PROJECT PERSEPHONE
PREPARED FOR THE GAIA FOUNDATION

By

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1 Permaculture and its use

Permaculture (permanent agriculture) is the conscious design and maintenance of agriculturally productive ecosystems that have the diversity, stability, and resilience of natural ecosystems. It is the harmonious integration of landscape and people providing their food, energy, shelter, and other material and non-material needs in a sustainable way.

The philosophy behind permaculture is one of working with, rather than against nature; of protracted and thoughtful observation rather than protracted and thoughtless action; of looking at systems in all their functions, rather than asking only one yield of them; and of allowing systems to demonstrate their own evolutions.

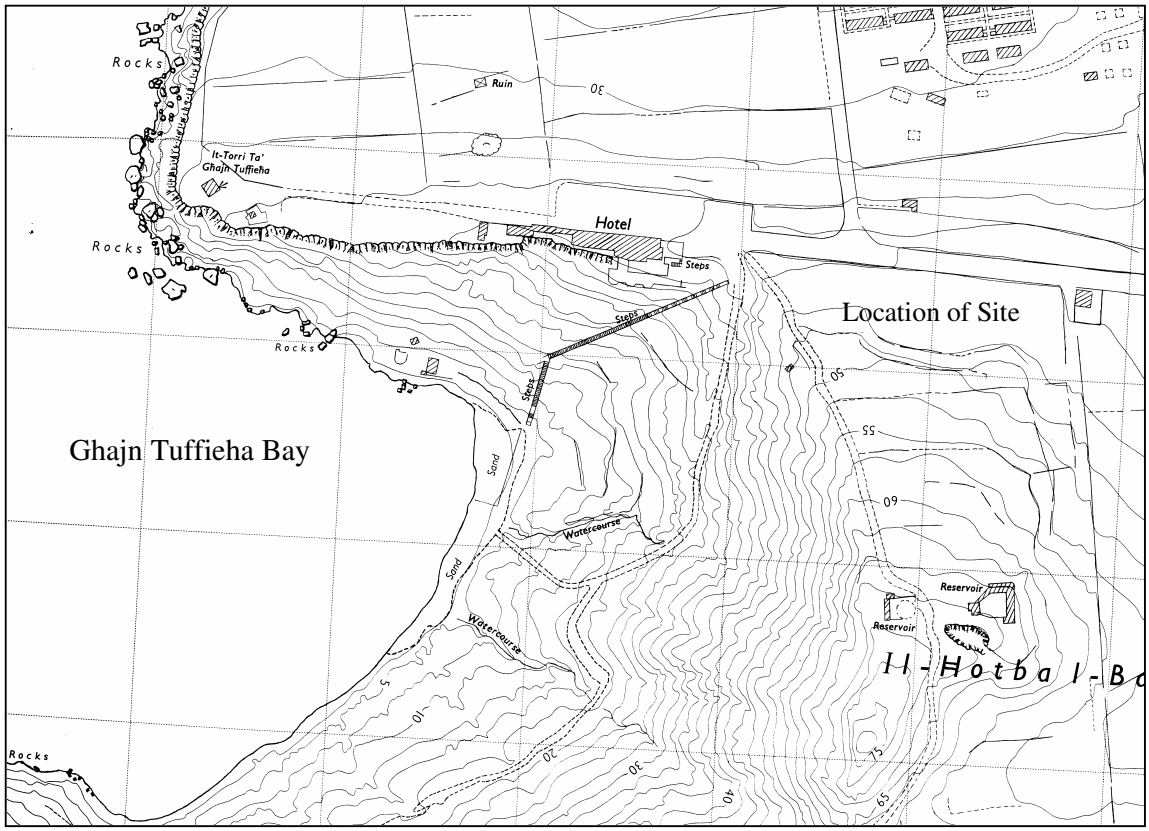
The aim of this project is to set up Malta's first sustainable agriculture experiment that will incorporate the principles of organic farming, permaculture and traditional farming methods. The project will serve to give a proven estimate of quality and yield of produce, which will include olives, honey, various fruit and vegetables, herbs and spices, and flowers.

2 Site description

2.1 Location

The site consists of an area of agricultural land located between the acacia grove at Hotba l-Bajda and the main road of Ghajn Tuffieha which leads to the car park (Map 1). It is found within the area scheduled by the Planning Authority as an AEI/SSI being under level 3 protection.

The area consists of three fields plus an area within the acacia stand that was cleared of trees. The fields cover a total surface area of 5.1 tumoli (0.56Ha). The first field (field A) is the largest having an area of 3.8 tumoli. The next two fields are smaller consisting of narrow terraced fields lying on slightly higher ground, to the south of field A. Field B has an area of 0.8 tumoli while field C covers 0.6 tumoli. The cleared up area within the acacia grove is of about 1.3 tumoli, which together with the three fields adds up to a total growing area of about 6½ tumuli (0.71Ha) (Map 2).



Map 1 – Map showing location of the site

2.2 Topography

The three fields lie in an east-west direction at an altitude of 40-55m above sea level. The lowest field being field A at 40m a.s.l., with field B being on slightly higher ground. Field C lies at the highest point at about 50m.

The fields are protected to the east by a grove of acacia, while to the south they are partly covered by the slope itself. To the west they are adjacent to a secondary road while to the north they are bounded by the main road leading to Ghajn Tuffieha and Golden Bay.

2.3 Soil

Maltese soils are characterised by their close similarity to the parent rock material, their relatively young age, the ineffectiveness of the climate in producing soil horizon development, and the great importance of human activities in modifying them. Three types of soil are recognised (Haslam *et al.,* 1977):

- **Terra soils** which are relict soils formed during the Pleistocene and which are little affected by the present climate.

- **Xerorendzinas**, and **Carbonate Raw Soils**, both of which are immature soils with a high calcium carbonate content and low in organic matter.

These soils are derived from calcareous rocks and generally have a pH slightly exceeding 8.0. In addition there are soil complexes formed through human agency.

The type soil in the three fields is similar, consisting of a xerorendzina, having a low organic content and a calcium carbonate level between 50 and 80 percent (Lang 1960).

2.4 Water resources

Presently there are very little water resources available in the area, except for a reservoir located at the nursery managed by The GAIA Foundation, next to Golden Bay. As a result every effort should be made to conserve water and reduce water loss by applying various water conservation measures (as mentioned later on).

2.5 Existing vegetation

As mentioned earlier, the site is surrounded by an acacia grove to the east and south of the fields. These are gradually being phased out to be replaced by native vegetation. Field B is partly occupied by a garigue dominated by wild thyme, whereas field C is devoid of vegetation (has been recently ploughed). Field A is also ploughed, however it is lined to the east, north and west by a row of pine trees (*Pinus halepensis* being planted at the edge of the field). Within the field there are also three rows of olive trees. These divide the field into four sections of equal surface area.

3 Climate of the Maltese Islands and its implications on productivity

The climate of the Maltese Islands is typical of the Mediterranean basin, having a characteristic biseasonality, with hot dry summers and mild, rainy winters. The average rainfall is 530mm of which 87.5% falls in winter (Chetcuti *et al.,* 1992). The summer experiences a drought that starts in April and continues until September. Dewfall is the only source of water most plants have during this dry period. When the annual potential evapotranspiration is considered, it is seen that it exceeds the mean annual precipitation by nearly 80%. This puts a great stress on the vegetation.

The air temperature never falls below zero and the climate is regarded as frost-free. However, in the case of grass temperature, there are several occasions, especially during January and February, when the temperature falls below zero and may cause damage to plants. The

Maltese climate is also characterised by the frequency and strength of its winds and it is only 7.7 percent of the days that do not have an appreciable air movement. The North-westerly wind, or *Majjistral,* is a stream of cool and dry air which blows very strongly, and it is the predominant wind of the Maltese islands in all seasons.

As a result of this distinct climate, the growing season will also be divided into two, the winter season and summer season. Plants grown in the winter season will need much less irrigation since they receive natural rain, however all plants grown in summer need to be irrigated, since there is very little rain falling at that time. Moreover plants growing in the spring/summer season are especially dependant on warm weather. An increase in temperature and in the lengthening of the photoperiod triggers the stimulation of growth.

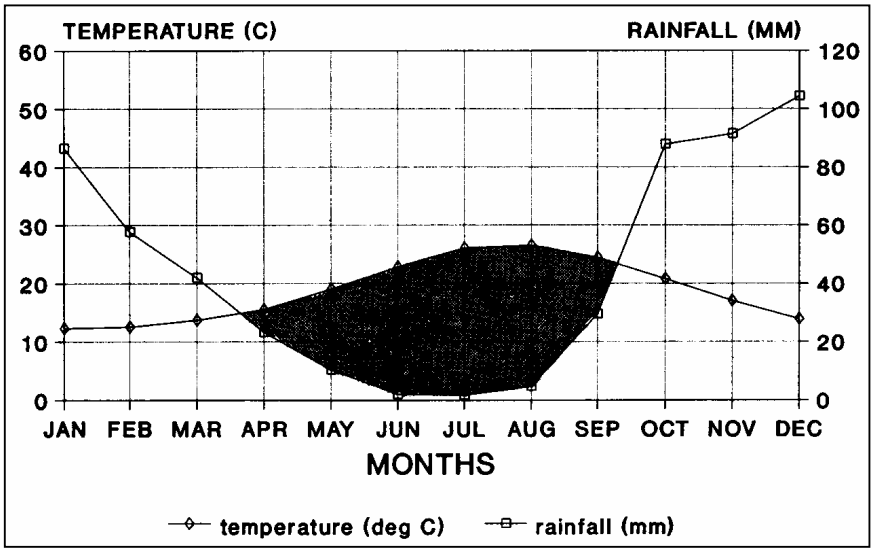


Fig 1 – Temperature and precipitation curve of the Maltese Islands. The shaded area represents the duration and intensity of the arid period (taken from Chetcuti et al. 1992).

4 Soil analysis

Eight samples were collected for the three fields. Four samples were taken from the first field (No 5-8), two for field B (No 3-4) and two for field C (1-2). Another two samples were also collected, this time consisting of compost from two different sources: mushroom compost and compost from San Antnin Recycling Plant. The results of the soil analysis are shown in table 1 below.

Soil sample N	Calcium and Magnesium mg/kg	Chloride mg/kg	Sodium mg/kg	Nitrogen %	Organic Matter %	pH	Phosphate mg/kg	Potassium mg/kg	Texture
1	364	113	92	0.12	2.92	7.5	12.89	212	Sandy loam
2	403	141	113	0.26	2.89	7.4	10.40	204	Sandy loam
3	268	113	87	0.13	3.12	7.2	4.16	258	Sandy loam
4	313	141	108	0.21	4.23	7.00	13.31	266	Loamy sand
5	377	283	206	0.20	3.09	7.3	7.90	416	Sandy clay loam
6	320	397	588	0.20	3.58	7.4	2.08	370	Loam
7	300	198	128	0.16	1.34	7.2	6.24	291	Sandy Loam
8	499	397	495	0.22	2.34	7.1	3.74	1041	Sandy loam
Mushroom compost	9088	3546	1443	1.27	5.47	7.0	126.82	6333	
Compost from San Antnin	19584	5673	2526	1.70	5.99	7.5	14.14	4458	

Table 1 – Results from the soil analysis

Using these data, the results were then pooled to give the mean for each field. Graphs were then plotted for each parameter in order to compare the results.

Source	Magnesium and Calcium mg/kg	Chloride mg/kg	Sodium, mg/kg	Nitrogen, %	Organic matter %	pH	Phosphate, mg/kg	Potassium, mg/kg
Field A	374	319	354	0.195	2.5875	7.25	4.99	530
Field B	291	127	97	0.17	3.675	7.1	8.735	262
Field C/D	384	127	103	0.19	2.905	7.45	11.645	208
Mushroom Compost	9088	3546	1443	1.27	5.47	7	126.82	6333
Compost from San Antnin	19584	5673	2525	1.7	5.99	7.5	14.14	4458

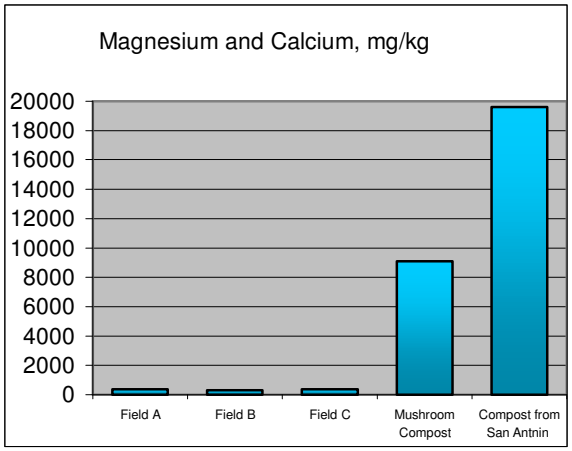
Table 2 – Pooled results for the various fields

The two composts used are purely organic composts that are widely available in Malta. The mushroom compost is available even in Gozo. The latter consists of the remains of the bedding material used to grow mushrooms on by the mushroom growing industry. This material is made of a mixture of straw irrigated by chicken manure, being finally covered (after 14 days) by a layer of imported compost having mushroom spores already inside it. Lime is also added to keep the pH high. Once the spores germinate, the mushrooms grow, thus composting the straw to give a reddish brown compost.

The compost obtained from Sant Antnin on the other hand, consists of composted vegetable and biodegradable wastes obtained from domestic waste. The waste material is first separated automatically at the recycling plant. The biodegradable waste is then composted using bacteria. The final result is a dark brown compost.

