Section 2

FRUIT AND VEGETABLE PRODUCTION

Session 2.1: Planning and planting

Key learning points

- The principles of variety selection
- The basics of soil structure
- Seed production and seedlings propagation
- Planting calendars and crop scheduling
- Planting techniques

Main objectives of the session

At the end of this session participants will be better able to:

- Plan a fruit or vegetable production enterprise
- Determine soil type and structure
- Decide on which crops or trees to plant
- Understand the basic differences between seed, tree and plant species
- Understand the basic national and European legislation for seed production, certification and sales
- Understand the different techniques for seeds production, germination and seedlings propagation
- Calculate seed requirements
- Prepare planting calendars and crop schedules
- Determine planting distances and cropping patterns
- Evaluate alternative planting and transplanting techniques
- Evaluate alternative e-commerce technologies for the planning and planting of fresh fruit and vegetables

2.1.1 Variety selection

Wise planning of an enterprise prior to planting can assist considerably in developing a more profitable horticultural business. A fundamental decision of all growers is deciding on what to plant. The basic rule of variety selection is to choose the most suitable variety or varieties according to the production objectives we want to attain and the market opportunities it provides.

Before planting a crop it is important to verify whether or not the area to be planted is suitable for that crop and so achieving acceptable production levels. It is therefore important to know the main features of the climate that influences the growing cycle and the characteristics of the soil in the area to be planted. To obtain the best productive performance, horticulturalists must then choose varieties best suited to the environment in which they are working.

Before making the choice, horticulturalists must ask themselves a few fundamental questions:

- Is the species to be cultivated suitable for the area under consideration? The suitability is evaluated through the calculation of the statistical frequency of the areas planted in that species in the last few decades.
- What are the minimum, maximum and average temperatures of the favourable season in the area being considered? What are the rainfall values?
- What type of soil do we have: clayey, silty, or sandy and how fertile is it?
- What are the main plant health and protection problems?
- What will be the commercial use of the species to be cultivated? The fresh foods market, processing, drying, canning, freezing?
- For each market, what the main needs, specifications and varieties of product required?

Once these questions are answered, the varieties most suitable for our purposes can be found by consulting the regional lists of recommendations or catalogues from the main seed companies. Generally, the regional recommendation lists and catalogues have two varietal sections: one on tested varieties and one on new varieties. When choosing it is always a good idea to go with tested varieties for large crop investments, without overlooking, however, the new varieties section, especially for experimental tests.

Within each species different groupings can be made up of individuals that are different from each other but are sufficiently similar to be grouped together. These groups are especially important for domestic species, constituting the plant varieties cultivated. From a genetic standpoint, the plant varieties can be of the following types:

- *Clones*: a set of individuals obtained from a single progenitor. The varieties of arboreal species (grapevines, olive, pear, apple, peach, etc.) are actually clones;
- *Pure lines*: a set of individuals derived by self-fertilization from a progenitor;
- *Hybrids*: these derive from crosses between pure lines;
- *Synthetic varieties*: these are the product of crossing in isolation for one or more generations, from selected individuals. In fruit-bearing species, these are called *cultivars*.

The varietal panorama is marked today by ever increasing numbers of hybrids among vegetables and cultivars for fruit species. Varieties have been developed for specific commercial use, such as for fresh or processed markets or whether it is intended that they are grown under glass/plastic or in the field. They also vary considerably according to shape, weight, colour, shelf life, harvest and planting periods, growth rate and disease resistance and even if they can be harvested mechanically. An example of tomato list varieties is shown in the following table:

Across Europe all selected seeds must be certified (virus free) varieties within the framework of national and European certification. The technical regulations for monitoring and certification followed across Europe are in accordance with the EEC directives and with OECD and ISTA rules.

In all countries seed testing is carried out by Institutes of Crop Husbandry and Plant Breeding or by specialised research institutions. New varieties are normally inscribed on an official national and EU variety list after official experimental trials have been carried out. Once certification has been given the multiplication of seeds is normally carried out by private seed companies. In many cases these seed companies maintain their own associations, to promote and develop seed production.

