squash contain only 1 row



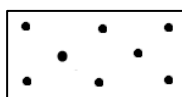
→ Set the plant/seedling the middle of the bed with 80 cm distance between each plants

Beds of yam, sweet potato, cucumber, eggplant, tomato, pepper and melon contain 2 rows



→ Set the plant/seed/vines in two rows at 20 cm from each side of the bed. There is 40 cm space between the two rows. Set the plant with 40 cm interval between each plant of the same line.

Beds with any other vegetable contain 3 rows



→ Set the plant/seed/vines in three rows at 25 cm from each side of the bed. There is 25 cm space between each of the three rows. Set the plant with 40 cm interval between each plant of the same line.

Plant association/intercropping

Like humankind, every crop has its strengths and weaknesses Therefore, association of different crops, called intercropping, could lead to positive interactions between plants. Disease spread will be reduced, and even protective effects could be observed. However, in some cases negatives effect, like pest attraction or disease hosting, could also be observed.

Making one line of one plant family (for example carrots) and another line on the same bed of another family (e.g. onions) is an efficient way to reduce the insect harms or disease spread. In the case of carrot and onion, the smell of onion will protect the carrots against insect bites.

For the intercropping and plant association, please refers to *Annex n°1*.

Crop rotation

As we are in a test phase and we don't know the exact composition of the future OPC vegetables garden, it is not possible to give a precise and definitive crop rotation. However we can give some important practices that should always be respected:

Never grow the same plant at the same place (See *Vegetable disease prevention 1&2*)

To avoid soil born diseases spreading, a temporal succession of crops from different families should occur on each bed. It means that at least two to three years should be waited before replanting a plant from the same family on a bed. The best is even to alternate plant families in order to minimise the risk of disease.

Knowing the different needs/properties of the plants

Some plants are known as "soil enhancer", meaning that they improve soil properties or through nutrients contribution (e.g. beans, see *Bean mulch* sheet) or chemical/physical soil properties enhancement. However others plants are also known as "suckers", meaning that they pull a lot of nutrients out of the soil and exhaust it (tomatoes, eggplants, cucumbers, beetroots, carrots, pepperoni, and sweet potato). By knowing that, try to avoid growing these high demanding plants successively and alternate their cultivation with less demanding crop.

Knowing the characteristics of the plants

Some vegetables are climbing (cucumber, squash, tomato...) whereas others are not (sweet potato, ginger, cabbage...). As the garden contains now specific structures for the climbing vegetables, always try to put these ones inside the structures and make a good rotation within it.

Let some time the beds to rest

To enable the soil to recover after the growing of high demanding plants, it is advised to let the soil recover for one week before planting the next crop. During this time you will prepare the soil for the next crop and fertilize it (See *Maintain soil fertility* sheet). For a positive effect of this measure, the soil has to be protected from the sun and kept moist. Thus always cover the bare soil with some mulch or palm leaves.

Knowing the growing time of the plants

Cultivation time differ between all vegetables. Thus, some crops can grow in less than three months (tomato, cucumber...) whereas others needs more time (sweet potato, ginger...). So, you should also adapt your planning according to the temporal need of each crop.

Composting (1)

Composting is a way to recycle and make available the nutrients of plants and organic waste. Its incorporation to the soil will enhance soil health and its properties (see *Maintain soil fertility* sheet). Therefore good compost is crucial in organic agriculture.

Material should be regularly added to keep it active and therefore create good compost.

Building a compost

To build the compost, follow these steps:

1. Find a flat place in shade and delimit the area with sticks. The compost size should be around 1 m² for 200 m² of gardening.
2. Take hard wood sticks to make a resistant compost structure. The structure should let pass some air but not allow compost or residues to fall out.
3. Fill the hole between wood sticks with palm leaves.
4. Separate the structure in two compartments with sticks

Building a compost juice collector

To build the juice collector, you first need one empty compost, and then follow these steps:

1. Buy metal sheet corresponding of the compost surface and a 10 liter bucket.
2. Buy a big pipe and wire netting (30 cm width) slightly bigger than the size the compost width.
3. Put few stones and wood on one side inside the compost and put the metal sheet on them. The metal sheet should be slightly curved to the inside and have a little slope.
4. Cut the pipe in half with the metal saw.
5. Insert the half pipe at the bottom of the metal sheet so that a small slope in the pipe occurs. The pipe should reach out the compost.
6. Cover the pipe with the wire netting so that it won't get stuck with compost
7. Dig a hole in the soil under the pipe exiting the compost and put the bucket inside.
8. Put 5 shovels of existing compost on the metal sheet and cover it with organic residue to start the compost.

Composting (2)

Feed the compost

The following material should be put into the compost:

Weeds	Old healthy plants	Organic food waste	Leaves
Fruits eaten by insect	Cassava peels	Eggs shell	

→ The softer the material the better.

The following material should NOT be put into the compost:

Palm leaves	Wood	Wood stick	Roots
Sick plants	Any kind of seeds	Decoction rests	Neem leaves
Lemon	Orange	Garlic	Onion
Any plastic			

→ The thicker and stronger the material the longer it takes to compost.

Maintain the compost

- Keep the compost humid in order to maintain composting process. Check regularly if the material is moist enough by returning the first layer and observing if the middle layer is still moist. Water the compost when it dries.
- Sometimes you can add some mulch beans with grasses to feed the compost.

Use compost

For the use of the compost itself or its juice, see the sheets *Maintain soil fertility* and *Planting beds* and *Fertilization and decoction system*.