4.1 Magnesium and Calcium

Magnesium and Calcium are intermediate plant nutrients. Calcium is needed for the formation of flowers and fruits, while magnesium is essential for formation of chlorophyll. Magnesium is also important in activating many enzymes needed in photosynthesis, respiration, and formation of DNA and RNA. Tomatoes are

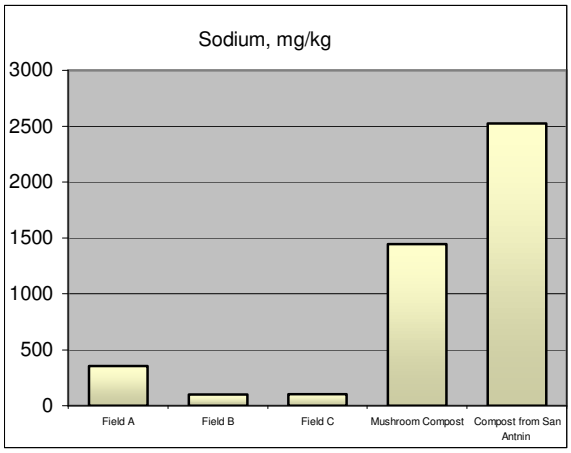


particularly vulnerable if Magnesium is not found in sufficient quantities.

Calcium and Magnesium are rarely limiting in soils. This is moreover the case in Maltese soils which are predominantly made of calcium carbonates. In the case of the two composts, the compost from Sant Antnin has a much higher level of Calcium and Magnesium than the mushroom compost.

4.2 Sodium

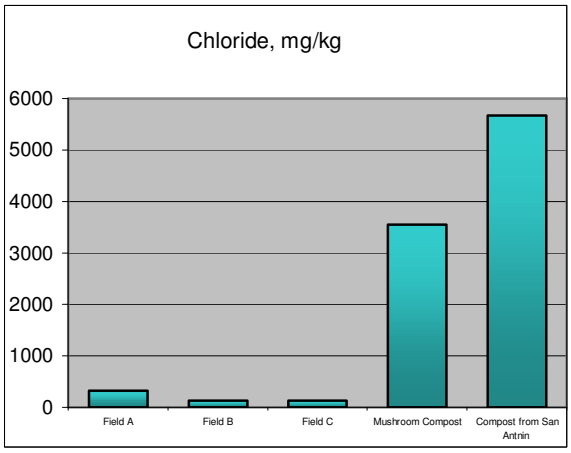
Sodium is an essential element only for C-4 plants (plants which germinate and grow during the summer months, such as *Dittrichia viscosa*). It is important for photosynthesis, in the metabolism of chloroplasts found in the mesophyll layer of the leaves. It is rarely absent in nature since it can be even carried by wind or through sea spray as salt (sodium chloride).



The level of sodium in these fields is low, however not low enough to create deficiencies in plants. In the case of the composts, the level of sodium in the compost from San Antnin is twice as high as that from the mushroom compost.

4.3 Chloride

Chlorine is an important trace element, being absorbed in plants as chloride. One function of chloride is to stimulate the split of water during photosynthesis, but it is also essential for roots and for cell division in leaves.

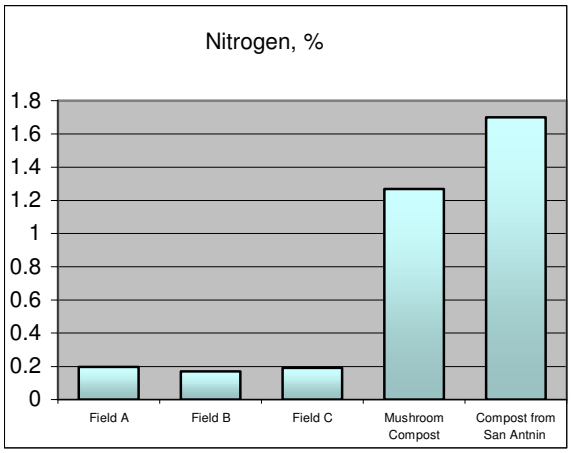


Chloride is rarely if ever deficient in nature because of its high solubility and availability in soils, and because it is also transported in dust or in tiny moisture droplets by wind and rain.

The amount of Chloride present in the soil can be used as an estimate of salinity. The soils of the fields that were tested were found not to be saline, however the compost was. The

mushroom compost was almost half as saline as the San Antnin compost. This makes it more favourable to use the mushroom compost since using the other regularly could lead to an increase in the salinity of the soil.

4.4 Nitrogen

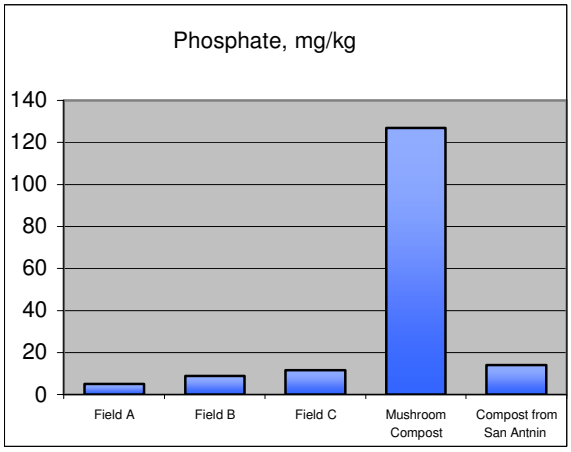


Nitrogen is a major plant nutrient. It is essential for all plants but especially for vegetables grown for their leaves, such as cabbage and lettuce.

Soils are more commonly deficient in nitrogen than any other element. This is also the case for Maltese soils. However too much nitrogen can also be detrimental. Potato plants grown with a lot of nitrogen show excess shoot growth with only small underground tubers. Excess nitrogen also causes tomato fruits to split as they ripen. Flowering and formation of seeds of several agricultural crops are also retarded by excess nitrogen.

Due to the above-mentioned reasons, the mushroom compost would be better since, even though it has 6 times more nitrogen than the soil in the three fields, it is less than what is present in the San Antnin compost. To further avoid an accumulation of nitrogen, the compost should not be applied more than once a year.

4.5 Phosphate



Phosphorus is a major plant nutrient. It is very important for the formation of roots. This is why young plants and root vegetables such as carrot have particularly high demand for phosphorus.

Second to nitrogen, phosphorous is most often the limiting element in soils. This is evident in field A. Field C however has a medium amount of phosphorous as compared to the other two (see also table 1).

In the case of excess phosphorous, root growth is often increased relative to shoot growth. This is in contrast to the effect of nitrogen which tends to slow down maturity. With excess phosphorous however maturity is accelerated.

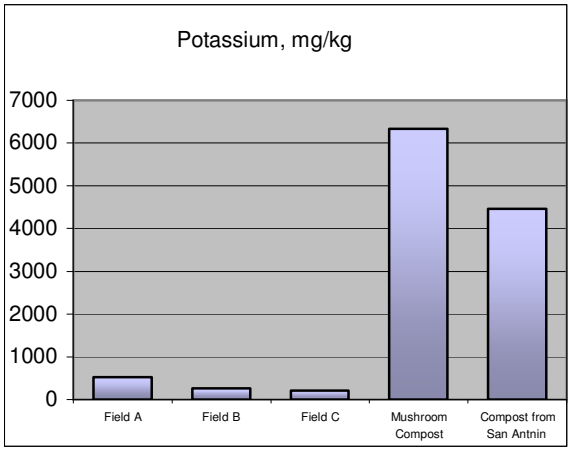
As a result, a high phosphorous concentration could be beneficial to the growth of vegetables. The high concentration will lead to the faster establishment of the seedlings through greater root development, and also to faster fruit production as a result of an accelerated maturity.

The higher concentration of phosphorous in mushroom compost (almost 10 times as much as the compost from San Antnin) leads to it being more useful in our case for growing vegetables than the other compost.

4.6 Potassium

Potassium is a major plant nutrient. It is one of the factors that affect flower and fruit formation. Potato is among the plants most in need of potassium.

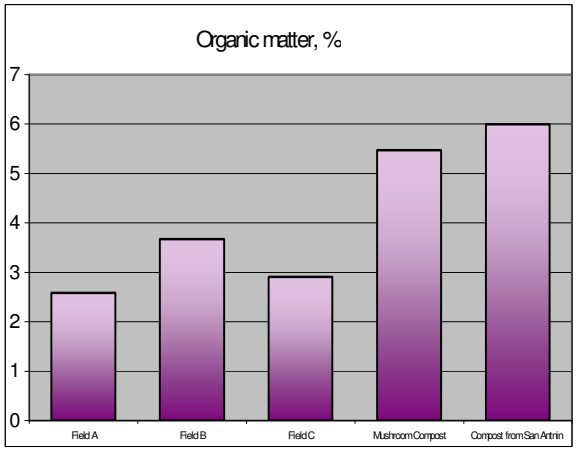
The soils checked from these three fields do not appear to be deficient in potassium. As in the case of phosphorous, the mushroom compost has a higher concentration of potassium. This however is not detrimental to plant growth.



4.7 Organic matter

The amount of organic matter determines the fertility of the soil. It is important for the soil structure, generally improving the aeration, and water and nutrient retention.

The organic content of these fields is typical of xerorendzinas, being over 2%, but still being lower than that of terra rossa soils (about 5%).



Field B has the highest organic content. This is explained by the presence of a garigue community growing along the field. The accumulation of dead plant material on the soil surface gives rise to the production of organic matter.

The organic content of the two composts is almost similar. Application of compost should be limited to fields A and C only. Field B should be left as it is since it will be used as a garigue for honey production (will be explained later on).

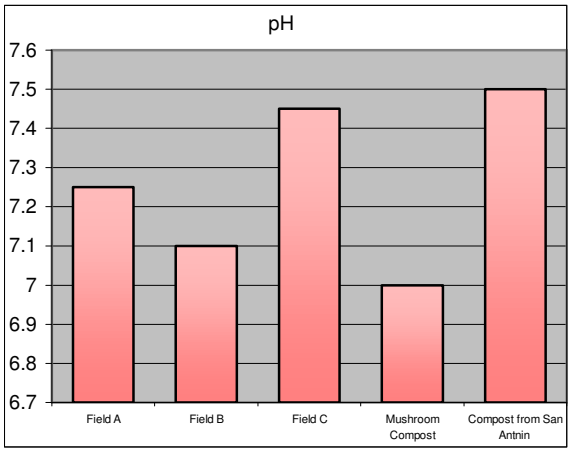
4.8 Texture

From tests carried out, the soils in the three fields were found to consist of a sandy loam. This means that they were predominantly a mixture of sand and silt. The implications of this is that they have good aeration, and they are also easy to work with machinery since the particles separate easily. However one big drawback of such soils is that they are faster draining and lose nutrients through leaching. The addition of compost on a yearly basis could reduce this problem.

4.9 pH

pH shows the acidity of the soil and determines the availability of different nutrients to the plants.

As a whole, both the soil samples and composts were found to have a neutral pH. This is an advantage since soils having a high pH (as usually is the case in Malta) result in an iron deficiency.



4.10 Choice of compost

After considering the results of the analysis for nutrients, and organic matter, we recommend the usage of the mushroom compost. The main advantages of using this compost instead of the compost from San Antnin is the lower salinity, and nitrogen content which otherwise could be detrimental to the development of the vegetables, and the higher phosphorous content. The latter is important especially since the compost from San Antnin only has a medium amount of phosphorous (almost the same amount as in field C). This would mean that other fertilizer would still have to be added in order to improve the concentration of phosphorous in the soil.

5 Allocation of the fields

These fields have been left unused for the last 6 years. As a result the surrounding walls have fallen out of neglect and soil has been lost due to runoff. Before anything can be planted, it is important that the walls are rebuilt. These will not only stabilize the soil, but also create a habitat for herbs to be planted underneath them.

5.1 Field A

Currently this field has four rows of olive trees running across it (see Map 2). This leads to the division of the field into five smaller areas of about 0.76 tumoli each. Once the trees grow, the growing area will be further reduced due to the shade left by the trees, so at the end a very small part of each section will have enough sunlight to sustain a high productivity. In order to have a high productivity, two of the rows of olive trees should be removed to reduce the area being shaded by the trees. As a result the field will be divided into three areas, one being small (~ 0.8 tumoli) and the other being larger and equal in area (~ 1.5 tumoli each). Two sets of three pomegranate trees will be planted in the middle of the two larger sections, one group in each field. This will give the sensation that the vegetables are grown in a circle around the trees.

These three sections are further divided into smaller sections. Field A1 will be divided into four, field A2 into eight, and field A3 into eight again (Map 3). These fields should be left for those vegetables that need more irrigation. Water is a problem here since there are no reservoirs close by, so to conserve water, only field A will be irrigated regularly.

Along the wall, just underneath field B, herbs will be planted. This site was chosen, since many herbs grow better in humid conditions, and since this wall is north facing, they will avoid being under direct sunlight for most of the day.

5.2 Field B

A considerable part of this field is already occupied by a garigue dominated by thyme (*Coridothymus capitatus*). The other part should also be planted with thyme together with other garigue plants such as rosemary (*Rosmarinus officinalis*) and origanum. The latter can also be used as a herb. Garigue species should be used since this area will not be irrigated, and these species survive well without watering.

5.3 Field C

Part of this field is in common with field B (the area shown by the brown thistles in photo 3). The common part will be used separately for growing vegetables that do not need irrigation. The area available is of 0.4 tumuli leaving another 0.4 tumuli in field C and 0.7 tumuli in field B (which encompasses all of the remaining garigue). This part will be called field D. Onions will be grown here since they do not like to be watered and they grow best under full sunlight (there are no trees here). The rest of field C will be used to grow avocados and apple trees.

5.4 Field E

This area consists of the open space of land just above field C that has been cleared of acacia trees. Due to the fact that it is well covered by trees, it will be used as a location for the beehives. The advantage of having bees here is that it is protected from the prevailing winds. Secondly it is away from the other fields, reducing the risk of the workers being stung by the bees. Moreover having bees here is not only good for the production of honey, but also to aid in pollination of the various vegetables and fruit trees that will be grown in the other adjacent fields. This will lead to an increase in fruit production. Apart from the bees, almonds, figs and vines will also be planted here (Map 4).