Genetically modified organisms (GMOs) can be defined as organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination. The safety of GMOs depends on the characteristics of the inserted gene(s), the final organism that is produced and its application. The objective of a risk assessment is to identify and evaluate potential adverse effects of GMOs), either direct or indirect, immediate or delayed and taking also into account the cumulative and long term effects on human health and the environment which the deliberate release or the placing on the market of GMOs may have.

European Union legislation on seeds, notably Directive 98/95/EC, specifies that national authorities that have agreed to the use of a seed on their territory must notify this acceptance to the Commission. The Commission examines the information supplied by the Member State concerned and its compliance with the provisions of Community seeds legislation. If such the case, the Commission includes the variety concerned in the "common catalogue of varieties of agricultural plant species" which means the seed can be marketed throughout the EU. The seed legislation furthermore requires that GMO seed varieties have to be authorised in accordance with the Directive 90/220/EEC before they are included in the Common Catalogue and marketed in the EU. Under Directive 90/220/EEC, a company intending to market a GMO must first submit an application to the competent national authority of the member state where the product is to be first placed on the market.

EXERCISE: Early and late fruit varieties

In Italy apricots are grown mainly in Campania, Emilia Romagna, Liguria and Sicily. Campania alone produces about 70% of the national total. One region of Campania in Abruzzo, apricots are grown on an area covering approximately 420 hectares and comprising almost entirely of the variety Cafona. In recent years the main strategic aim of the region has been to extend the production season through the gradual introduction of early and late season varieties. Cafona ripens around June 15-20. New varieties being introduced are shown in the following table with the difference in days for reaching maturity compared to Cafona:

***TABLE*: Apricots varieties maturation dates compared to the variety Cafuna**

Apricot Variety	Maturity date compared to Cafuna (Days) +/-
Tyrinthos	-12
Bebeco	-2
Monaco Bello	-2
Cafona	0
Frasco	+2
San Castrese	+3
Palummella	+5
Boccuccia spinosa	+11
Pellecchiella	+11
Boccuccia liscia	+13
Mandorlone	+20
Tardif de Bordoneil	+24

Choose a fruit or vegetable from your region and prepare a chart indicating early and late varieties.

***EXERCISE:* Selecting varieties**

Antonio has a farm located 30 km from Athens and at an elevation of 50 m above sea level. He needs to choose a variety of tomato for the fresh produce market and having the following characteristics:

- High productivity
- Stores well for long periods
- Can be cultivated in open fields

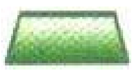
Can you identify the most suitable variety or varieties from among those given in the recommended list that follows? Give reasons for your choices.

TOMATO LIST VARIETIES

VARIETY	USE: FRESH MK	USE: PROCESSING	GROWING TYPE: I	GROWING TYPE: D	FRUIT: SHAPE	FRUIT: WHEIGT g	FRUIT: GREEN SHOULDER	FRUIT: SHELF LIFE	HARVESTING				GROWING	DESEASE RESISTANCE TOLERANCE	CYCLE
Miura F1	✓	✓		✓		90	UG	medium	✓		✓		Outdoor	VF Pt	medium
Nemador		✓		✓		80	UG	medium	✓		✓		Outdoor	VFN	medium
Alice		✓		✓		55	UG	medium	✓		✓		Outdoor		early
Agata		✓		✓		65	UG	medium	✓		✓		Outdoor		medium-late
Salomone F1	✓			✓		>250	GS	LSL	✓		✓	✓	Outdoor	VF	medium-late
Saul F1	✓			✓		90-110	UG	LSL	✓		✓		Outdoor	VF	medium-late
Saidan F1	✓			✓		200	GS	LSL	✓		✓	✓	Outdoor	VF	medium-late
Chipano F1	✓		✓			20-22	GS	LSL		✓	✓		Indoor, Outdoor	VF TMV	early
Corfù F1	✓		✓			150-190	UG	LSL	✓	✓	✓		Indoor, Outdoor	VF1-2 TMV	medium-early
Tomira F1	✓		✓			120-150	UG	LSL	✓	✓	✓		Indoor, Outdoor	VF1-2 TMV	early
Duplo F1	✓		✓			180-200	UG	LSL	✓		✓		Indoor, Outdoor	VF1-2 TMV	medium-early
99.123 F1	✓		✓			200-220	UG	LSL	✓	✓	✓		Indoor, Outdoor	VF1-2 TMV	medium
Red Pear	✓		✓			200-250	GS	limited	✓		✓	✓	Indoor, Outdoor		early
Touring F1	✓		✓			200-250	GS	LSL	✓		✓	✓	Indoor, Outdoor	VF1-2 TMV	medium
Marmo F1	✓		✓			160-180	GS	LSL	✓			✓	Indoor, Outdoor	VF1-2N TMV	medium-early
Sarom F1	✓		✓			180-200	GS	medium	✓			✓	Indoor, Outdoor	VF TMV	early
Polluce F1	✓		✓			200	GS	medium	✓			✓	Outdoor	VF TMV	medium-late
Tirreno F1	✓		✓			120-150	GS	medium	✓		✓	✓	Indoor, Outdoor	VF1-2 TMV	early