Beans mulch (1)

As explained in the sheet *maintain soil fertility*, it is necessary to sustain the crops with nutrients. For that, beans are useful crops because they could fix nitrogen from the air. In order to make the fixed nitrogen available to the plant, whole green bean plants have to be incorporated to the soil. Thus, you can use them as soil cover or put them in the compost. More than enhancing soil fertility, beans bushes are known to attract vegetable pests. Therefore they will trap the insects which will feed on them and not on the vegetables. For the pest control, please refer to the sheet *alternative pest control*.

Which seeds to use

Any kind of bean will do the job. Try to use beans which make a lot of biomass (lot of leaves). Certain types of beans are climbing beans so you will need to put sticks that they could climb. Thus, we recommend you to use bush beans.

In our trials, we used the cheap (small) white beans bought on the market and this type gave good results.

In order to lower the cost, try to use cheap beans of smaller calibre and buy them in big quantity. However do not plant seed which show sign of disease because these ones could spread diseases to the beans we plant to eat.

How to sow the beans

As the beans take nitrogen from the air and that they won't produce any harvestable vegetable, these beans require minimal input/attention. Thus, you could sow them in poor soils, without tillage or fertilization. The only input needed is water, so try to water them time to time if possible.

The cultivation of mulch beans between two vegetables crops (see the sheet *crop rotation*) is beneficial. This will allow the soil to rest between two intensive cropping periods.

Use as pest trap and for mulching:

1. Find a place next to the vegetable production. This could be a empty bed, a empty space or the edge of the garden (see "fencing the garden" in the *alternative pest control*).
2. Take the hoe and make furrows of 3cm deep. The space between two furrow is 15cm
3. Sow 1 seed every 5 cm on the furrow then recover the seed with soil.

Use as mulch only:

1. Find a free space at any place of the land. This place does not need to be close to the garden. Plan the surface according to the mulching bean need and seeds availability.
2. Same as above
3. Same as above

Beans mulch (2)

How to mulch the beans

After some weeks, beans will be big enough to use. To mulch them follow steps below:

1. Pull out the bean plants with the roots and collect them.
2. Take the cutlass and chop them coarsely.
3. Spread the chopped beans in the target area.
 - a. Compost: put it on the compost and compact them softly
 - b. Surface mulch: spread them on the soil surface at the feet of the crops
 - c. Soil incorporation: incorporate 3 shovels of bean mulch per bed meter length

Maintain soil fertility (1)

Nutrients are crucial for the crops development. Nutrient deficiencies will decrease plant productivity and increase disease spreading. As the plants take their nutrients from the soil, maintenance of well-balanced soil fertility is an important part in the process of growing vegetables.

Compost

Compost is especially rich in nutrients as well as in organic matter. Therefore its incorporation to the soil will maintain and enhance soil fertility. Compost can be incorporated into the soil (1 to 2 shovels per bed meter length) before the planting of new crops. If manure is available try to mix 1 shovel of compost with 1 shovel of manure instead of using only one of the two fertilizers.

Manure

All manures contain a lot of useful nutrients for crops. Manure can be incorporated into the soil (1 to 2 shovels per bed meter length) before the planting of new crops. If compost is available try to mix 1 shovel of compost with 1 shovel of manure instead of using only one of the two fertilizers.

Compost juice and manure decoction

Contrarily to compost and manure which release nutrient slowly, compost juice or manure decoction will supply the plant quickly. Thus, when the crop is planted and you still want to fertilize your crops, compost or manure juice is very effective. Just collect the juice coming from the compost, sieve it and put it into the fertilization tank (See *Fertilization and decoction system* sheets).

For the manure decoction, soak 5 shovels of manures in 25 liters of water and let it rest for 24h. Then sieve the juice and put it into the fertilization tank (See *Fertilization and decoction system* sheets). Hence the growing plant will directly benefit from the given nutrients.

Organic matter material

Organic matter is crucial for vegetables growing and especially when sandy soils are dominant. Though compost or manure contain organic matter, other source of organic matter are available. Therefore palm shaft or any plant residues could be incorporated (1 shovel per bed meter length) to the soil in order to supply it with organic compounds. **Always** bring material rich in organic compound with compost or manure, otherwise opposite effect (nutrient immobilization) will occur.

Bean mulch (See *Bean mulch sheet*)

Beans are atmospheric nitrogen fixer. Thus they contain high amount of nitrogen, which we could use to fertilize our crop. Use either the green bean mulch as surface mulch or incorporate it in the soil. For the surface mulch, spread the mulch on the soil surface at the feet of the crops. For soil incorporation, incorporate 3 shovels of bean mulch per bed meter length.

Maintain soil fertility (2)

Bean cultivation in the crop rotation (See *Crop rotation sheet*)

Beans can be considered as natural fertilizer due to their capacity to fix N_2 from the air and bringing it to the soil. Moreover their roots/residues are very rich in nitrogen which will stay into the soil after the harvesting. Therefore beans should take a significant part of the crop rotation in order to enhance soil fertility.

No soil exhaustion

It is crucial to not work too intensively the soil in order to maintain its fertility. It means that after the incorporation of organic matter and fertilizers, the soil should not been worked anymore and have some time to rest. It will enable the microorganisms grow and release nutrients.