In the first few years until the trees grow, melons and watermelons can be planted here. Flowers and other herbs can also be planted in between the trees (see section 6.8), although not next to the vines since this could increase virus infection.

5.5 Preliminary stages

In order for the project to be a success it has to have a successful preliminary stage. There a few things that have to be done before any vegetables can be planted. Assuming that work can start in December, below is a list of priorities that could be tackled from December:

- Find a site for a possible reservoir or plan another means of supplying water to the area.
- Start restoring the rubble walls. These should be ready by the end of February.
- Remove the two rows of olive trees as shown in map 3. The trees whose graft has died could be used in afforestation elsewhere, whereas the ones with live grafts could be kept or transplanted to replace dead grafts.
- Plant cypress trees next to the pines in a herringbone pattern. The current pines are not enough as windbreakers. Another row is needed inside the rows of pines to close the gaps. The cypress trees chosen should be from the variety *"horizontalis"*. Both the cypresses and pines should be watered more heavily to increase their growth rate.

- Mushroom compost should be spread all over the surface of the fields and ploughed well using a tractor. The dosage should be a small truck for each of Fields A1, C and D, and two small trucks or a large truck each for fields A2 and A3.
- Plant the pomegranates in the middle of fields A2 and A3.
- Plant green manure at the end of December (use silla – *Hedysarum coronarum*)

In Mid-February plough the green fertilizer using a tractor and leave the fields fallow until March. In March start planting the spring/summer crop of vegetables, and all the other fruit trees. Plant the vines the following autumn.

If the fields are not ready yet by the beginning of March, start planting the vegetables in the Autumn season after soil solarization in summer.

6 Fruit trees and other fruits

There are some essential precursors to success in this endeavour, some of which are:

- Plant in relatively cool periods.
- Plant in a long swale (furrow) or in sloping pits to collect, absorb, and retain moisture.
- Plant a few legumes, or ground cover crop around the tree to cool the root area.
- Supply water as drip for one to two years, or until the tree root area is self-shaded.
- Supply mulch in quantity in pits near the plant and around its roots, or stone-mulch the tree root areas. The large pits act as night condensers, trapping cold night air and hence condensation.

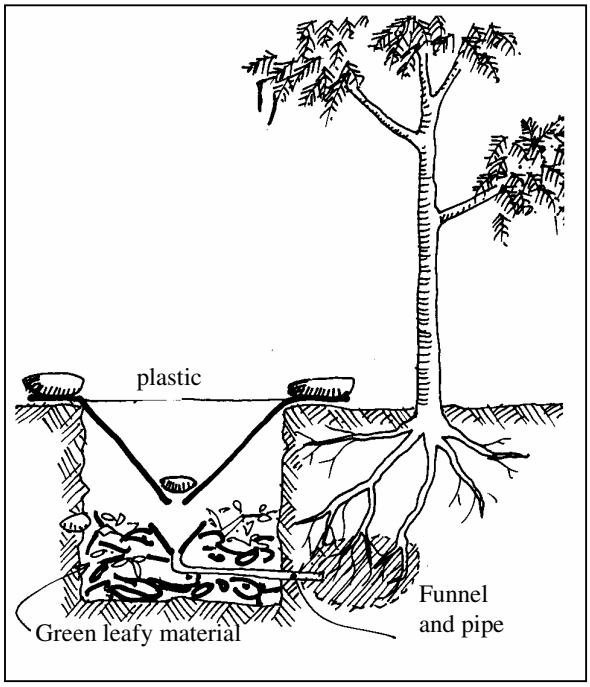


Fig 2 – Pit evaporation system. Green leaf material in a pit gives off water which condenses at night on the underside of a plastic cone, perforated at the center to allow rain through.

6.1 Olives

6.1.1 Selection of variety

The variety selection should be done not only with the criterion of yields but also with additional criteria such as:

- weather requirements and adaptation to the microclimate of the area;

- resistance to insect pests and pathogens, which occur in the area;
- nutrients and water requirements related to their availability in the area.

Regarding planting density, the later development and the final size of the trees should be taken into consideration to avoid phenomena of shadow, insufficient air movement, competition for water and nutrients, insufficient sun, difficulties to use machinery, especially for management of the floor of the fields. Spacing of the trees is particularly important for plant protection and the levels of insects and diseases in ecological fields.

6.1.2 Regulation of The Olive Tree Size

Regulation of olive tree size in ecological groves is done exclusively by pruning. Pruning of olive trees is done by removing old unnecessary wood.

In ecological farming, pruning is a vital cultural practice as it secures:

- regular fruiting and long productive life of the olive tree;
- olive tree adaptation to local conditions (temperature, humidity, sunlight and soil), a better balance between vegetation growth and flowering; besides regulating the alternate bearing of the trees;
- prevention of pests and diseases due to better aeration and easier control; water and humidity saving (as it reduces transpiration of foliage). This is essential because of the semi-arid conditions of the area and the long dry Mediterranean summer;
- regulation of the nutrient requirements of the trees;
- easier mechanical harvesting

6.1.3 Timing of Pruning

Pruning must be done every year in winter, to avoid the need for severe pruning, which creates alternate fruiting, excessively vigorous shoots, problems from extreme temperatures, and sun burns of trunks. It is important for pruning residues to be chopped and returned as organic material to the grove.

6.1.4 Shaping Pruning

This type of pruning aims at giving a shape to the olive trees that has nothing to do with the "nice appearance of the tree but with its sanitary conditions and regular fruiting. In agroclimatic conditions, the most preferable shape is the hemispherical one in which the olive trees have the shape of an open umbrella. In this shape excessively vigorous shoots are removed, provided that large open spaces will not be created in the canopy of the tree. In case that this happens, the shoots are cut at the top to create axial shoots.

- Fruiting pruning: Some trees have bumper crops on a biennial basis. For this reason the bearing of the trees is adjusted with a rather heavy biennial fruiting pruning. For example, in a heavy-cropped year, the trees are also pruned heavily, while in the next year they will be pruned less.
- Regenerative pruning: Applied when the trees are old or when frost or harsh climatic conditions damage them. As olive trees age, their capacity to produce productive shoots declines, and they should be rejuvenated to regain productivity. Even well spaced trees after many years shade out lower shoots and cause production to become confined to the top, which is difficult to harvest.

6.1.5 Advantages of permaculture in organic olive production

In ecological olive groves management of the grove floor is done by cover crops. They have a multi-functional role and contribute substantially to a rational and effective ecological management. Among the functions of cover crops in ecological olive groves, they include the following:

- nitrogen sources, when leguminous plants are included;
- improvement of nutrient cycling and preventing of soil-born pests and diseases by improving soil structure, promoting soil micro-organism activity and creating unfavourable environments in the top soil for pests;
- prevention of loss of the fertile top soil and of soil erosion;
- increased water absorbtion and storage efficiency by decreasing run-off;
- prevention and management of harmful plant species (weeds) through competition;
- stimulation and conservation of beneficial insects, parasites, vertebrates and birds by providing shelter and food, thus, contributing to the prevention of insect pests and pathogens;

6.1.6 Fertilization With Organic Materials

Fertilization with organic materials is done to provide the required nutrients to the soil and to provide the same positive effects that cover crops have on the soil.

Timing: Distribution of organic materials in the olive grove is done before sowing of the green manure plants early in autumn or winter (October-November or later, or depending on rainfall). It is important that the organic materials are ready for use early in autumn according to the fertilization program and their availability.

6.1.7 Monitoring the insect population (olive fly)

The most significant problem in the groves is the olive fly *(Bactocera oleae),* which infests the olives, resulting in quantitative and qualitative reduction of the production. Protection against olive flies in ecological olive production is done with mass trapping. In case of severe infestation, due to incorrect cultural practices, such as unbalanced fertilization (excess of nitrogen), irrigation (high humidity), or pruning (insufficient air circulation and sunlight), or adverse climatic conditions (high temperature and humidity), extra control measures should be taken. For example those measures may include bait sprays with hydrolyzed protein and insecticides like rotenone or pyrethrum.

6.1.8 Irrigation

Irrigation of ecological olive production systems aims at maintaining the physical and chemical soil conditions and the conservation of water resources. The irrigation period starts at the end of flowering and continues till the end of September depending on the weather. Water is applied every week or every fortnight depending on the weather. In case of insufficient rainfall in autumn and when high yield is expected the coming year, then winter watering is recommended for promoting flowering in spring. In all cases water applications must be related to pest population, especially of the olive fly, and potential damage. Irrigation should not create favourable conditions for fruit and tree infestation or the spreading of pests and diseases. Irrigation should be avoided during the appearance of a new pest generation, as observed by monitoring traps.

6.2 Almonds

The wild almond is one of the most resilient fruit trees found in the Maltese Islands. It is widely used as a rootstock for both sweet almond and for stone fruits (such as peaches and plums). It is not only hardy, but also drought resistant, and very well adapted to Maltese soils. The most important thing however is that any seeds used should be certified to be virus free. This can be done in cooperation with the Department of Agriculture which have a section within the Plant Health Division itself which has an ongoing program for testing stone fruit trees for viruses. Presence of viruses would lead to inferior fruit or even lower production.

Once the right source is found, seeds are collected in September and sown immediately. The one year old seedlings are then used as rootstocks and the sweet almond variety (also from a virus free source) is grafted onto it in December.

The almonds will be planted in section E together with the figs and vines (see Map 4). The trees will be planted at 4m intervals. This site was also chosen since almonds need to be planted in virus free soil in order not to get infected. Since the best way to reduce virus

incidence in the soil is by leaving it devoid of stone fruits for four years, this field should be virus free since it has been an acacia plantation for the last 25 years.

6.3 Figs

Figs are one of the most popular traditional summer fruits in the Maltese Islands. They are both easy to grow and require very little care. The secret is to have the right fruit varieties. There are four popular Maltese varieties as follows:

- Bajtar ta' San Gwann
- Tin
- Farkizzan
- Parsott

Their fruit mature at different times of the year, starting from the end of June, and lasting almost all summer.

The method of propagation is by first producing the rootstock by taking cuttings of the wild variety in January. The fruit producing variety is then grafted at a later stage. Note however that the female plant has to be grafted since both male and female trees exist, and grafting male trees by mistake would end up being "fruitless".

6.4 Apples

The traditional rootstock used for apples in the Maltese Islands is *Cydonia oblonga.* Cuttings could be obtained from Majjiesa itself. The chosen variety could be grafted at the end of January. The site chosen for the apple trees was field C, together with the avocados (see map 5).

6.5 Avocados

Origin: The avocado probably originated in southern Mexico but was cultivated from the Rio Grande to central Peru before the arrival of Europeans.

6.5.1 Description

Growth Habit: The avocado is a dense, evergreen tree, shedding many leaves in early spring. It is fast growing and can, with age, reach 25m, although usually less, and generally branches to form a broad tree. Growth is in frequent flushes during warm weather in warm regions with only one long flush per year in cooler areas. Injury to branches causes a secretion of dulcitol, a white, powdery sugar, at scars. Roots are coarse and greedy and will raise pavement if

planted close to buildings. Grafted plants normally produce fruit within one to two years compared to 8 - 20 years for seedlings.

Flowers: Avocado flowers appear in January - March before the first seasonal growth, in terminal panicles of 200 - 300 small yellow-green blooms. Each panicle will produce only one to three fruits. The flowers are perfect, but are either receptive to pollen in the morning and shed pollen the following afternoon (type A), or are receptive to pollen in the afternoon, and shed pollen the following morning (type B). About 5% of flowers are defective in form and sterile. Production is best with cross-pollination between types A and B. The flowers attract bees and hoverflies and pollination is usually good except during cool weather. Off-season blooms may appear during the year and often set fruit. Some cultivars bloom and set fruit in alternate years.

Fruits: The flesh of avocados is deep green near the skin, becoming yellowish nearer the single large, inedible ovoid seed. The flesh is hard when harvested but softens to a buttery texture. Wind-caused abrasion can scar the skin, forming cracks which extend into the flesh. Off-season fruit should not be harvested with the main crop, but left on the tree to mature. Seeds may sprout within an avocado when it is over-mature, causing internal molds and breakdown. High in monosaturates, the oil content of avocados is second only to olives among fruits, and sometimes greater. Clinical feeding studies in humans have shown that avocado oil can reduce blood cholesterol.

6.5.2 Culture

Location: Avocados will grow in shade and between buildings, but are productive only in full sun. The roots are highly competitive and will choke out nearby plants. The shade under the trees is too dense to garden under, and the constant litter can be annoying. Give the tree plenty of room--up to 6m. Once established the avocado is a fairly tough tree. Whitewashing the trunk or branches will prevent sunburn.

Soil: Avocado trees like loose, decomposed granite or sandy loam best. They will not survive in locations with poor drainage. The trees grow well on hillsides and should never be planted in stream beds. They are tolerant of acid or alkaline soil.

Irrigation: Avocado trees may not need irrigation during the winter rainy season, but watch for prolonged mid-winter dry spells. Over irrigation can induce root rot which is the most common cause of avocado failure. Watch soil moisture carefully at the end of the irrigating season. Never enter winter with wet soil. Avocados tolerate some salts, though they will show leaf tip burn and stunting of leaves. Deep irrigation will leach salt accumulation.

Pruning: Columnar cultivars require pinching at early age to form a rounded tree. Others need no training. Current orchard practice avoids staking. The best results are obtained by fencing the tree with plastic mesh for the first two to three years. Branches exposed to sun by

defoliation are extraordinarily susceptible to sunburn and will surely die. Such branches should always be whitewashed. It is better to avoid any pruning. Most cultivars are ill-adapted to espalier. They are too vigorous. Avocado fruit is self-thinning.