Square *Oblate Ribbed* *Deep Oblate* *Globe* *Enlongated*

Indoor



Outdoor

V *Tomato yellow leaf crl virus*
F *Cladosporium fulvum*
N *Meloidogyne arenaria*
TMV *Tobacco Mosaic Virus*

I *Indeterminated*
D *Determinated*
GS *Green shoulder*
UG *Uniform green*

2.1.2 Soil structure

Different fruit and vegetables require different types of soils and organic matter and are often sensitive to soil acidity or excess salts, especially at germination. The soil will have to be properly tested prior to planting to ensure suitable growing conditions are available. Acquired soil properties include nutrient status, organic matter content, soil reaction (pH) and certain aspects of drainage and water retention and will influence the intensity with which the land can be cropped. Nutrient and pH levels can be determined accurately by laboratory analysis and the results used in conjunction with the inherent properties to decide their suitability for vegetable growing.

The relative proportions of sand silt, clay and organic matter particles will determine soil texture and the properties associated with different textures will influence the growth and development of plants. *Sandy soils* ensure good drainage and rapid soil temperature increase and are easy to cultivate. However their moisture holding properties are poor and nutrient levels inherently low. Organic matter is rapidly broken down in sandy soils and regular, heavy applications of organic matter are required to ensure long-term improvements. Irrigation is also essential on these soils.

Silts have a larger proportion of small sized particles that contribute to undesirable properties such as slow drainage. A strong crust will form on these soils after heavy rain or irrigation and are difficult for emerging plants to penetrate and although more fertile than sandy soils they are rarely suitable for intensive crop production.

Clay has the highest proportion of small sized particles. They are very sticky when wet and very hard when dry. However clay particles are also an important source of plant nutrients, such as potassium, magnesium, calcium, iron and sodium. Clays retain a high percentage of moisture and require very skilful management in order to maintain their structure.

Soils with a high percentage of *organic matter* are dark coloured and rich in nitrogenous materials but low in nutrients such as potassium. These soils will absorb large quantities of water but are extremely difficult to re-wet once they have dried out. They tend to be acidic, but easily cultivated even after heavy rain or irrigation. They are ideal for root crops such as carrots or parsnips, which can be lifted cleanly and with the minimum of damage.

Accurate determinations of the sand, silt, clay and organic matter fractions will require mechanical and chemical analysis in a laboratory, but approximate determinations can be carried out in the field by rubbing a small quantity of moist soil between the thumb and the forefinger. Grittiness indicates a sandy soil. Silkiness shows a predominance of silt or organic matter, while clays become polished with continual rubbing and are very sticky when wet.

An ideal soil has silt, clay and organic matter particles but is dominated by the sand fraction. Good soil structure normally needs to be encouraged by sensible management with particular attention paid to drainage, cultivation and the addition of organic matter. Deep soils are also more desirable, particularly in dry conditions.

2.1.3 Seed production and seedlings propagation

Most vegetable and fruit crops are produced from seed, although the seed may often have been produced in different parts of the world from where it is to be planted. Well grown, pest and disease free mother plants produce the best seed. Propagated materials can also be raised from stem and root cuttings.