No soil compaction

Roots need air, nutrients and water. Thus, in order to have good air circulation and good access to water and nutrients, the soil should be loose. If the soil where you want to plant the crops is hard and compacted, always work on it to try to make it looser (see *Planting beds sheet*). After having loosed the soil, never cram the soil or step on it.

Maintain soil humidity

Soil humidity is crucial in order to let the crops have a good and constant access to water as well as for the microorganisms. Therefore maintain soil humidity is important for soil fertility. For this purpose never let the soil bare but rather cover it with mulch or leaves to maintain humidity into the soil. Provide irrigation when needed.

Maintain soil porosity

Clay particles can aggregate and form an impermeable crust surface on the soil. It will inhibit the penetration of air and water in the soil. Thus, regularly de-crust the soil surface with a cutlass. Do not go too deep in the soil with the cutlass not to wound or cut crop roots.

Vegetable disease prevention (1)

There are simple practices to prevent the development of diseases on vegetables. Here are some examples:

Lowest leaves and flowers removal

Leaves close to the soil are the older leaves, often humid and always splashed with water by the rain or the watering. This makes these leaves more susceptible to diseases. Thus, when the plant has at least 6 leaves you can remove some leaves close to the soil (10 to 20 cm to the soil). Try to always keep at least 4 healthy leaves on the plant. Similarly to the leaves, the lowest flowers are also important to remove as their future fruits are likely to touch the ground, be humid and splashed by water, making them also susceptible to diseases.

Crop rotation (See *crop rotation sheet*)

Diseases come often from the soil. Thus, in order not to “cultivate” the diseases by planting always the same plant in the same bed, a crop rotation should be implemented. The temporal rotation of crop will brake the host range of certain soil born disease making them disappear before bringing back it host on the bed. Therefore, the longer the interval between the plantation of a crop and its return on the bed the less soil born diseases will occur.

Thus, a temporal succession of crops from different families should occur on each bed. Examples of bad rotation are: 1) eggplant then tomato then potatoes 2) squash then cucumber then zucchini. Good examples of rotation are: 1) eggplant then beans then cucumber. 2) Squash then cabbage then beetroots.

By always rotating the family, it avoids the disease to continue to infect plants seasons after seasons.

Good pest management

Sucking insects such as aphids are important disease vectors. They carry mostly viruses and bacteria which infect plants when they bite them. By maintaining them away from the plant with repellent decoctions or alternative methods, it will prevent some disease spreading.

Tools and hand sanitation

Cutting tools, your own nails, hand or gloves could be vector of diseases. To avoid the spreading of bacterial, viral or fungal disease, you should wash your tools/gloves with bleach after pruning or harvesting **each plant**. The best procedure would be to have a container with bleach on the farm which you could carry along when working on the plants. After each manipulation soak quickly the tool in bleach then proceed to the next plant. Try not to use your hand as it is not healthy to bleach you hands.

As it is very tedious you can also decide to do that only after having touched the plants that are obviously sick.

Vegetable disease prevention (2)

Good water and nutrients supply

As for humans, plants are more susceptible to diseases when they are weak. It means that they need sufficient water and nutrients to be fit to fight diseases. Rigid leaves show good water supply when wilting leaves show drought stress or virus/bacterial disease. Greenness could be used as nitrogen indicator, thus dark green leaves show sufficient nitrogen supply while light green to yellow leaf coloration show lack of nitrogen. However, many other deficiencies or diseases could induce such symptoms. Therefore take these information with precaution.

Avoid harming or wounding plants

Wounds or cuts caused by mistreatment or natural cause are an opening for pathogen. Many diseases will start from these points. Thus, always handle carefully the plants to avoid any injury.

Keep plant dry

- **Hang up the climbing vegetables:** Hanging up these vegetables, the whole plant will be exposed to sun or wind which will avoid them to stay humid. A special attention should be paid to the fruits like cucumber, squash or melon which should always be hanged up and never lay on the ground.
- **Maintain good space between plants:** By having sufficient space between plants, it allows the air to circulate in the leaf space. This will therefore enable the plant to dry. Thus never plant vegetables too dense.

Recognise vegetables diseases

Besides insects, viruses, bacteria and fungi can also harm the vegetables. Viruses and bacteria are difficult to recognise and identify whereas fungi disease show some typical symptoms easier to identify. This is a non-exhaustive list of infections, containing only the diseases observed during our stay.

Bacterial infections

The most typical symptom of bacterial infection is leaf wilt. This means that the leaves are limp, weak and totally shriveled rather than standing straight. **Be careful:** this can be also the symptom of lack of water. To differentiate if it's a disease or a watering problem, look at the behaviour of the surroundings plants: if this is the only one suffering of wilting and the other around look healthy, it indicates most certainly a bacterial infection. To confirm this diagnostic, give some water to the concerned plant and observed its behaviour during the following hours. If the wilt symptom persists it means that bacteria have infected the plant. Most common affected vegetables are: cucumber, squash, melon, tomatoes, eggplant and green pepper

- ➔ Insects are the principal vectors of bacterial infections. By having a good pest management, risk of bacterial disease is reduced (See *Common pest control* sheet).

Virus infections

Virus infections are recognisable with different symptoms. Decolourations of certain part of the plant (mosaic viruses), necrosis or deformations of the leaves or flowers are typical symptoms of virus infections.

Most common affected vegetables: tomatoes, long beans, cucumber, zucchini and beetroots

- ➔ Insects are the principal vectors of bacterial infections. By having a good pest management, risk of bacterial disease is reduced (See *Common pest control* sheet).