6.5.3 Pests and diseases

Leaf-rolling caterpillars (*Tortrix* and *Amorbia*) may destroy branch terminals. Avocado Brown Mite can be controlled by powdered sulfur. Six-spotted Mite is very harmful; even a small population can cause massive leaf shedding. A miticide may be required if natural predators are absent.

Two fungi and one virus cause more damage than any pests. Dothiorella (*Botryosphaeria ribis*) canker infects the trunk, causing dead patches that spreads to maturing fruit, causing darkened, rancid smelling spots in the flesh. Flesh injury begins after harvest and is impossible to detect on outside. Root Rot (*Phytophthora cinnamomi*) is a soil-borne fungus that infects many plants, including avocados. It is absent as yet in Malta. Select disease-free, certified plants and avoid planting where soil drainage is poor. Once a tree is infected (signs include yellowing and dropping leaves), there is little that can be done other than cut back on water.

6.5.4 Harvesting

The time of harvest depends upon the variety. Commercial standards requires fruit to reach 8% oil content before harvesting. To be sure ask the agent when buying the tree.

6.6 Pomegranates

This is one of least demanding fruit trees. No irrigation or any pest control is needed, except for annual pruning. As mentioned earlier in the text, two pomegranates will be planted in field A, one in each of A2 and A3 (see Map 3). Rooted plants can be planted directly without any need of further grafting onto any other rootstock.

6.7 Grapes

The rootstock in the case of grapes is the american vine. Virus-free rootstocks should be used. These in turn should be grafted with virus free Maltese varieties such as Ghirgentina and Gellewza.

Growing season:

- April – any shoots coming out of the rootstock should be cut off at this time
- June – some more shoots should be pruned to reduce shading of the fruit

- August/September – collection of grapes
- December/January – pruning of most of previous year's growth (leave only one inch of this year's growth)

As mentioned earlier, the grapes will be planted in field E, in between the figs and almond trees (Map 4). Two rows will be planted along the field. The vines will be supported by a stake fence (Fig 3). The choice of the site was due not only to its sheltered condition, but also due to the type of soil (tal-bajjad). This is one of the best soils for viticulture.

Fig 3 – Vines growing on a stake fence

6.8 Ground covers for the fruit orchard

The enemy of deciduous orchards is grass, thus non-grass crop below tree canopies is ideal. A selection or mix of the following plant groups can be made:

- **Spring Bulbs** *(Narcissus,* hyacinth): These flower and die back by early summer, as does *Allium triqetrum* (onion weed), and create a grass-free area below trees in fruit, plus a crop of bulbs, flowers, and honey. Iris and tuberous-rooted flowers also assist grass control.
- **Spike Roots:** (comfrey, dandelion, globe artichoke) cover the ground and encourage worms, yield mulch and crop. Soil below their foliage is soft, free-draining, open to roots feeding near the surface.
- **Insectary Plants**: *Umbelliferae* and small-flowered plants: fennel, dill, carrot, and parsnip flowers, and so on. Tachynid and other predatory wasps, robber flies, ladybirds, jewel beetles, and pollinator bees or wasps are attracted to interplants in orchard. All of these can be placed in windbreaks around orchards, interplanted in rows, or as clumps in orchard. All bring predatory or pollinating insects into crops. In the herb layer, catnip, fennel (or any *Umbelliferae),* small varieties of daisy (or any *Compositae),* and flowering ground covers generally attract wasps, pollinator bees and insectivorous birds.

- **Nitrogen and Nutrient Crop:** Clovers, and inter-plants of tagasaste provide root-level nitrogen. Some control root nematodes (these are microscopic parasitic worms - not necessarily on plants only - which are found in the soil) *(Crotalaria),* as do marigolds (by "fumigation" of soil).

Fig 4 – Fruit tree with herbs, flowers and vegetables growing underneath it

In general, we aim to maximise the floristic or flowering components of orchard interplant, to reduce or even to eliminate grasses, to attract a variety of pollinators and predatory insects, insectivorous birds (using *Fuchsia spp. Echium fastuosum, Salvia* spp.). Soft ground covers such as *Nasturtium* prevent soil drying and give mulch.

7 Herbs

Nearly all herbs are easy to grow. The points to remember are that they should be cropped little and often, and rampant spreaders such as mint must be kept in check.

Planting method: Keep them in pots under shade until rains have fallen, then transplant them in cool weather. Dig holes to accept full root system; soak this hole and add a small handful of fertiliser or soil improver. Turn out the pot and plant the seedling, pushing a shade branch in nearby to shade and shelter the plant until it establishes itself.

Most types can be raised from seed but it is better to buy them as small plants in pots from nurseries or garden centres.

7.1 Basil

Growing conditions: Basil is usually grown in the warmer months of the year. It loves sunny well-drained beds. This herb prefers a well-manured soil. Basil can be grown anywhere - in a herb circle or on its own. But the best way to grow basil is by planting it with tomatoes. Basil and tomatoes are good companions. Their growth is substantially boosted when planted together.

Garden care: Seeds can either be directly sown where your basil is to grow, or sown into seed raising mix. Basil seedlings in seed raising mix can be transplanted once their first "true" leaves are grown. Basil will retain its flavour better if you pinch off the flowering tips.

Harvest time: It's easiest to cut sections of basil using scissors or a knife. At the end of your harvest pull out your basil bushes and hang them upside down in a dry place (e.g. shed or garage). After 7-10 days the leaves will dry nicely. Cut the leaves finely and the dried basil is ready for the market.

7.2 Parsley

Growing conditions: Parsley can be grown all year round. It will grow better in moderately moist beds that are partially shaded. Parsley prefers soil manured the previous season. Parsley, like basil, is a companion of tomatoes. If you plant the two together your yields will be boosted.

Garden care: Parsley can sometimes be difficult to germinate. You should try to use fresh seed. If you're having problems getting parsley to germinate you should try soaking the seed in warm water a day before sowing. This herb is a perennial and flowers at the end of its second year. You'll find it generally tastes best in its first year.

Harvest time: You shouldn't harvest the whole plant. Just cut a sprig off each plant until you've got enough. This will not put any stress on the plants and they'll quickly grow some more leaves to replace the ones you've taken.

7.3 Thyme

Growing conditions: Thyme grows well in a moderately dry, free draining soil. It loves full sun.

Garden care: Thyme can be grown by cuttings. Take a few cuttings a couple of inches long and strip the leaves from the bottom half. Dip this in rooting hormone powder and plant it. Thyme is a perennial and can last for several years.

Harvest time: Cut a few branches at a time and it'll keep growing.

Herbs	Method of propagation	Likes shade or sunny areas	Site for planting	Watering	Harvesting
Basil	Seeds	Slightly sunny	Under wall	Yes	
Bay laurel	Seeds	Slightly sunny	Under wall	No	
Celery	Seeds	Slightly sunny	Under wall	Yes	
Fennel	Seeds	Sunny	Garigue	No	Collect seeds in Sep
Merqtux	Cuttings - Jan	sunny	Under wall	Yes	
Mint	Cuttings - Jan	Shade	Under wall	Yes	
Parsley	Seeds - Sep	Slightly sunny	Under wall	Yes	
Rosemary	Cuttings - Jan	Sunny	Garigue	No	
Wild thyme	Cuttings - Jan	Sun	Garigue	None	

Table 3 – Table showing methods of propagation and growing needs of various herbs

8 Vegetables

The main vegetables can be divided into five families as follows (table 4):

- Potato family
- Legume Family
- Cucumber Family
- Cabbage Family
- Onion Family

Solanaceae Potato Family	**Fabaceae Legume Family**	**Cucurbitaceae Cucumber Family**	**Brassicaceae Cabbage Family**	**Alliaceae Onion Family**
Potato	Beans	Cucumber	Broccoli	Onion
Tomato		Marrow	Cabbage	Garlic
Pepper		Melon	Cauliflower	
Eggplant		Pumpkins	Radish	
		Watermelon		

Table 4 – Table showing the main 5 families of vegetables

Members of the same family tend to have similar growth patterns and characteristics. Below is another table showing the nutrient requirements of the various vegetables and fruit mentioned in this section (melons and watermelons were included in this chapter). In fact vegetables can be divided into three main categories - light feeders, medium feeders and heavy feeders – according to the amount of actual nutrients needed.

	N	**P_2O_5**	**K_2O**
Light Feeders	3.9	4.4	4.4
Medium Feeders	10.7	8.7	9.2
Heavy Feeders	14.6	13.6	13.6

Table 5 - Comparison of fertilizer needs for light, medium, and heavy feeders in g/m^2.

Light Feeders	**Medium Feeders**	**Heavy Feeders**
Onions	Artichokes	Cabbage
	Beans	Lettuce
	Broccoli	Tomatoes
	Carrot	
	Cauliflower	

Light Feeders	Medium Feeders	Heavy Feeders
	Cucumbers	
	Marrow	
	Melon	
	Peppers	
	Potato	
	Pumpkin	
	Radish	
	Sweet Corn	
	Watermelon	

Table 6 - *List of vegetables based on whether a light, medium, or heavy feeder*

There are two main planting periods. The first months of spring are for salad vegetables and all summer crops, and the last month of summer or first month of autumn for all over-winter crop and all root crops of the year.

Since different vegetables have different growth periods and time-spans, a plan was set up to coordinate the planting period of various vegetables, such that most of the fields had something growing on them throughout the year. Field A was further subdivided into 20 smaller sections (as mentioned earlier on). Various species were allocated to the different sections, with compatible species being placed in adjacent sections. Incompatible species were put further away. Compatibility was an important factor in our choice of species, since some particular species attract beneficial insects, or send away insects that could otherwise cause havoc with certain crops. Some crops will even be intermingled; e.g. basil will be grown amongst the tomatoes. Some of the plants chosen are flowers. These not only attract beneficial insects but they can also be sold thus creating an extra source of income (see section).

Once each crop is harvested a second unrelated but compatible crop will be planted instead of it, such that there will be continuous crop rotation. The next year, field A2 and A3 should be rotated as well, such that all the crops that were originally grown in A2 are now grown in A3 and vice versa. This means that if tomatoes were grown this year in $A3^2$ next year they will be grown in $A2^2$.

Whereas some crops can be sown directly into the soil, others have to first pass a preliminary stage at the nursery. Sowing them directly would end up in a considerable loss of seedlings, since they are not hardy enough. Most plants are at their most vulnerable stage when they are seedlings. Many die by wilting off (due to fungal attack), others are eaten by insects or slugs. By growing them in a nursery, they have a much better chance of surviving since you can control their growing conditions more easily. A month after germination, they can be planted

directly into the ground at regular intervals from each other. In some cases it is easier to buy the seedlings directly from an agricultural supplier. However if the health of the plant were in doubt it would be better to buy certified seeds and grow them yourself.

8.1 Solanaceae (Potato family)

8.1.1 Potato

- Potatoes like growing in a medium to rich soil.
- They love sunny well-drained soils.
- Potatoes are from the same family as tomatoes. So to avoid soil disease and pests don't plant either of these in the same bed. Tomatoes and potatoes generally hate each other, they're bad companions, stunting each other's growth.
- You can technically grow potatoes from a seed, but it takes long and you generally get poor results.
- Potato prefers organic dry soils (pH 5.0—6.8) achieved by compost, perhaps some sulphur, and thick damp mulch. Subsurface water is ideal, and a few marigold interplants aid root health.
- Make sure you buy certified seed potatoes. These should be disease free. Potatoes you buy from the green grocer could add disease to your soil.

Growing conditions

Growing potatoes is easy under mulch. A good organic mulch like straw will do nicely. Avoid hay as it still has seeds. A thick layer is needed to keep the potatoes away from the sun's light. On top of the straw you can put a layer of mushroom compost. Once the compost is ready pass the pipe (drip irrigation) through the compost and water the tubers for at least 5 minutes.

In about 3 weeks the foliage will start creeping out of the mulch. Remember to regularly water the potatoes (in the spring season), as they need a lot of water to grow the tubers.

Harvest time: Harvest the tubers a couple of weeks after the flowers had set the fruit and the foliage died back. This can be anywhere between 3-5 months after you first plant the tubers.

8.1.2 Tomatoes

- Tomatoes are usually grown in warmer months as they grow very slowly in cold weather.
- Tomatoes generally prefer a soil that has had a green manure crop previously.
- They love sunny well-drained soils.

- Tomatoes grown in the same spot each year can be badly effected by root nematodes. So it's important to rotate your tomatoes each season.
- Tomatoes can tolerate about twice the salt in soils than peppers.
- Plant some basil with your tomatoes. They act as companions and make a beneficial effect on each other's growth.
- Tomatoes are very susceptible to pests and diseases. Some means of tackling the diseases are mentioned in chapter 9.7.

Growing conditions

Sow your seeds in the nursery in the beginning of March. Make sure the seed raising mix has a good dose of compost. Mix some wood ashes or sulphate of potash to the soil before planting your seedlings. This encourages flowering. Plant the seedlings in cool weather, towards evening, in well-watered soils.

Tomatoes are fussy with water. Too much water and they'll split. Not enough water and they'll split. The important however is to provide water through drip irrigation to avoid getting water on the leaves, otherwise the tomatoes might get powdery mildew.

Harvest time: To pick tomatoes make sure you cut the stem cleanly with scissors or a knife. This reduces the chance of damaging the fruit.

8.1.3 Peppers

- Plant peppers away from tomatoes. Since they are from the same family, they are susceptible to similar diseases.

Growing conditions

Plant the seedlings in March. Make sure the soil temperature is about 60^0F before transplanting. Cooler temperatures will only result in slowed growth and productivity. Once in the ground, provide a stake for the main stem to support the growing peppers. Pepper plants require no pruning, however they need an adequate supply of water. Watering should be done through drip irrigation to avoid wetting the leaves (as in tomatoes).