Genetic variations between seeds can affect germination and performance. A growers livelihood can often depend on the availability of seed and propagation materials of high quality and high germination percentage. In most countries legislation exists to ensure that marketed seeds reach the necessary standards by which the potential field performance of seed can be predicted with some confidence. Even so germination is also dependant on a number of other factors including:

- The moisture, temperature, light and oxygen ranges that are specific to particular crops
- Seed size and weight. Mixed (ungraded) seed sizes tend to emerge irregularly and hinder the development of those merging later
- The quality of seedbed preparation
- The extent of pest or disease attack or mechanical damage to the seed

Most vegetable and fruit crops are raised from seed but many are propagated in laboratories and through extracting and replication from single plant cells. This technique avoids the genetic variation that accompanies propagation from seed. Young plants produced in this way are genetically identical with their parent and uniform population of this type are known as clones. A totally uniform population of fruit and vegetable plants has many production and marketing advantages. They should grow uniformly and mature at the same time. Mechanical harvesting can be used and programmed crop production should be easier. Isolation, regular inspection, great attention to detail and sterile laboratory facilities are needed in order to maintain and generate this type of seeding materials.

Sowing untreated, dry seed will often lead to variable emergence of seedlings. Often seeds are pre-treated to help germination and including simple soaking in water or treatments with nutrient solutions, specified chemicals and growth regulators.

Pelleted seed and seed attached to tape is also available and although increases the overall cost often helps to enable better germination as well as simplifying mechanical seeding and accuracy of spacing.

2.1.4 Planting calendars and crop scheduling

The choice of areas for vegetable production and scheduling of production is determined by many factors, physical, economic and sociological. Physical factors primarily involve the climate, the soil and the landscape.

Climate is the result of the interaction of a number of atmospheric factors, such as temperature, pressure, humidity, rainfall, sunlight, and wind. Latitude and elevation are also important in determining the climate.
The temperature directly determines the intensity with which the various plant functions take place: germination, root absorption, photosynthesis, respiration,

translocation, etc. The *optimal* temperatures are those at which vital plant functions take place at the greatest speed. The minimum and maximum *cardinal* temperatures are those below and above which a vital function stops, possibly restarting again with a return to better temperature conditions. *Critical* temperatures, also minimum and maximum, are those temperatures below and above which there is irreparable damage to the plant functions or organs. For example, early autumn or late spring frosts cause serious damage to fruit and vegetable plants because they are in a stage of vegetative activity. In other cases a drop in temperature of only a few degrees but which lasts for many hours below the cardinal mean of 12°C can cause lettuce plants to flower early.

Rainfall is a decisive physical environmental factor for fruit and vegetable crops. In particular, the *frequency* and *distribution* of rainfall are directly important. The *frequency* is indicated by the total annual number of days of rain. In Paris it rains only slightly more than in Marseilles – 602 mm compared to 542 mm – but the frequency is very different: 200 days per year in Paris, and less than 60 in Marseilles. This explains in part the considerable difference in climate between these two cities. The *distribution* of rainfall during the year is fundamentally important for correctly appraising the agronomic value of crops. It appears that rain that falls during the vegetative season is more valuable than that which falls during periods of vegetative rest.

Sowing and planting calendars for fruit and vegetable crops coincide with the resumption of vegetative activities, which in turn is influenced mainly by the favourable trend of the optimal temperature. Planting, growing periods and harvest dates for the same vegetable or fruit variety can vary significantly according to climatic and soil conditions. Two tables are given below as an example of harvest and planting calendars for lettuce in two climatically different areas of Italy – Fiumicino and the Fucino basin:

TABLES: Lettuce Planting Calendars

1. Fiumicino (Elevation Sea Level)

Harvest Date	Planting Date	Days growing period	Variety
7 April	7 January	90	Davos - Congo
10 April	14 January	86	Davos - Congo
15 April	21 January	84	Davos - Congo
18 April	28 January	80	Davos - Congo

2. Fucino (Elevation 650 ms.)

Harvest Date	Planting Date	Days	Variety
15 May	01 March	75	Davos - Congo
20 May	07 March	74	Davos - Congo
25 May	14 March	72	Davos - Congo
30	21 March	70	Davos - Congo

At Fiumicino harvest can begin as early as the first week in April because the average temperature in January (18°C) is favourable for transplanting. In the Fucino basin it is necessary to wait until mid-May to harvest the same varieties of lettuce transplanted in early March. In the Fucino basin there are also fewer days needed for cultivation because both the climatic and soil fertility conditions are more favourable.