Fungal infection

In contrary to virus and bacterial infection which show rather unclear symptoms, fungal infections are most of the time easier to assess. These are the most common fungal disease infecting vegetables and observed on the field:

Powdery mildew: white powder covering the leaves. Mostly infecting cucumber, squash or melon but also tomatoes, carrots...

- ➔ Fungi need humidity to develop and spread. By assuring that the leaves are well spaced, well ventilated and kept dry, most of the fungal disease will be avoided. Removing of leaves and flower close to the soil will also prevent fungal disease (See *Vegetable disease prevention* sheet).

Recognise the presence of vegetable pests

There are many insects on OPC land and there are some which will harm the vegetable we grow. The pest will decrease the yield by eating the root or the shoot of the plant but also by transmitting diseases to our crop. The vegetable pests could be identified with typical symptoms:

1. You can see the insects on the plants

Many insects eat the leaves and stay on it, especially beetles (yellowish ones are known to be very destructive) and grasshoppers. So when you go near the plants and you can see them, it means that they will destroy the plants → treatment is necessary

2. The leaves are eaten

That is the most typical symptom of the presence of vegetable pests. You can then observe some round holes on the leaves. Okra, watermelon, cucumbers and beans have soft and appetent leaves so they show often eaten symptoms. After a while, when most of the leaf surface is eaten, the leaf will turn orange/yellow and die.

3. Insects on and in the flowers

Sometimes the insects are not on the leaves but directly on or in the flower. The pests are eating flowers organs which will prevent the formation of the fruit. In this case you need to treat the plant immediately.

4. Insects/holes on the fruits

Insect can feed also directly on the fruits. In this case you will see them on the fruits. If the insects are feeding on the fruit, you need to treat the fruits or harvest the fruits and make it ripen at home to prevent further feeding.

Sometimes, pest do not feed on the surface of the fruit but penetrate it and feed themselves from the inside of the fruit. In that case, you will see some little holes on the fruits, where they penetrated it. → If you see holes and you suspect that an insect is inside, harvest directly and eat it quickly if possible.

Common disease control

Once you have noticed that the plants are sick and that you have recognised the nature of the disease, you need to treat it efficiently.

Bacteria and virus infections

Unfortunately there is no effective way to treat and heal a plant once it is infected with viruses or bacteria. Therefore the infected plant needs to be removed as quickly as possible:

1. Pull out the infected plant
2. Throw it away in the bush
3. Wash your hands/tools properly with soap/bleach

Be careful: never throw away an infected plant into the compost and never touch healthy plants after you have touched an infected one.

Fungal infection

When you have recognised an odium infection, follow these steps:

1. Pull out the old infected leaves
2. Throw it away into the bush
3. Prepare a **baking soda** mixture (see below) and apply it

Baking soda mixture

- 1) Fill 1/3 of soup spoon with baking soda
- 2) Dissolve it into 1 liter of water
- 3) Add ½ soup spoon of soap to dissolve properly the baking soda
- 4) Spray only the infected leaves

Be careful: respect very carefully the proportion of the mixture and only apply it to infected leaves, otherwise it can burn the plant tissues

Common pest control

How to control vegetable pests?

Once you have observed that insects are feeding on your vegetables (See *recognise the presence of vegetable pests*), you need to fight them. As we make organic farming, we use different decoctions made from natural ingredients. The main decoctions that we use are **garlic**, **chilli** and **neem** decoctions (see sheet *Prepare insect repellent decoctions* to prepare them). These three products, when applied on the vegetables plants to protect, have strong repellent effects against insect. Garlic and chilli can be used on every plants but chilli should be avoided on young plants.

Repellent effect last for days when it is not raining. After a rain, the decoction will be washed from the leaves, letting them unprotected again. Thus, spraying of decoction should occurs regularly (see when to spray below) and after a raining event. Application of repellent decoction will therefore be more often needed during rainy season than in dry season.

Concerning the budget of decoction, following budget should be allocated: 2-3 GHS garlic decoction, 3 GHS for chili decoction, 6 GHS for the onion garlic chili decoction and nothing for the neem decoction because leaves are free !

When to spray?

In order to have an efficient control, the decoctions need to be sprayed very regularly.

This is an example of a weekly schedule for rainy season:

Monday: prepare the chili decoction in the evening

Tuesday: spray the chili decoction

Wednesday: /

Thursday: prepare the garlic decoction in the evening

Friday: spray the garlic decoction and prepare neem decoction

Saturday: /

Sunday: spray the neem decoction

In dry season, 1 to 2 applications per week are sufficient. Be sure to change the decoction type at every application. The onion garlic chili decoction should not be used more than every 2 weeks.

To be efficient, the preparation should stay as long as possible on the leaves. **Therefore there is no spraying when it's raining or when it's likely to rain in the coming hours**

Prepare insect repellent decoctions (1)

There are many insects on OPC land and the following preparations repel them out of our vegetables. All the following instructions are calculated to fill the hand white spraying machine (5 liters, see *Use the hand spray machine (White Birchmeier)*), which is enough to spray the garden area, without the terraces (approximately 400 m²). To include the terraces, just double the quantity.

ALWAYS SIEVE WELL THE DECOCTIONS & ALWAYS RINCE THE SPRAYING MACHINE !