Harvest time: Pick the peppers in the same way as the tomatoes, by cutting the stem cleanly with a knife or scissors. This reduces the chance of damaging the fruit.

8.1.4 Eggplant

- Purple and white varieties are available. Shapes range from oval to elongated.
- Choose well-drained, moderately fertile, sandy loam soils. Fertility requirements are similar to those of tomato and pepper.

- To reduce risk from verticilium wilt and other diseases avoid using fields in which tomato, pepper, potato, or strawberry had been planted.
- Use transplants grown in jiffy pots or similar containers so as to minimize shock of field transplanting.

Growing conditions

Eggplant requires a long growing season, so transplants are most commonly used. They are usually started in the greenhouse or hotbeds. Sow seeds in shallow flats of soil mix 9 to 10 weeks before transplanting to the field. Constant temperatures must be maintained as young plants are easily damaged by cool temperatures or droughts. Transplants grown in the greenhouse should be kept at the following temperatures for best results: days 21 to 27 C; nights: 18 to 21 C. Space the plants in rows 3 to 4 feet apart, with the space between adjacent plants in the row being 1.5 to 2 feet. Water regularly with drip irrigation to avoid fungal attack.

Harvest time: Harvest eggplant fruit when they have developed full bright colour for the variety, but while they are still firm to touch. At this stage, the seeds will be young, white, and tender and the flesh firm and white. As the fruit passes the prime stage for eating and becomes over-mature, the fruit surface becomes dull, the seeds harden and darken, and the flesh becomes spongy. Prompt picking increases fruit set and yields.

8.2 Fabaceae (Legume family)

8.2.1 Beans

- Being legumes, beans draw nitrogen from the air and fix it into the soil on their roots.
- They love sunny well-drained soils.
- Beans like a medium rich soil.
- Keep an eye out for bean bugs. They look like ladybirds with many spots on an orange shell. You might also see them on the potatoes. Eliminate them before they get too many otherwise they'll eat all the leaves (see section 9.7.1).

Growing conditions

Sow the bean seed directly into the soil, since transplants don't work very well.

Harvest time: To avoid damaging the plant always harvest beans by cutting their pods off with scissors or a knife. Pick your beans frequently; it encourages flowering resulting in even more beans. When the beans are producing their last fruit cut them off at the ground, leaving their nitrogen fixed roots in the soil.

8.3 Cucurbitaceae (Cucumber family)

8.3.1 Cucumber

- Cucumbers are best grown in the warmer months of the year, in full sun.
- They like a rich organic soil with added compost.
- Cucumbers are good water-consumers, so keep their soil wet, especially on warmer days.
- The main disease problem with cucumbers is powdery mildew on the leaves (which eventually kills the plant). Therefore use drip irrigation.

Growing conditions

Cucumbers can be directly sown into the soil in March. Create a foot wide mound of soil, about an inch taller than the surrounding soil. Plant 3 or 4 cucumber seeds as deep as your first knuckle. A month later, in April, thin the seedlings down to 1 or 2 plants.

Harvest time: Once they are ripe (one tell tale sign is when small spikes start forming on the skin), cut the cucumber stem using scissors or a knife to minimise impacts on the plant. Remember, like beans, frequent harvesting encourages more flowers, which means more cucumbers.

If you are experiencing bitter cucumbers, then you are letting the cucumbers get too large before you are cutting them. Keep the watering even, this will help the cucumbers to stay bitter free.

8.3.2 Marrow

- Marrows can be badly effected by cold weather, so grow them during the warmer months.
- They're grown in full sun or partial shade.
- Marrows like a medium rich soil.
- They love well-drained soils.
- The main disease problem with marrows again is powdery mildew on the leaves so use drip irrigation.

Growing conditions

Sow your seed directly into the soil. Create a foot wide mound of soil about an inch taller than the surrounding soil. Plant 3 or 4 marrows seeds as deep as your first knuckle. After a few weeks, thin the seedlings down to your strongest plant in each mound. Marrows consume a lot of space so plant them about 2 feet away from each other. Apart from space, they also consume a lot of water especially in summer, so water them well. Some mulch would help in conserving decreasing water loss.

Harvest time: You'll need a knife to cut through the thick stem between the marrows and the main stem.

8.3.3 Melon

- Melon is a summer growing fruit; they adore hot, sunny, well-drained soils.
- Melons love a medium-rich soil. Potassium helps to encourage flowering.
- As with the other vegetables till now, use drip irrigation, otherwise you may get powdery mildew.

Growing conditions

Sow your seed directly in the soil at the end of March. Create a foot wide mound of soil about an inch taller than the surrounding soil. Plant 3 or 4 melon seeds as deep as your first knuckle. After a month thin the seedlings down to 1 or 2 plants.

Harvest time: Harvest melons when they develop a fragrant musky aroma and the melon pulls away easily from the stem.

8.3.4 Pumpkin

- Pumpkins grow in the warmer months of the year; grow them in full sun or partial shade.
- They love an organically rich free draining soil mixed with compost.
- Pumpkins are very susceptible to hot days. Make sure you water them sufficiently on warmer days, otherwise the leaves will wilt.
- The main disease problem with pumpkins is powdery mildew on the leaves, so to avoid it use drip irrigation (avoid watering overhead).

Growing conditions

Sow your seed directly where you want your pumpkins to grow. Create a foot wide mound of soil about an inch taller than the surrounding soil. Plant 3 or 4 pumpkin seeds as deep as your first knuckle. After a month thin the seedlings down to 1 or 2 plants.

Harvest time: In around 3 to 4 months you can start harvesting the pumpkins. Using a knife or scissors cut the pumpkin from the vine. Make sure you leave a good 4 to 5 inches (10-15cms) of vine connected to the pumpkin. This minimises deterioration to the pumpkin during storage. Pumpkins can easily be kept in a cool dry place for 6 months.

8.3.5 Watermelon

- Watermelon is definitely a warm season grower. It performs well in almost all climates during late spring and summer.

- They love sunny, well-drained soils.
- Watermelons like medium rich soils. Some potassium could help to encourage flowering.
- Avoid watering the leaves, otherwise you may get powdery mildew.

Growing conditions

Sow your seed directly into the soil. Create a foot wide mound of soil about an inch taller than the surrounding soil. Plant 3 or 4 watermelon seeds as deep as your first knuckle. A few weeks after they germinate thin them to 1 individual. Contrary to what you'd expect with their name, watermelons are reasonably drought tolerant so water reasonably.

Harvest time: Harvest watermelons when: the stem starts to shrivel; the underside yellows; the melon makes a hollow sound when you knock on it. Cut the stem of watermelons cleanly with a knife or scissors.

8.4 Brassicaceae (Cabbage Family)

8.4.1 Broccoli

Growing conditions

Start the seeds in the nursery in September. Plant the seedlings at least 1½-2 feet away from each other. Planting broccoli plants too close together will result in the plant producing smaller heads. To obtain more space plant them in a herringbone structure (in a diagonal pattern).

Harvest time: On harvesting, pull the whole plant out of the soil, then cut the stem and pull the outer leaves away from the heart, and compost the rest of the plant.

8.4.2 Cabbage

- Cabbages can be grown all year round in most climates, however in Malta they are best grown in the warmer months.
- They love sunny well-drained soils.
- Cabbages prefer rich soils, so feed them once every three weeks with liquid organic fertilizer.
- Cabbages tend to take up a lot of space so give them two feet between each other.
- Caterpillars love cabbage leaves so spray every 10-14 days with BT (*Bacillus thuringensis*), a natural bacterium that just affects pest caterpillars. Don't forget to reapply if it rains.

Growing conditions

Seeds can be directly sown where the cabbages will grow, but it's often easier to sow them in the nursery, transplanting them once they have at least two true leaves. On planting, place them in a herringbone pattern to allow more space.

Harvest time: It takes around 3 months before cabbages can be harvested. Harvest them by pulling the whole plant out of the soil, then cut the stem and pull the outer leaves away from the heart.

8.4.3 Cauliflower

- They like a free draining soil and prefer growing in cooler conditions.
- Cauliflower loves a medium-rich soil.
- Adding organic nitrogen would help stimulate more leaf growth, thus producing bigger cauliflowers.
- Cauliflowers take up a lot of space so leave about 1m between plants.

Growing conditions

You can directly sow cauliflower seeds into the soil or in the nursery. Seedlings can then be transplanted out into the field after they've got their first two true leaves. Plant them in a herringbone pattern, and water the cauliflower regularly if the soil is dry. Water the soil from below using drip irrigation, avoiding the white head.

When the white cauliflower head starts developing you'll need to protect it from the sun and rain. Tie two leaves together using rubber bands. This will blanche the head. Otherwise it goes brown. Tie bigger leaves together as the head grows. When it comes to pests watch for caterpillars and spray every 10-14 days with BT (*Bacillus thuringensis*).

Harvest time: It usually takes around 4 months for a cauliflower to reach maturity. Harvest the head around 20cm (8 inches). Heads bigger than this may discolour and lose their firmness. Pull the whole plant from the ground. Cut the cauliflower head off and compost the rest.

8.4.4 Radish

- Radishes are very versatile, growing year round in all but the coolest climates.
- They prefer a slightly shaded aspect. Avoid growing them in full sun during summer.
- Radishes like a loose soil rich in organic matter.

Growing conditions

Directly sow the seeds where your radishes will grow. Radishes can germinate as quick as 3-5 days after sowing. When sowing carrots mix them with some radish seeds. The radishes will

pop up fast, showing the drill where you sowed. The radishes will be harvested only a week or two after the carrots have germinated. This will give the carrots plenty of room to grow.

Harvest time: Don't leave your radishes growing too long. Otherwise their sweet flesh will become hot and bitter. Generally crop 4-5 weeks after sowing. If left too long you might get club root disease in the soil.

8.5 Alliaceae (Onion Family)

8.5.1 Onion

- In Malta, onions are usually sown in August, growing through winter and spring and harvested in early summer (to allow enough time for the bulb to dry).
- They love sunny well-drained soils, especially when the bulbs mature in summer.
- They are usually grown in fields with poor soils that do not need any irrigation. In our case we chose field D for this purpose.
- Keep away from nitrogen based liquid fertilisers when your onions are maturing. Otherwise their efforts will go into their leaves instead of their bulb.
- Because of its strong taste pests generally leave onions alone.

Growing conditions

Sow the onion seeds in August. You can leave them unattended, except for the occasional weeding. Hand weed around the onions to avoid disturbing their roots and bulbs.

Harvest time: Harvest onions when the flower starts drying. Pull the whole plant from the ground and hang them in a cool dry place for around 3 weeks to cure.

8.5.2 Garlic

- In Malta garlic is sown in summer and harvested around 6 months later in January.
- They love sunny well-drained soils.
- Garlic has very few pest problems. Its strong oil and natural chemicals repel pests. Which is why garlic spray is a great organic deterrent for the other vegetables. Garlic could also be planted in between other crops to deter pests (except in the case of legumes, e.g. Beans and peas).

Growing conditions

To plant garlic separate the cloves and plant them 10-15cm (4-6 inches) apart. Push them down so their tops are just below the soil.

Harvest time: When the leaves go yellow-brown stop watering the garlic. By continuing to water the garlic the cloves become spongy and rot once harvested. Harvest a couple of weeks later. Leave the garlic out to dry and cure for 3 weeks. Once the bulbs are thoroughly dried store them (in a mesh bag) in a cool, ventilated place away from sunlight.

8.6 Asteraceae (Daisy Family)

8.6.1 Lettuce

- The variety of lettuce types makes it easy to grow lettuce in almost all seasons.
- Lettuce prefers a sunny to partial shade aspect.
- They love an organically enriched, well-drained soil.
- Feed them fortnightly with liquid organic fertilizer.

Growing conditions

Seeds can be directly sown in the soil or else in a nursery. When the leaves are just short of an inch long they can be transplanted into the field. Like most transplants, lettuce seedlings should be transplanted either late in the afternoon on an overcast day to avoid wilting.

Harvest time: Harvest it after 1½ months, otherwise if it's grown too long, it will be very bitter. Try to pick the lettuce in the morning when their sugar content is highest instead of the afternoon.

8.6.2 Artichoke

- In Malta artichoke is best grown in late summer.
- Artichoke likes growing in fertile, well-drained soils that promote maximum root development.

Growing conditions

Sow the seeds directly into well-drained soil. Sow to a depth of 3/4 inches between seeds. Thin seedlings to 2-3 feet after they have reached the 4-leaf stage. Plants should produce buds within a few months after planting.

Harvest time: Harvest before they get too old, otherwise they become tough and woody.

8.7 Apiaceae (Carrot Family)

8.7.1 Carrot

- Carrots can grow in all but the hottest and coldest climates. They grow year round in the Mediterranean.
- They prefer full sun but can grow in partial shade.
- Avoid adding manure to the soil, otherwise the carrots will fork.
- There are very few pest and disease problems with carrots.

Growing conditions

Carrots are directly sown into the soil. Carrots have one of the longest germination times of all vegetables, often taking over 3 weeks. Intersperse the carrots with radishes. Thin the carrot seedlings out when they're about 5cms tall to a distance of 2cm. And again when 15cms tall to a distance of 5cm apart. Avoid excessive watering as roots may crack.

Harvest time: Carrots usually need 3-5 months to grow to their full size. If you encounter problems harvesting deeply rooted carrots try watering them. Then slowly rotate them around to loosen the carrot from the soil. Don't forget to twist off the leaves. If you don't the leaves will draw water out of the root, which will dry it out.

8.8 Poaceae (Grass Family)

8.8.1 Sweet Corn

- Sweet corn is a warm weather crop, getting its best results during spring and summer regardless of the climate.
- They love sunny well-drained soils.
- Sow the corn seed in soil fertilized with compost.
- Sometimes you can get cobs with no kernels. In that case corn ear worm (they look like caterpillars) were responsible for destroying your harvest. When the female silks of the corn appear spray them with BT (*Bacillus thuringensis*). Reapply weekly or if it rains.