A primary challenge of fruit and vegetable growing is to ensure a steady supply through the marketing season. Careful planning and timing of planting dates are crucial. Fruit and vegetables grow and mature at varying rates during different seasons. In cooler temperatures, short days, and the low light levels of autumn and winter, it is especially challenging to maintain a reasonably steady supply. In summer the length and severity of the hot dry period may become a problem. The maturity time (planting to harvest) can double or triple for plantings to be harvested and planting dates need to be adjusted accordingly. It may be desirable to harvest every week, but this does not necessarily mean that crops should be planted at seven-day intervals.

EXERCISE: Organising planting schedules

In Bulgaria potatoes have been grown for decades with sowing completed from mid-April to mid-May. In this way harvesting of most known varieties takes place between 20th September to 20th October with a crop cycle of 150 days.

However, in recent years a processing factory has been established in the area. With the aim of capitalising on this opportunity growers aim to lengthen the harvest season, from 20th August to 10th November. Can you organise the best planting schedule with the varieties in the following list? Also provide technical reasons for your choices.

Variety	Growing Cycle (days)
Agria	150
Agata	160
Caesar	130
Sirco	120

EXERCISE: Seed sowing schedules

The following schedule, recommended by a greenhouse lettuce producer in Britain, provides an example of seeding intervals required to time weekly harvesting from early November through April. The seemingly conflicting intervals probably reflect adjustments for varying day length, which has an effect on the growth rate of winter greens. Adapt this schedule to suit your local conditions. By keeping detailed planting and harvesting records overtime, you can gradually develop a fine-tuned schedule that suits your farm location and mix of vegetables. Your local vegetable specialist may also have a sowing schedule that can be adapted.

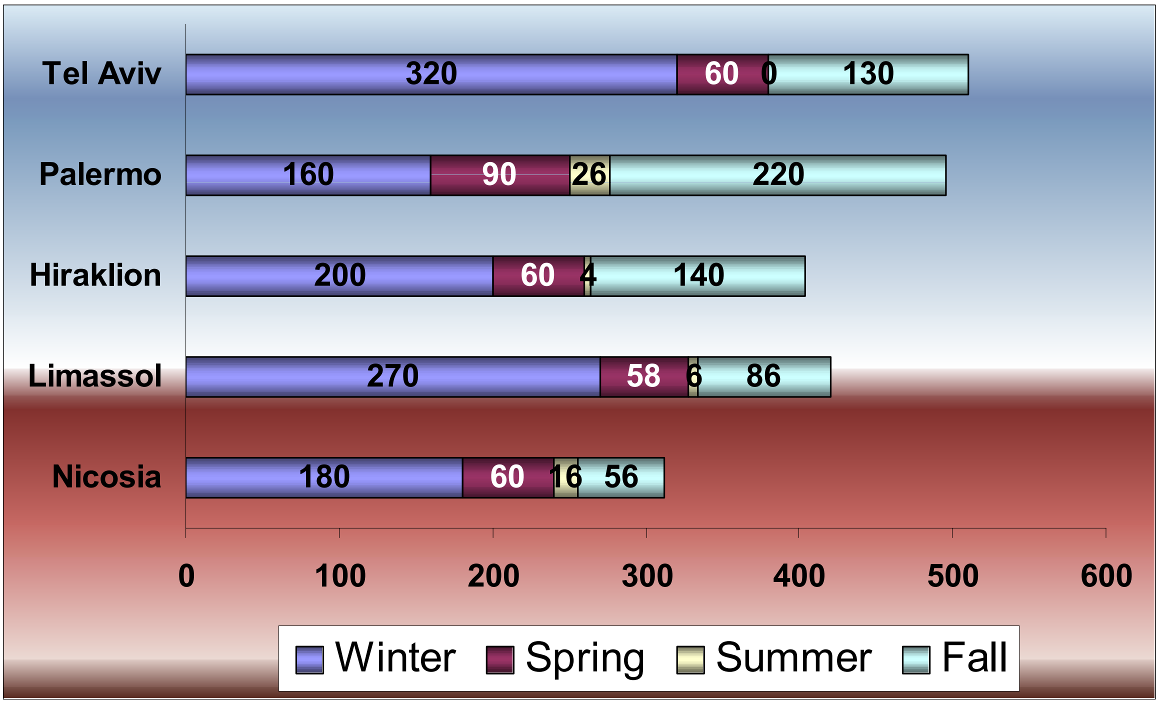
September 1-10	Sow every 3 1/2 days
September 10-18	Sow every 2 days
September 18-October 10	Sow every 3 1/2 days
October 10-November 15	Sow every 7 days
November 15-December 15	Sow every 10 days