Decoctions (for 5 liters preparation)

Neem decoction

1. Take a full bucket of neem leaves from the neem tree to the farm. Bring black soap from home to the farm.
2. There chop the leaves with the grinding stone and put them in a bucket.
3. Add 4 liters of water and leave it for 2 days.
4. After this time, sieve two times the decoction (one time with coarse and one time with the thin sieve) to another bucket.
5. Pour the sieved decoction through the thin sieve into the spraying machine.
6. Dilute the equivalent of a tee spoon of black soap into 1 liter of water. Sieve it with the thin sieve to the spraying machine.
7. Pour the equivalent of a tee spoon of neem oil. If we have no more neem oil, then only use soap.
8. Shake the machine while always taking care to not damage or dirty the nozzle of the machine and the sprayer itself. The decoction is ready to spray.

This decoction should be used once a week on all plants during rainy season.

Garlic decoction

1. Grind with the hand mortar two bulbs of garlic (no need to peel it). DO NOT USE THE BLENDER.
2. Add the garlic in 2 liters of water.
3. Bring the preparation to boil and boil it for 5 minutes.
4. Grind a half bulb of garlic with one onion and put them in 1 liter of fresh water.
5. Let the two preparations (the one boiled and the one not boiled) separated and leave it for one night.
6. After the night, sieve two times the decoction (one time with coarse and one time with the thin sieve). Pour the sieved decoction through the thin sieve into the spraying machine.
7. Dilute the equivalent of a tee spoon of black soap into 1 liter of water. Sieve it with the thin sieve to the spraying machine
8. Add water in the spraying machine through the thin sieve to fill it up at 5 liters.
9. Shake the machine while always taking care to not damage or dirty the nozzle of the machine and the sprayer itself. The decoction is ready to spray.

This decoction should be used once a week on all plants.

Prepare insect repellent decoctions (2)

Chilli decoction

1. Buy three GHS of chilli powder.
2. Soak it into 2 liters of water for 12 hours.
3. Sieve two times the decoction (one time with coarse and one time with the thin sieve). Pour the sieved decoction through the thin sieve into the spraying machine.
4. Dilute the equivalent of a tee spoon of black soap into 1 liter of water. Sieve it with the thin sieve to the spraying machine
5. Add water in the spraying machine through a sieve to fill it up at 5 liters.
6. Shake the machine while always taking care to not damage or dirty the nozzle of the machine and the sprayer itself. The decoction is ready to spray.

This decoction should be used once a week but **only on adult plants**.

Onion garlic chilli decoction

1. Peel two big onions and two bulbs of garlic
2. Grind them with the hand mortar. DO NOT USE THE BLENDER.
3. Add the equivalent of 3 GHS of fresh chili pepper and grind them.
4. Put the grinded onions, garlic and chilli into a cloth and tie it. Verify that the cloth is sealed.
5. Soak it into 4 liters of water for 24 hours.
6. Squeeze the cloth and sieve two times the decoction (one time with coarse and one time with the thin sieve). Pour the sieved decoction through the thin sieve into the spraying machine.
7. Dilute the equivalent of a tee spoon of black soap into 1 liter of water. Sieve it with the thin sieve to the spraying machine.
8. Shake the machine while always taking care to not damage or dirty the nozzle of the machine and the sprayer itself. The decoction is ready to spray.

This decoction should be applied twice a month on all plants (when you apply it, don't apply during the same week the garlic decoction)

Comments (see *Use the hand spray machine (White Birchmeier)*)

All the preparations need to be sieved before they are used. Therefore when one decoction is ready to spray, take with you to the field a clean bag with the spraying machine and the sieves/cloth inside. Always sieve minimum two times before pouring it into the spraying machine and always have a sieve on the machine when you pour it.

IMPORTANT: after each use, the spraying machine needs to be washed with clean water as soon as possible. Therefore after the preparation application, first rinse out the machine with the farm water (make sure the water is as clean as possible). Then **bring the machine back home**, wash it well with clean water and spray out some water. After that, put the machine in the clean bag with the sieves/cloth to dry.

Use the hand spray machine (White Birchmeier)

ALWAYS SIEVE WELL THE DECOCTIONS & ALWAYS RINCE THE SPAYING MACHINE !

How to use the material

All the preparations need to be sieved before they are used. Therefore when one decoction is ready to spray, take with you to the field a clean bag with the spraying machine and the sieves/cloth inside. Always sieve minimum two times before pouring it into the spraying machine and always have a sieve on the machine when you pour it. Moreover the spraying nozzle should always be totally cleaned and should never touch the ground.

IMPORTANT: after each use, the spraying machine needs to be washed with clean water as soon as possible. Therefore after the preparation application, first rinse out the machine with the farm water (make sure the water is as clean as possible). Then **bring the machine back home**, wash it well with clean water and spray out some water. After that, put the machine in the clean bag with the sieves/cloth to dry.

How to spray

- For efficient use of the preparations, the sprayer should spread very small droplet in a homogenous fog. To ensure this, always pressurise the pump enough. At low pressure, the nozzle will spray a spurt rather than a nice fog.
- Always be sure to spray on and under the leaves. For that make some nice circles with the rubber pipe of the machine when spraying the decoctions.
- To be efficient, the preparation should stay as long as possible on the leaves. **Therefore there is no spraying when it's raining or when it's likely to rain in the coming hours.**

Alternative pest control

In addition to the elements described in the sheets *Common pest control* and *Prepare insect repellents*, there are further way to prevent/control insects.