Growing conditions

Sow the seeds directly into the soil. Add some potash into the soil when sowing to encourage good flowering. Sweet corn is wind pollinated so plant in blocks instead of rows. Water the regularly since they will grow quickly.

Harvest time: There are a number of tell tale signs which tell you when to harvest the cobs: harvest the ears 18 to 21 days after the silk first appears; the female silk goes from pale

yellow to dark brown; the angle of the cob changes from being straight to around 30 degrees from the stalk; and finally you can peel back the husks for a peak - if the kernels look juicy stick a thumb nail in -the kernel should ooze a milky substance. This means it’s ready for harvesting! Then grab the stalk and pull the cob down. You'll hear the cob break away from the stalk. Once your corn plants turn yellow things are starting to die (it happens fast). So quickly harvest the remaining cobs. Compost the rest.

Table 7 – Summarized table on how to grow various vegetables and other fruit crops

Vegetable	Variety	Source	When to plant/sow	Likes shade or sunny areas	Distance between each plant	Use of fertilizer	Watering	Harvesting
Artichokes		Any green-grocer	Seeds - Aug	Sun	2 feet	Manure	Water regularly	Oct
Beans		Agricultural Coop	Seeds Feb -Aug	Sun	20cm	Not necessary	Once fruit appear water regularly	6 weeks
Broccoli		Agricultural Coop	Seeds - Sep	Sun	1½ - 2 feet	N	Water to help	3 – 4 months
Cabbage		Laflafet	Seedlings Apr - Aug	Sun	2 feet	Source of nitrogen	Water regularly	1½ - 2 months
Carrot		Agricultural Coop	Seeds All year	Sun	Close to each other		Water	3 months
Cauliflower	Winter variety	Agricultural Coop	Seeds Sep - Oct	Sun	1m		A little to help	Feb
Cucumbers		Agricultural Coop	Seeds - Mar	Sun	1m	A little	Water regularly	2 months
Eggplant			Seedling Mar	Sun	30cm		Help with water	Jun
Garlic		Any green-grocer	Seeds - Aug	Sun	20cm		Help with water	Jan
Lettuce	Winter variety	Laflafet	Seedlings Nov	Sun	50cm	N	Water regularly	1 – 1½ months

Vegetable	Variety	Source	When to plant/sow	Likes shade or sunny areas	Distance between each plant	Use of fertilizer	Watering	Harvesting
Marrow		Agricultural Coop	Seeds Mar - Sep	Sun	1½ - 2 feet	Manure	Water regularly	1½ months
Melons		Agricultural Coop	Seeds End of Mar	Sun	1m	Potassium & Phosphorous	Water regularly	Jun - Aug
Onion		Agricultural Coop	Seedlings Aug	Sun	20cm		None	June
Peppers		Laflafet	Seedlings Mar	Sun	30cm	Manure	Water regularly	May - Jun
Potato		Agricultural Coop	Tubers Aug – Sep (summer) Dec (winter)	Sun	20cm	Source of nitrogen and phosphorus	Once fruit appear water regularly	Dec Apr
Pumpkin			Seedlings May - Jun	Sun	2m		Water regularly	4 months
Radish		Agricultural Coop	Seeds All year	Slightly shaded	Close to each other		Water to help	1 month
Sweet corn			Seeds - Feb	Sun	1½ - 2 feet		Water	Jul - Aug
Tomato	Flat variety	Laflafet	Seedlings End of Mar	Sun	60cm		Water regularly	Around May
Watermelons	sharon	Agricultural Coop	Seeds End of Mar	Sun	1½m	Potassium & Phosphorous	Water regularly	Jun – Aug

Table 7 – Summarized table on how to grow various vegetables and other fruit crops

9 Growing strategies for maintaining optimum plant growth and production

9.1 Green Manure

Green manure are plants which are grown for the sole purpose of soil improvement. These could be of two types;

- Legumes – these increase the nitrogen content of the soil thanks to the presence of nitrogen fixing bacteria in the roots.
- Cereals – these improve the soil structure due to their fibrous root structure.
- Examples of these are *Hedysarum coronarium* (a legume called silla in maltese) and hay. Once they are cut they can be used as forage, and if they are free from weeds they can even obtain a high price from animal breeders.

9.2 Flowers

One of the principles of permaculture is to grow a mixture of plants together, some even in between each other. Some of the species we are recommending are flowers that can be grown for the flower market. These can be of two types, those grown from seed and others grown from bulbs. The species, which grow from bulbs, could be planted as individual bulbs sparsely among the crops. This will produce flowers at different periods without having a negative affect on vegetable production. Actually the result would be even more beneficial since some of these species attract natural predators of common pests.

Examples of Bulbs:

- Gladiolus - sow bulbs in March and cut flowers from July to August
- Dhalia – sow bulbs in March and cut flowers from May to November
- Fresia – sow bulbs in September/October and cut the flowers in December to January

Flowers grown from seeds should be planted in between the various rows. These have to be sown every year unlike the bulbs, which can support shallow tilling of the soil.

Some examples of seed flowers:

- Chrysanthemums (also known as marigolds) – sow seeds from July to August and cut the flowers between October and November.

9.3 Condensation Strategies for field C

The aim is to condense water either from dew, from transpired water, or from weeds and trimmings, and return it to the root level for reuse. The following methodologies can be used:

9.3.1 Plastic bags around trees

Small trees, planted with a 3 or 4-stake frame over which a bottomless and topless bag is pulled, and around which loose weeds are placed, live in a protected environment in which, at night, soil moisture condenses and runs down the inner bag surface to the roots. Growth may double in tall clear plastic bag tubes around a small tree. In our case this method will be used on the small trees until they establish themselves (should be removed 4 years after planting).

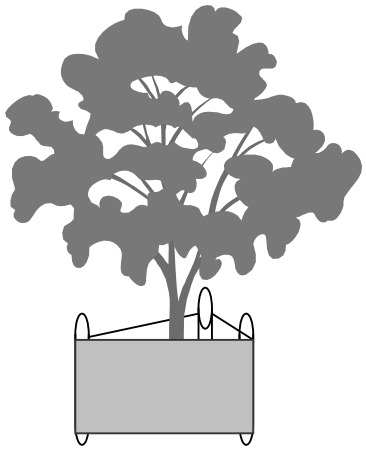


Fig 5 – A three-stake frame placed around the tree, supports a plastic bag around it that traps moisture around the tree.

9.3.2 Stone Mulches

Wherever stone is plentiful, stone mulch acts as a condenser, screen, and weed control mechanism. Small invertebrate animals take refuge under the stones and add nutrients, and the ground below the stone piles is always kept damp. Even a few flat stones at a tree base assists with condensation of water. Linear stone mounds between crops have a similar effect. In our case one stone mound of about 30cm high and wide, should be placed in each growing plot. More could be used under the trees, as shown in fig 6.

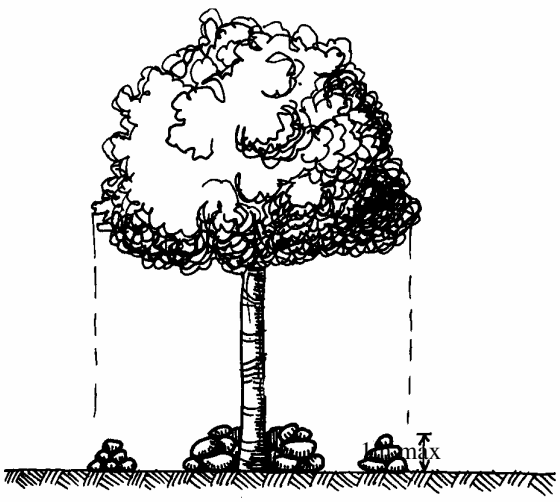


Fig 6 – Stone mulch under tree

9.3.3 Pit Evaporation Systems

These are used as survival strategies in deserts, but can be adapted to grow trees in climates such as ours. The water that condenses on the surface of the plastic drips into the pit (see fig 2) and reaches the funnel, where it is channelled into the soil under the tree. This method

could end up reducing the need for regular watering, thus preserving the water for use of other more needy crops. This method could be used for the trees being planted in field C since those in field A will be receiving enough water as a by-product of the irrigation of the surrounding vegetables.

9.4 Mulching

A mulch is a layer of bulky organic matter placed on the soil surface around plants. Mulches are not applied around annuals, but around shrubs, trees and herbaceous perennials. Vegetables are not often given a humus mulch but are sometimes grown through a weed control mulch.

Humus mulches provide several distinct benefits:

- The soil below is kept moist during the dry days of summer.
- The soil below is kept moist in summer, reducing the need to water. It is also kept cooler than soil without a mulch, and research has shown that this moist and cool root zone promotes more active growth than plants in unmulched areas
- Annual weeds are kept in check - the ones that do appear can be easily pulled out
- Some mulches provide plant foods
- Soil structure is also improved for a number of reasons. Humus is added, earthworm activity is increased and soil capping by rain or watering is eliminated

Many materials are suitable for mulching - you can use moist peat, pulverised bark, leaf mould, well-rotted manure, mushroom compost, Bio Humus and garden compost. Grass clippings are sometimes recommended and are often used, but do not use them if they are weedy.

9.4.1 How and when to mulch

Humus mulches *are* insulators which help to retain the conditions occurring at the time they are put down. This means that the soil should be just right for active growth - warm and moist and not cold and dry.

The standard time for applying a humus mulch is May. Before you begin putting down organic matter it is necessary to prepare the soil surface. Remove debris and hand pull or hoe annual weeds (in our case, use a rotary cultivator). It is also important to get rid of perennial weeds. The final job is to apply a fertilizer (such as mushroom compost) and rake in lightly. The soil is moist, warm and free from weeds - it is now time to spread a 2-3 in. (5-7.5 cm) layer of the chosen mulching material over the ground around the stems. This covered area should extend for about 1½ ft (45 cm) around the centre of a shrub and for 2½ ft (75 cm)

around the trunk of a moderate-sized tree. You must make sure that the mulch does not come right up to the stems. A build-up of moist organic matter against the shoots can lead to rotting. Do not disturb this layer during the summer months. If weeds do appear pull out by hand.

9.4.2 The Weed Control Mulch

Weed control mulches are forms of organic or inorganic sheeting which suppress perennial as well as annual weeds. The soil surface is protected, the need to water is reduced but improvement to the soil structure is either slight or does not take place.

Polyethylene Sheeting is widely available and is the most popular type of weed control mulch. Standard 150-200 gauge sheeting will only last a single season if not covered but heavy-duty 500 gauge sheeting will last for several years. The only disadvantage with such mulch is than water doesn't pass through the plastic but has to percolate through the edges of the sheet.

Another great advantage of using plastic sheeting is that potatoes do not need earthing up and marrows, etc are kept off the ground. The greatest bonus however, is in weed-infested land as the plastic sheeting forms a weed-proof barrier.

Old Carpeting makes an excellent weed control mulch. Use as a strip between rows of plants or cut into squares and use as tree spats. It is very easy to lay, but it does need a surface cover if appearance is important. It is long lasting and of course free when you decide to recarpet a room!

Cardboard is not often used, but old cardboard boxes are freely available at most supermarkets and can be used as tree spats when cut into squares. Several sheets of newspaper can be used for the suppression of annual weeds. In both cases a cover is needed to cover the appearance.

9.5 Watering

One of the main problems concerning this project is that there isn't any source of water close by. In order to be successful, a reservoir has to be made available close to these fields. Since the ground water here would tend to be salty, it is out of the question to use a borehole, since this would lead to salinization of the soil. The best way is to build a resevoir in the area at a higher altitude than the highest field itself. The best site would be one that has a suitable water-catchment area, thus allowing itself to fill automatically with each rainfall. Once the site is found and the reservoir is built, a system of pipes will be set up such that the water will flow through gravity thus avoiding using any pumps.

Plants have particular times when they are more susceptible than usual to drought and wilting. The high-risk areas

- Bedding plants for 4-6 weeks after planting.
- Herbaceous perennials for the first year after planting.
- Shrubs and trees for the first two years after planting.
- Tomatoes, Cucumbers, Marrows, Beans, and Peas.

There are also a few general principles to watch out for in irrigation:

- A plant should never be left to show visible signs of distress during a prolonged period of drought. Wilting means that you have waited too late - the time to water is when the soil below a few inches depth is dry and the foliage appears dull.
- Never apply a small amount of water (less than 1 gallon per sq. yd) and then repeat the watering every few days. This constant soaking of the surface and water-starvation of the lower root zone leads to rapid evaporation, surface rooting which is damaged in hot weather, and germination of weed seeds.
- Water thoroughly once you decide to water. If you are using a pipe hold the spout close to the base of the plant and water slowly. Do not use sprinklers since water landing on the leaves could induce watery mildew. The best option is to use drip irrigation since this not only avoids wetting the leaves, but also conserves water.

Irregular watering damage: The outer skin of many vegetables hardens under drought conditions, and when heavy rain or watering takes place the sudden increase in growth stretches and then splits the skin. This results in the splitting of tomatoes, potatoes, carrots, etc. Avoid by watering before the soil dries out. A common disorder due to the irregular watering of growing bags is blossom end rot - a sunken, dark-coloured patch appears at the bottom of tomatoes.

9.6 Soil Solarization

Difficult-to-control weeds and soil borne pathogens may be controlled with soil solarization. Soil solarization should, however, be reserved for solving these specific problems in the growing area (field A and D) because it can also kill beneficial microorganisms and insects.

Soil solarization involves covering the soil surface with clear plastic for four weeks or longer. To begin with, all plant material and crop residue, as is practical, should be removed. The soil should be ploughed well. The area should be watered thoroughly so the soil is saturated. The area then should be covered with a plastic sheet. The sheet can be secured along the edges with soil or rocks. Soil solarization works best when air temperatures are high and sunlight is most intense during the summer months. Soil solarization is not effective during extended

periods of cool temperatures or overcast weather. In our case we shall apply it during July or August, the two hottest months of the year.

9.7 Pest management (control)

One of the fundamentals of organic pest control consists of prevention rather than eradication. Preventing the conditions that bring about pest establishment is a priority. Some pests do not establish, or find it hard unless the conditions for them are ideal.

Below is a list of prevention techniques:

- Pathogen-free planting material should be used. It makes no sense planting seedlings which are already infected (ex. Seed-born diseases, tissue cultures, grafting material). Wherever possible especially in the case of vines, phytosanitary certificates should be available as a proof. Seedlings should be obtained only from supervised nurseries.
- Use tolerant resistant cultivars: TYLCV resistant tomatoes, TMV & CMR resistance, V/F, OIDIUM (1,2)R., Phytophtora resistant potato, Lettuce-aphid resistant.
- Dispose of diseased crop waste. Plants with disease symptoms should be removed and destroyed.
- Provide for soil drainage (no standing water means less soil-borne pathogens such as Pythium, Rhizoctonia, etc.)
- Adequate water management and irrigation. Keeping your plants dry will help reduce disease pressure (especially from fungi). Using trickle irrigation rather than overhead will reduce the amount of time plants remain wet and also conserve water.
- Provide mulching
- Nutrient management and prevention of stress. Stressed plants tend to be more easily attacked by pathogens.
- Controlling weeds
- Provide a good habitat for natural enemies
- Crop rotation also can be an important method of controlling some but not all soil borne diseases. The proper crop rotation can substantially reduce nematodes in the soil.
- Soil solarization to kill off seeds of various weeds and soil-borne viruses

9.7.1 Integrated Pest management strategies in outdoor vegetables

Integrated Pest management consists of using various organic and prevention techniques that aim at preventing and reducing pest establishment and loss in plant productivity.

Examples of such techniques include:

- Coating seeds with Gaucho against whiteflies, thrips, aphids etc. Could be used for onion, tomato and watermelon.
- Oil sprays (such as Virol, JMS) for prevention of infection by nonpersistance viruses (CMV, CARNA V) in melons and peppers.
- Mulch films – Yellow/Brown film placed on the ground reduce the spread of viruses in tomato and cucurbit crops
  Yellow – attracts whiteflies
  Brown – Prevents light penetration
- Transparent film – soil solarization
- Cross protection in cucurbit plants from the virus ZYMV – infection of transplants at the nursery with a mild strain of ZYMV to get immune plants against virulent virus. Ex. With marrows, watermelons, and melons.
- Liquid sulphur – controls fungal infection
- Neem - Neem oil is a byproduct of the Neem tree seed. It is considered a natural way of killing aphids.
- *Bacillus thuringensis* – bacterium which attacks the digestive system of caterpillars thus killing them off
- Soap water – could be used to spray on the plants to get rid of pathogens. Use special soap which could be bought from an agricultural store.
- Skimmed milk - for aphids. Spray the leaves of your plants with the milk. The aphids get stuck in the milky residue and perish.
- Repellant spray - This can be used to repel aphids and whiteflies and slugs. Reapply after rains or once a week. Mix one minced bulb of garlic, one small minced onion, one-tablespoon cayenne pepper, and one-quart of water. Let it soak for three hours. Next add one-tablespoon liquid soap. Strain and put in sprayer. Spray on plants.
- Alcohol sprays - Use for aphids, mealy bugs, scale, thrips and whitefly control. Mix ½ cup of isopropyl alcohol (70%) with one cup water and spray on leaves and pests. Alcohol can burn the leaves of certain plants. Apple trees are sensitive to alcohol sprays. Test a few leaves on your plant before you spray the whole plant.
- Tobacco spray - Soak tobacco leaves in water for 24 hours. Dilute solution until it looks like weak tea. Then spray on plants having aphids and other sucking insects.
- Pyrethrins - Pyrethrins are extracts from a chrysanthemum. Dust or sprays are available from agricultural suppliers.

- Pheromone traps – these consist of traps, which have a chemical that emits the smell of a receptive female insect. They are quite effective methods of control since they attract the male insects from a distance.
- Sticky insect traps – these consist of adhesive plastic sheets which are hung close to the target species, and any pathogen which comes close by is attracted to it and gets stuck. Home made yellow sticky traps can be made by smearing honey onto a bright yellow plastic and place it amongst the plants. When the plastic gets full of bugs, wipe it off and reapply the honey and set the trap out again.
- Rotenone - Rotenone is a product derived from the root of two different legumes. Rotenone has been used as a pesticide since 1649 in Europe. Dust or sprays are available from agricultural suppliers.

Note that care should be taken with any of these organic sprays since they might have a negative impact on beneficial insects.

9.7.2 Diseases of cucurbit crops

Diseases can be important factors limiting production of cucurbits. Effective disease management is essential in the production of high quality cucurbit vegetables. Infection and spread of some pathogens is associated with the presence of certain weeds (as alternate hosts) and insects (as vectors). One of these insects is the cucumber beetle. These carry the bacteria wilt, which can kill the plant very fast. Since it is very difficult to control, any plants that die from this disease should be removed and burnt, or disposed of.

9.7.3 Pest management in onions

- **Pink root** – *Pyrenochaeta terrestris* – Treatment: soil disinfection by soil solarization
- **Root stem nematode** – *Ditylenchus dispaci* – Treatment: Pathogen-free planting material through a reliable source; soil solarization; dip garlic in nemacur 400e.c. at 1% for 5 min (kills nematodes and soil mite – *Rhizogliyphus echinopus*)
- **Onion fly/seed maggot:** Gaucho, 3kg for 100kg of seeds
- **Onion thrips:** *Thrips tabaci* – Neemix-45 for soil treatment against larval stages; Abamectin (vertimic) – larvacide; Metamidophos and carbosulphan against adults and larvae; Alsa (garlic extract) repellent to the western flower thrips; Blue/Yellow sticky trap; Thripstick.

9.7.4 Problems and diseases in Tomatoes

Tomatoes are subject to a number of problems including diseases, insects and environmental stress. Many tomato diseases, such as septoria leaf spot, early blight, late blight and

anthracnose fruit spot, can be controlled or minimized by chemical sprays and sanitation. Reduce fusarium and verticillium wilts by planting wilt-resistant cultivars and rotating crops. Remove diseased plants immediately to reduce future disease problems.

Blossom drop, a common problem, rarely persists through the season. Blossom drop is caused by, 1), low spring temperatures, usually below 60ºF, 2), high summer temperatures, especially daytime temperatures above 85ºF, 3), nighttime temperatures above 70ºF, or 4), excessive nitrogen fertilization. Low temperatures reduce pollen production and viability. In some cases, spring blossom drop due to low temperatures may be prevented with a fruit set hormone. The easiest solution is to wait for later flowers to set fruit. Tunnels can be used to encourage earlier fruit set by increasing temperatures around the plant. High temperatures also can reduce flower development and pollen viability. High temperature, especially if accompanied by low humidity and moisture, hinders fruit set through pollination and/or fertilization failure. The adverse effect of high daytime temperature on flower formation and fruit set is somewhat mitigated when night temperatures are within the optimal range of 59ºF to 68ºF.

Fruit cracking can be a common phenomenon. Heavy moisture following dry periods may cause fruit cracking. Some cultivars crack more easily than others. Mulching plants to help maintain uniform soil moisture levels helps reduce cracking.

Leaf curl commonly occurs in hot weather or after cultivation. Keep plants adequately watered. Deep cultivation around the plants can damage roots and cause wilting. Some cultivars have naturally curling leaves even when not stressed.

Blossom-end rot of tomatoes results from an irregular or insufficient supply of moisture and/or not enough calcium in the fruit. Indications of blossom-end rot are that the tips of tomato fruits, especially the first fruits to ripen, become water-soaked, turn light brown in color and become sunken as the fruits enlarge and begin to ripen. To reduce this condition: mulch to maintain uniform soil moisture; do not cultivate deeply around the plant; and avoid using high-nitrogen fertilizer. Disease organisms are not responsible for blossom-end rot, so fungicides are of no value in its control.

Tomato yellow leaf curl virus: TYLCV is one of the most recent pathogens to have been introduced in Malta. The virus infects several crop plants but has been reported as a problem only in tomato. Symptoms vary somewhat but in general, leaves produced shortly after infection are reduced in size, distorted, cupped inward or downward, and have a yellow mottle. The most significant effect of TYLCV infection is flower abscission: fewer than one in ten flowers will set fruit after TYLCV infection, severely reducing yields. The virus is spread mainly by whiteflies, and also by movement of infected plant material. TYLCV is a very difficult pathogen to manage. The most successful strategies to date use a combination of

management practices: yellow mulches (plastic, straw or sawdust), timely pesticide applications, and resistant cultivars.

9.7.5 Problems and diseases in Peppers

Peppers are subject to a number of problems. These include diseases, insects and problems brought on by weather and other environmental factors.

Blossom-end rot of peppers usually results from an irregular or insufficient supply of moisture. This problem is characterized by small areas at or near the tip of pepper fruit that become light brown and sunken. They develop a leathery texture as the fruit reaches full size. It is usually more of a problem on the first fruit. Mulching helps avoid this condition. Avoid frequent light watering. Parasitic disease organisms are not responsible for blossom-end rot, so fungicides are of no value in its control.

Sunscald on pepper fruit is caused by exposure of the fruit to direct sunlight, especially after being shaded by foliage. A light-colored area that becomes slightly sunken, with a papery appearance, characterizes sunscald. Keep the plants vigorous and healthy so leaves do not wilt excessively, and foliage protects the fruit from direct sunlight.

Insects occasionally are a problem on peppers. Cutworms may feed on new leaves or cut the stems on small plants.

Diseases of peppers include seed rot, damping off, virus infection and bacterial spot. Seed treatment and proper growing conditions can reduce seed rot and damping off. Mosaic, a virus disease, can be avoided by growing mosaic resistant varieties.

9.7.6 Problems and diseases in Lettuce

Several species of aphids and the cabbage looper are insect pests that frequently attack lettuce. Besides feeding damage that reduces quality, insects can spread diseases. Therefore, control of the insects and nearby weeds is important. The fungal diseases downy mildew, white mold (*Sclerotinia*), gray mold (*Botrytis*), and powdery mildew; viral diseases lettuce mosaic; and the mycoplasm-induced aster yellows are diseases that can be damaging to lettuce. Use of clean seed, sanitation - especially control of weeds in and near the lettuce planting - and control of insects (see section 9.7.1) are the most effective ways to combat those diseases. Good air movement through the canopy of lettuce does much to minimize problems with fungal diseases.

9.8 Storage of harvested crops

- **Potatoes** are stored in straw in dark boxes or humid cellars.

- **Apples** are separately wrapped or spread out on attic floors (they are not stored with root crop because of their ethylene production, which causes root crop to shoot)
- **Cabbage** can be stored, uprooted, by covering with hay in the open.
- **Carrots** keep well when picked and layered in cool sand in pits 0.5-1 m deep; the green tops are removed to 1 cm from the crown, and they are pitted without washing or removing any roots.
- **Onions** are hung in dry airy plaits.

10 Apiculture

Bees produce several valuable and unique products such as; honey, wax, pollen, and royal jelly. They also carry out the essential service of pollination for a wide variety of food, oil, fruit, and seed crops (such as mustard, clovers, most small fruit, apples, and grain legumes). Bees form a hive or clustered hive site range over an area about 2.5 km in radius.

Bees prefer to fly 100 m or more to forage, and their flight assists in the transformation of nectar to honey, so that forage species are planted this distance or more from hives. Bees more efficiently harvest clumped rather than scattered nectar sources, so that fields, or clumps of preferred forage species are better than a scatter of the same species in a mosaic of individual plants.

The hive site itself should be sheltered from extremes of cold, wet, wind, and sun. Cold winds most restrict foraging, so that a hedgerow (even low hedgerow of 0.5-1 m) is an essential cover, preferably leading from the hive site to the forage. Such hedges can be made of rosemary, *Acacia,* or even soil ridges with catmint, thyme, or field daisies to assist foraging.

As well as nectar producers, bees need pollen to rear replacement workers, especially early in the season. Thus, garigue plants, pines, and vine crop yielding early pollen are very beneficial on range. Bees also gather propolis, a hard waxy substance, used to plug wind gaps or repaint hives, and a good source of this are pines (very few sources of propolis are needed in the whole range).

Finally, clustered hives use very large quantities of water, which is used by the bees to cool the hives. In areas of hot summers, hives need shade and good ventilation, or honey is lost as energy used in cooling (fanning) by the hive. Access to water is most safely achieved by providing soaked mats or Hessian at pond edges, so that bees cannot drown while drinking, and *small* ponds or troughs free of dragonflies give less losses than large ponds (where dragonflies are efficient predators).

One of the best quality honey produced is that obtained from bees foraging on garigue plants. Every effort should therefore be made to conserve the garigue found in the surrounding area, and wherever possible garigue species should be planted (such as in field B).

Given that we have designed a range for bees, then the same areas presents a unique opportunity to grow crops, especially seed crops, dependent on bee pollination. Such crops are: small fruit, mustards and *Brassicas,* clovers, apples or pome fruits, buckwheat, and so on. Crops within a mile of hives will out yield crop in bee-deficient areas by a factor of 3-10 times.

11 Marketing Organic Products

Marketing is about identifying products that the consumer does want, and supplying them at the right price, at the place and time, and in the form which the consumer wants them.