Safety net

Working exactly as a mosquito net, this should prevent any insects or grasshoppers to reach the leaves and to eat them. However in order to be effective and prevent bacteria or virus vectors such as aphids, the net should be very tightly weaved (much more than a mosquito net). Moreover, UV resistant net has to be employed long lasting use. We recommend the nets from Andermatt Biocontrol firm.

Push pull system

This system involves two compounds: one supposed to repel the insects (“push”) and the other supposing attracting insects (“pull”). Considering the material available at OPC, we establish a trial push pull system consisting of citronella grasses at the end and inside the vegetables beds (push) and a natural fence of beans around the garden (pull). Citronella grasses are well known to have insect repellent effects whereas beans leaves are very soft and very appreciate by insects (See *Bean mulch* sheet). Moreover inside two beds we made some trials with the half bed covered with beans/mustard/beans and mustards and the other half bare soil as comparison. Result has not come yet.

Grow adapted species

The choice of plant is crucial for the fighting of insects. Some plants are more appreciated by pests than other (for example okras are especially targeted by grasshoppers when tomatoes are almost intact and ginger not touched). Therefore when choosing to grow some more susceptible plants, try to not plant them in high density and take specifically good care of them. If you want to reuse the seeds of the vegetables (See *Reproducing vegetables, tuber and spices* sheet), use the plants which seem to be the less attractive to pests.

Plants association/intercropping

As mentioned above, some plants are attractive to insects and some are repellent. Like humankind, every crop has its strengths and weaknesses Therefore, association of different crops, called intercropping, could lead to positive interactions between plants. Disease spread will be reduced, and even protective effects could be observed. However, in some cases negatives effect, like pest attraction or disease hosting, could also be observed.

Making one line of one plant family (for example carrots) and another line on the same bed of another family (e.g. onions) is an efficient way to reduce the insect harms or disease spread. In the case of carrot and onion, the smell of onion will protect the carrots against insect bites.

For the intercropping and plant association, please refers to *Annex n°1*.

Crop maintenance (1)

Crop maintenance is probably the most demanding and tedious part when having a vegetables garden. Nevertheless each following measure is crucial and has to be applied regularly in order to have a fruitful garden.

Binding climbing/standing vegetables

This concerns only the beds where wire structures are present, if needed, install wire structure on beds.

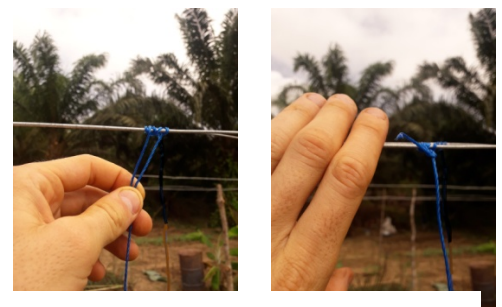
Many vegetables are climbing or need to be tied to stand vertical. In OPC garden it concerns tomatoes, cucumbers, eggplants, squashes and melons. In order to gain space and to avoid disease, it is very important to make them climb/stand and not letting them growing on the ground. When the vegetables are sufficiently high (cucumber, squash, pumpkin, melon: around 20 cm; tomato, eggplant, chilli: minimum 30 cm) this is the time to start to bind them:

1. Cut 20 cm of rope and attach it in a loop (Figure-eight loop or double knot) at the base of the vegetables. Be sure to let a thump space in the loop.



2. Take the tip of the rope and circle three times around the wire before making a double knot.

3. Pull the rope down until the base of your plant where you have the loop and cut the rope there.



4. Attach the long rope with a double knot to the loop.



5. Turn the plant around the rope to roll it up. The rope should always go under the leaves and support the plant.



→This is not a one time job! Each day watch your crop and roll up the growing tip.
Be gentle by the rolling to not harm them

Crop maintenance (2)

Pruning climbing/standing vegetables

Climbing/standing vegetables (tomatoes, cucumbers, eggplants, squashes and melons) are growing very quick and need to be pruned almost every day. The pruning is a technique to concentrate the energy of the plant on only few branches in order to have more fruits. Follow these instructions to prune climbing vegetables correctly. **Always follow hygiene measures for pruning.** These are exposed in the *Vegetable disease prevention* sheet.

Tomato: we want to keep only one main stem. Therefore watch every day the plant and remove all the side sprouts growing between the main stem and the leaves.

Eggplant: we want to keep only one or two main stem (depending on the variety and the space that you have left between the plants). Therefore watch every day the plant and remove all the side sprouts growing between the main stem and the leaves (or let just one if you want two main stem).

Moreover eggplants tend to make too quickly flowers. In order to have high productivity, remove the first flower.

Chilli: no need to prune them, they can make a nice bush and still be very productive.

Cucumber: let the cucumber grow and prune the first three appearing side stems. Then let it grow again until it has done 4 viable side stems. At this stage cut the main stem just above the 5th side stem. Let the 4 first side stems grow until you see a small cucumber on the node (see picture). Then cut the tip of these side stems. Let the 5th one growing as main stem.

Moreover as mentioned in the sheet *Vegetable disease prevention*, the lower leaves and flowers should always be removed because they are more susceptible to diseases and pests.



Squash and melon: no need to be pruned but take care to attach carefully the side stem

Watering (1)

Vegetables need to receive minimum every two days some water. In rainy season, the rain will naturally water them. However, in dry season, watering is needed. Normally the irrigation system will provide them the necessary water (see the sheet *Irrigation*). But if there is any technical problem with it, you have to irrigate the vegetables with the watering cans. In that case, follow these precautions:

- If the weather is very clear and dry, water every day preferably early in the morning or late in the afternoon. If the weather is grey with some rain during the night, give water every two-three days (check the soil to see if it is moist or dry).
- Give water to the soil and not to the leaves. Thus when the crops are still small, give water around the crop and not directly on it.
- Always stand next to the line that you are watering (especially when watering climbing vegetables). If you try to water the next line, you have more chance to harm the plants.