Close attention to marketing is an integral part of successful organic farming. The market for organic food appears, therefore, to have developed as a result of exogenous factors relating to the wider area of public concerns such as health, the environment, and resource use. Because it has been for a long time, the image of organic produce in the consumer's mind has been one of food which is in some way "better" and more "healthy than that produced under conventional agricultural systems. The primary market for organic produce has thus been in the health-food sector. These concerns have hitherto been largely ignored within the food industry, leaving discerning consumers to search out for themselves food that satisfies their selection criteria. Despite their lack of resources, organic producers have been remarkably successful in attracting the attention of these and other consumers.

Undoubtedly, media coverage, which has been antagonistic to conventional agriculture and relatively sympathetic to organic alternatives, has been important in attracting this market.

11.1 Organic agriculture can adequately feed the world's population

Organic agriculture *can provide, to industrialized* as well as developing countries, a qualitatively as well as quantitatively sufficient, varied and healthy food package, with less energy, at lower cost, a fair income and a just social status to the farmer and maintaining good stewardship of the environment. On top of all that, it brings professional satisfaction and a sense of management.

Organically produced food must not be more expensive; the present prices do not reflect the real costs. Marketing, quality, control and labelling should also be improved so that consumer organizations can recommend these products as high quality, low contaminated foods. Price difference with ordinary products should diminish to a more reasonable level.

11.2 The local situation

Currently, organically grown vegetables and crops in the Maltese Islands are all but non-existent. As the consumer mentality changes from big, beautiful, tasteless and possibly toxic vegetables, to sweet, juicy, and healthy crops, a demand for organically grown crops is being born. In the last few years, consumers have become more aware of the health risks involved in

consuming crops grown with unrestricted use of pesticides. This has lead to the opening of a number of health shops in Malta. However unfortunately, there are very few organically grown crops available locally. A market exists however the supply is non-existent.

One of the major setbacks faced by local farmers in organic farming is the way the pitkali system works. Currently all crops are sold in the same category, whether they are organically grown or whether they are coated with pesticides. Thus the growers are not rewarded for their extra effort by higher selling prices. As a result they cannot compete with other farmers who use conventional methods. Secondly, the produce has to be sold three times until it reaches the consumer; farmers sell to the pitkala, who sell to the greengrocers, who sell to us the consumers.

In order for this project to be successful, all products, whether vegetables, fruit, honey, or syrup, should be sold directly to the consumers. This could either be done on site, or else at another chosen place, such as the nursery. Potential clients would visit the nursery directly, and buy from the Foundation itself. People could be informed of the availability of the product by an effective public relations campaign, especially in the local media. A club could also be set up offering discounts to members. People could be brought to the fields for a site visit, especially schools. Groups of housewives could be brought on site in cooperation with various local councils (these usually are very active and frequently organize excursions for their citizens). This could be followed by a site visit around the Ghajn Tuffieha Conservation Area.

An increase in public awareness will automatically lead to a rise in demand of organically grown crops. As a result the price of such crops will rise leading to more farmers changing to organic methods of agriculture. This would lead to the success of the project, which originally was to show the Maltese that organic and green farming can indeed be profitable.

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13 Appendix 1

13.1 Fruit and vegetable calendar

MONTH	ACTIVITY	FIELD
JANUARY	☞ PLANT	
	• wild thyme	B
	• rosemary	B
	☞ HARVEST	
	• garlic	A1[2], A1[4]
	• broccoli	A3[2]
FEBRUARY	☞ SOW	
	• corn	A2[4], A3[1]
	☞ HARVEST	
	• cauliflower	A3[4], A3[8]
	• broccoli	A2[2], A2[8]
MARCH	☞ SOW the seeds of:	
	marrow	A3[8]
	carrots	A3[5]
	beans	A2[7]
	melons	A1[2]
	watermelons	A1[4]
	☞ PLANT the seedlings of:	
	• pepper	A2[3], A3[4]
	• lettuce	A2[5]
	• eggplant	A2[2], A2[8]
APRIL	☞ PLANT	
	• cabbage	A3[3]
	• tomato	A2[6], A3[2], A3[7]
	• cucumber	A3[6]
	☞ HARVEST	
	• potato	A1[1], A1[3], A2[1]
	• lettuce	A2[5]
	• marrow	A3[8]

MONTH	ACTIVITY	FIELD
MAY	☞ SOW	
	• carrots	A1[1]
	• beans	A2[5]
	• PLANT	
	• pumpkin	A1[3]
	• lettuce	A2[1]
	☞ HARVEST	
	• marrow	A3[8]
	• beans	A2[7]
	• cabbage	A3[3]
	• pepper	A2[3], A3[4]
	• carrots	A3[5]
JUNE	☞ HARVEST	
	• peppers	A2[3], A3[4]
	• eggplant	A2[2], A2[8]
	• lettuce	A2[1]
	• beans	A2[5]
	• cucumber	A3[6]
	• tomato	A2[7], A3[2], A3[7]
	• onion	C
	• cabbage	A3[3]
JULY	☞ HARVEST	
	• carrots	A1[1]
	• melon	A1[2]
	• watermelon	A1[4]
	• tomato	A2[7], A3[2], A3[7]
	• beans	A2[5]
AUGUST	☞ SOW	
	• garlic	A1[2], A1[4]
	• artichoke	A1[1]
	• marrow	A1[2], A2[8]
	• bean	A2[3]
	☞ PLANT	
	onion	C
	☞ HARVEST	
	• pumpkin	A1[3]
	• corn	A3[1], A2[4]

MONTH	ACTIVITY	FIELD
SEPTEMBER	☞ SOW	
	• carrots	A3[7]
	• broccoli	A3[2]
	• cauliflower	A3[4], A3[8]
	• potato	A2[4], A2[5], A2[7], A3[1], A3[3],A3[5]
	☞ PLANT	
	• cabbage	A2[6], A3[6]
	• lettuce	A2[1]
	☞ HARVEST	
	• marrow	A1[2], A2[4]
OCTOBER	☞ PLANT	
	• broccoli	A2[2], A2[8]
	☞ HARVEST	
	• artichoke	A1[1]
	• bean	A2[3]
	• lettuce	A2[1]
NOVEMBER	☞ PLANT	
	• lettuce	A2[3]
	☞ HARVEST	
	• cabbage	A2[6], A3[6]
DECEMBER	☞ SOW	
	potatoes	A1[1], A1[3], A2[1]
	☞ HARVEST	
	• potatoes	A2[4] A2[5], A2[7], A3[1], A3[3],
	• lettuce	A3[5]
	• broccoli	A2[3]
	• carrot	A3[2]
		A3[7]

14 Monthly maps

These maps show the crops being grown in each field every month. Text in blue shows the crops which are being sown or planted. Text in green shows the crops that are still growing. And text in red shows the crops which are being harvested that month.

14.1 Crop table

	A1[1]	A1[2]	A1[3]	A1[4]	A2[1]	A2[2]	A2[3]	A2[4]	A2[5]	A2[6]	A2[7]	A2[8]	A3[1]	A3[2]	A3[3]	A3[4]	A3[5]	A3[6]	A3[7]	A3[8]
Jan	pot	gar	pot	gar	pot	broc						broc		broc		caul				caul
Feb	pot		pot		pot	broc		corn				broc	corn			caul				caul
Mar	pot	mel	pot	wate	pot	eggp	pep	corn	let		bea	eggp	corn			pep	car			marr
Apr	pot	mel	pot	wate	pot	eggp	pep	corn	let	tom	bea	eggp	corn	tom	cab	pep	car	cuc	tom	marr
May	car	mel	pump	wate	let	eggp	pep	corn	bea	tom	bea	eggp	corn	tom	cab	pep	car	cuc	tom	marr
Jun	car	mel	pump	wate	let	eggp	pep	corn	bea	tom		eggp	corn	tom	cab	pep		cuc	tom	
Jul	car	mel	pump	wate				corn	bea	tom			corn	tom					tom	
Aug	art	gar	pump	gar		mar	bea	corn				mar	corn							
Sep	art	gar		gar	let	mar	bea	pot	pot	cab	pot	mar	pot	broc	pot	caul	pot	cab	car	caul
Oct	art	gar		gar	let	broc	bea	pot	pot	cab	pot	broc	pot	broc	pot	caul	pot	cab	car	caul
Nov		gar		gar		broc	let	pot	pot	cab	pot	broc	pot	broc	pot	caul	pot	cab	car	caul
Dec	pot	gar	pot	gar	pot	broc	let	pot	pot		pot	broc	pot	broc	pot	caul	pot		car	caul

art – artichoke

bea – beans

broc – broccoli

cab – cabbage

car – carrot

caul – cauliflower

corn – corn

gar – garlic

let – lettuce

marr – marrow

mel – melon

pep – peppers

pot – potato

pump – pumpkin

eggp – eggplant

tom – tomatoes

wate - watermelon

Table 8 – This table shows exactly which crops are being grown in each field at different times of the year.

15 Good and bad Companions

15.1 Good companions

VEGETABLE	GOOD COMPANIONS
Asparagus	Sunflower, Cucumber, Cabbage, Potato, Celery, Tomato, Corn, Cauliflower, Beet, Carrot
Basil	Most garden plants
Beans (Bush)	Potato, Cucumber, Beet, Carrot, Cabbage, Cauliflower, Corn, Savory, Strawberries, Marigolds, Catnip, Nasturtium, Rosemary, Petunia
Beans (Pole)	Potato, Corn, Radish, Marigold, Petunia, Rosemary, Nasturtium
Beets	Onions, Beans, Cabbage, Broccoli, Chard, Brussels Sprouts, Cauliflower, Kohlrabi
Broccoli	Beets, Tomato, Onions, Dill, Sage, Celery, Potato, Mint, Carrot, Rosemary, Thyme, Chamomile, Hyssop, Marigold
Cabbage	Same as Broccoli Cantaloupe Corn
Carrot	Lettuce, Peas, Cabbage family, Leeks, Onions, Chives, Radishes, Sage, Rosemary
Cauliflower	Same as Broccoli
Celery	Beans, Tomato, Cabbage, Leeks
Chives	Tomato, Carrot, Peas, Grapes, Berries, Apples, Roses
Corn	Potato, Beans, Peas, Melon, Cucumber, Soybean, Pumpkin
Cucumber	Radishes, Corn, Potato, Cabbage, Beans, Sunflower Dill Cabbage, Cucumber, Broccoli, Cauliflower, Onions, Lettuce
Eggplant	Tomato, Beans, Potato, Pepper
Garlic	Tomato, Cabbage, Raspberry, Blackberry, Fruit Trees, Roses
Grapes	Hyssop
Henbit	A good general insect repellent for anywhere in the garden, as are Basil, Marigold, Marjoram, Oregano, Tarragon, Mint and Thyme.
Kale	The Cabbage family, Rosemary, Mint, Marigolds, Nasturtium
Kohlrabi	Beet, Onion, Dill, Sage, Celery, Potato, Carrot, Rosemary, Mint, Thyme, Marigold
Lettuce	Strawberries, Carrot, Radish, Tomato, Beet
Marigold	Plant throughout the garden
Mustard	Peas, Beans, Grapes, Fruit Trees
Onions	Beets, Carrot, Tomato, Lettuce, Camomile, Savory, the Cabbage family

Parsley	Tomato, Pepper, Corn, Roses
Peas	Radishes, Carrots, Corn, Cucumber, Potato, Beans, Squash, Turnips
Pepper	Tomato, Beans, Eggplant, Onion, Carrot, Basil, Parsley
Potato	Beans, the Cabbage family, Corn, Peas, Eggplant, Squash, Basil, Horse Radish, Marigoid
Pumpkin	Corn
Radishes	Chervil, Peas, Lettuce, Cucumber, Melons, Nasturtium and other root crops
Raspberries	Garlic
Rutabagas	Peas
Sage	Carrots, Tomato, the Cabbage family, Rosemary
Spinach	Strawberries, Eggplant, Celery, Cauliflower
Squash	Corn, Borage
Strawberries	Borage, Bush Beans, Spinach, Lettuce
Sunflower	Cucumber, Pumpkin, Squash
Swiss Chard	Beans, Onions, Kohlrabi
Tomatoes	Asparagus, Cucumber, the Cabbage family, Lettuce, Onions, Mustard, Carrot, Basil, Borage, Parsley, Sage, Mint, Rosemary, Marigold
Turnip	Peas

Table 9 - Good companions

15.2 Bad Companions

NAME	BAD COMPANIONS
Basil	Rue
Beans (Bush)	Onions, Garlic, Shallots, Leeks, Fennel
Beans (Pale)	Beets, Onions, Leeks, Shallots, Kohlrabi, Chard, Kale
Beets	Mustard, Pole Beans
Broccoli	Strawberries, Lettuce
Cabbage	*Strawberries, Lettuce*
Cantaloupe	None
Carrots	Dill
Cauliflower	Strawberries, Lettuce
Chives	None
Corn	None
Cucumbers	Potatoes, Sage
Dill	Carrots
Eggplant	None

Fennel	Most plants in the garden. Plant fennel outside the garden, but especially never near pole beans or kohlrabi.
Garlic	Peas, Beans
Kale	Pole Beans, Strawberries
Kohlrabi	Tomatoes, Pole Beans, Fennel
Lettuce	Keep away from the entire cabbage family.
Mustard	Beets
Onions	Beans, Peas
Parsley	None
Parsnips	None
Peas	Garlic, Onions, Leeks, Shallots, Leeks
Peppers	Kohlrabi, Fennel
Potatoes	Tomatoes, Pumpkin, Sunflower, Apple, Cherry, Raspberry, Walnuts, Cucumbers
Radishes	Hyssop
Rutabagas	Mustard
Sage	Cucumbers
Spinach	None
Strawberries	The entire cabbage family
Sunflower	Potato
Swiss Chard	Pole Beans
Tomatoes	Potatoes, Kohlrabi, Fennel
Turnips	Mustard

Table 10 – Bad companions