Crop maintenance (3)

Watering (2)

- Concerning the nursery, check the soil moisture and in case it looks dry, give only a bit of water.
- Be gentle with the watering can in order to not harm the plants.

Crop protection

Crop protection is a crucial and **daily work** to maintain healthy vegetables. Hence you should walk around the garden every day to check the fitness of the plants and see if there is any disease symptom. For more information see the sheets concerning *pest* and *disease prevention, recognition and control*.

Plan and plant new seedlings

The garden production should run constantly over the year. Therefore it is important to sow regularly new seeds to have continuously series of vegetables. For this matter, always check if you have enough seeds to continue the production. Moreover, as the plants which need to be nursed (See *Raise the seeds in the nursery & Plant seedling / sow seeds in the beds* sheets) need some time to reach the seedling stage, sow the seeds in advance before pulling out the previous crop. For the seed you sow directly in the bed (See *Raise the seeds in the nursery & Plant seedling / sow seeds in the beds* sheets), you don't need to plant anything else than having seed in reserve.

Harvesting

Harvesting is an important step in the crop maintenance. Some vegetables will give several times some fruits while other will give only one time a fruit. Moreover not all the vegetables will ripe at the same time. Therefore always watch closely the size and ripeness of the vegetables on the field (see the *Harvest vegetables* sheet).

Fertilization

In order to grow, crops need nutrients and that will be supplied through the fertilization. Therefore good soil fertilization (see the *Planting beds, Composting, Beans Mulch* and *Maintain soil fertility* sheets).

Mulching

Mulching plays a role in the crop fertilization as well as in water supply of the crop. Mulching can consist of random leaves or rest of plants to maintain soil humidity but can also serve as nutrients source (see the *Beans Mulch* sheet). Thus protecting the soil with mulch is always important to maintain healthy and productive crops.

Soil aeration

Because of the soil component, intensive sun and watering, a soil crust could be build on the top of the beds. In order to keep the air and water permeability of the soil (see *Planting bed* sheet), check in the bed soil and in case it is crusty, loose the first centimeter with the cutlass. Do not go too deep not to wound the plant roots.

Crop maintenance (4)

Observing daily and carefully the garden

As sensitive plants, vegetables can quick be destroyed. Therefore a daily control is required in order to check if anything goes wrong. For that matter go every day to each crop and observed the changes.

Harvest vegetables (1)

The harvesting is an important and grateful moment of growing vegetables. However there are certain elements that have to be known before harvesting them. The two first chapter define the type of harvest for each crop while the third chapter explain how to harvest them.

Vegetables that need to be matured to be harvested/eaten

- **Tomato:** the fruits should have reached their maximal growth before harvesting them. However tomatoes can still continue to ripe at home if you harvest them when they just begin to turn red.
- **Eggplant:** the fruits should be totally formed and coloured before harvesting them (the local eggplant can still be harvested light yellow and turn orange/red after).
- **Beans for seeds:** if you want to eat beans or to plant some new ones, they should be totally formed. It means that you should feel the beans inside all the pods. At this time stop the irrigation and let the pods drying on the plant (or even cut the plants and let the pods dry on it).
- **Peppe:** can be harvested green and eaten as such. However if you want to eat them red, wait until they reach this stage on the plant and then harvest them.
- **Melon:** the fruits become light green and a crack appears around the peduncle. In addition touch the fruits and verified that the opposite part to the peduncle is slightly soft.
- **Squash:** the squashes are ready to be harvested when the leaves are turning yellow and the peduncle is dry (sometimes the peduncle is even detaching itself naturally from the plant).
- **Garlic:** wait minimum four months (can even reach 9 months) and check that most of the leaves are in 2/3 yellow. It means that your garlic is ready.
- **Ginger:** wait minimum 4 months (usually 8 months until it is ready) and that the plant is yellow and dry.
- **Radish:** the radishes will grow out of the soil and are ready when they are as width as a beer capsule. Don't wait until a stem grow in the middle of the leaves.

Vegetables that can be harvested/eaten at any time (1)

These following vegetables are good to eat as soon as they are formed. However most of the time, the more you wait the more you will have to eat. But as soon as you see some pest lesions on them, you should directly harvest them to avoid them to spoil. It includes the following vegetables:

- **Okra:** when the size is satisfying.
- **Long beans:** when the size is satisfying.
- **Sweet potato:** six months after planting they are ready.
- **Basil / Coriander / Parsley / Marjoram / Dill / Ganja:** when they have grown until be a small bush.
- **Cucumber:** when the size is satisfying
- **Cabbage:** press the upper surface. When it's hard and the size is sufficiently big, harvest it.
- **Carrots:** dig up around the collar to check if the carrot as a sufficient diameter.
- **Salad:** when the size is satisfying.

Harvest vegetables (2)

Vegetables that can be harvested/eaten at any time (2)

- **Onion:** for spring onion, the sprouts should be big enough. For the classical onion, when the bulb is big enough. Let them dry on the sun if it's not raining. By rainy time, dry the at home.
- **Celery:** when the stems are as large as thumb.
- **Beetroots:** when the fruit has approximately the size of a fist.

How to harvest them

As for pruning, disease could be spread through crop harvest. Therefore **always follow hygiene measures for harvesting**. These are exposed in the *Vegetable disease prevention* sheet.

- **Tomato, eggplant, peppe, melon, squash, cucumber***: with a knife cut at the upper tip of the peduncle.
- **Garlic:** dig up carefully the garlic with the cutlass and let them (leaves and bulbs) dry on the field for two-three days if it's not rainy time. If the sun is strongly shining, cover the bulbs with the leaves of the neighbouring garlic so that all bulbs are covered with leaves.
- **Ginger:** dig the rhizome carefully with a fork or a cutlass. Keep the sprouting part for replanting.
- **Radish:** pull them out of the soil with the leaves and keep them with the leaves until you eat them. You can eat the leaves in soup.
- **Okra***: with a knife cut at the upper tip of the peduncle.
- **Long beans***: cut the beans at the peduncle with a knife.
- **Sweet potato:** dig carefully the potatoes with a cutlass.
- **Basil / Coriander / Parsley / Marjoram / Dill / Ganja***: cut small leaves bunch. Take maximum half of the leaves
- **Cabbage, beetroot:** pull out the whole plant and cut the small roots.
- **Carrots** pull it out of the soil, use the leaves to make soup or salad.
- **Celery:** cut branches at the basis of the plant. Take maximum half of the branches.
- **Salad:** cut just above ground and pull out the roots

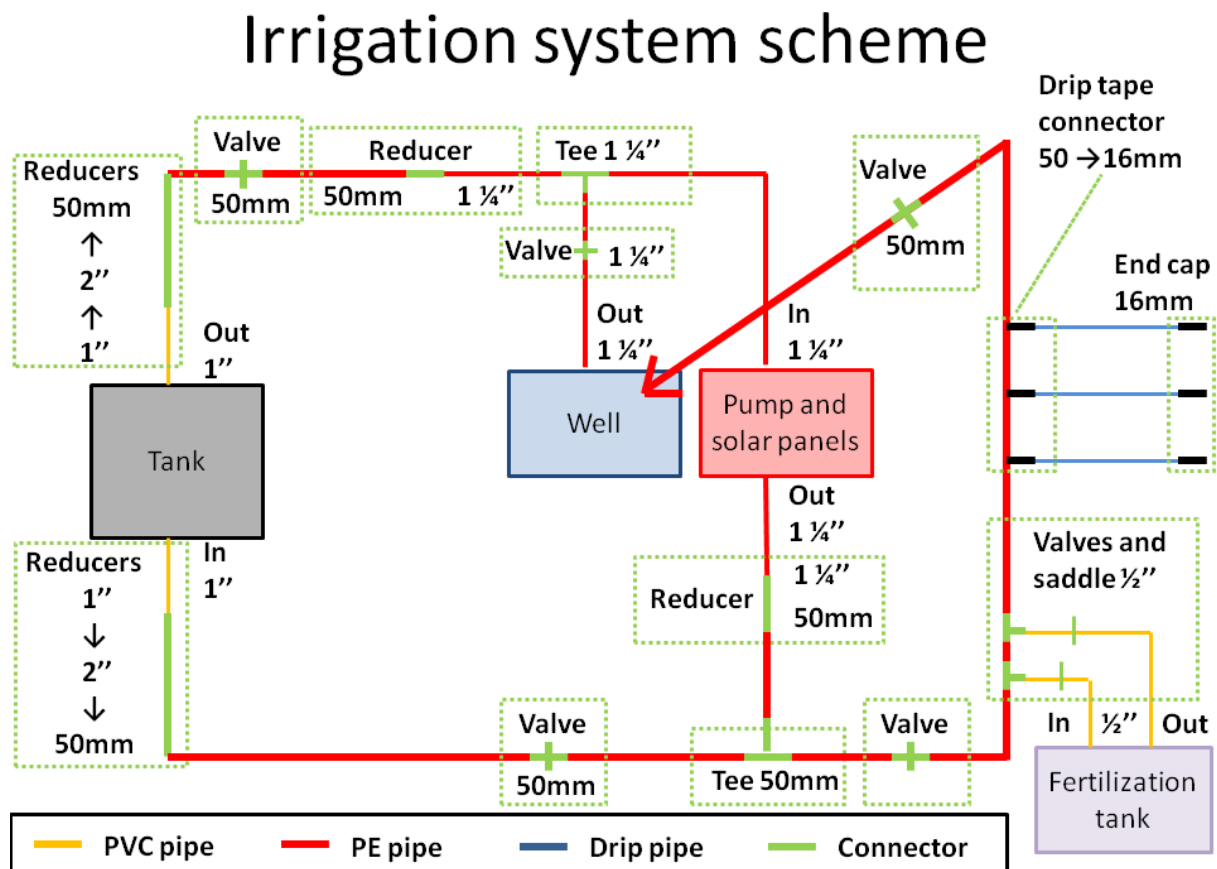
* These plants will produce several series of vegetables so don't cut the plants once you have harvested the first vegetables

Irrigation (1)

Pumping system

See the manual for the setting and use of the pump.

Actual piping system



Dripping system

- Drip installation
- End cap & tie
- Pressure
- connectors

Fertilization system

NOT YET FUNCTIONAL

A Companion Planting Chart

Some Natural Insect Repellant Tips

[illegible]

White Fly
Nasturtiums •
Basil: Use as spray