EXERCISE: Climatic considerations

Attached is rainfall data covering 5 region of the Mediterranean basin. Provide comments on this data and prepare your proposals as its suitability for growing different fruit and vegetables.

Figure: Rainfall in the Mediterranean basin (mm)

	Nicosia	Limassol	Hiraklion	Palermo	Tel Aviv
Winter	180	270	200	160	320
Spring	60	58	60	90	60
Summer	16	6	4	26	0
Fall	56	86	140	220	130
Total	312	420	404	496	510



Exercise: Production planning

One of our clients has presented us with a commercial budget for the supply of 960 tons of lettuce for the month of July. Can you transform this budget into a weekly supply plan, knowing that for lettuce there are 50 days from transplanting to harvesting and that the average yield is 40 tons/ha?

Use the diagram shown below.

Harvest Date	Planting Date	Days	Variety
01 July		50	Fabula - Prando
07 July		50	Fabula - Prando
14 July		50	Fabula - Prando
21 July		50	Fabula - Prando

Case study

Wireless Application Protocol (WAP technology)

The vegetable growers association of Fucino in order to have information on crops immediately is constructing a wireless application protocol (WAP) page dedicated entirely to providing grower information through the association. This information is short, immediate, up to date and specific. It will include transmitting data from other sources such as the national meteorological centre. The structure of the WAP page is shown in the following picture.

Fucino Growers WAP page

2.1.5 Planting techniques

Planting and cultivation techniques are important because they create the basis for obtaining a good harvest. To achieve a field with the right population of quality plants it is important to properly carry out each stage of cultivation, especially those of sowing and planting. To implement each stage we must know the key factors on which they depend. A job well begun is a job half done!!

Plant populations and spacings have a great influence on yield but their effects are conditioned by other factors that can limit crop growth, such as water availability, soil fertility or use of fertilisers. Basically however two population/yield relationships exist:

- Yield per unit area increases with population until a certain point, beyond which further population increases cause yield reductions
- Individual plant sizes decrease steadily as the population rises

Planting distances are important and they depend mainly on the plant size. The aim is to have the optimal population of plants that permits the maximum productivity for the prevailing soil fertility conditions. These can vary significantly between regions and as shown in the following table.

Table: **Density (Plants/Ha) for selected vegetables in different areas of Italy**

Cultivation	**Areas**			
	Fucino	**Fiumicino**	**Giulianova**	**Ragusa**
Lettuce	76 000	50 000	50 000	50 000
Fennel	80 000	60 000	70 000	70 000
Tomato	28 000	24 000	25 000	32 000
Melon	5 000	4 000	4 000	5 000
Cauliflower	30 000	25 000	26 000	26000

High plant densities increase yields per m^2 but reduce the size of the plants and favour the development of fungal diseases. If the plants become too crowded, humidity also increases owing to low air circulation.

Soil surfaces that are not covered by crops are more likely to develop weeds, to lose water by evaporation and to suffer erosion damage. Sometimes the ground between rows of slow growing, widely spaced crops can be used to produce rapidly maturing crops. Maximum use of space is a good concept but the danger of intercropping is that the "main crop" will be affected by the "short term" crop. Sprays that are necessary for one crop may not be suitable or desirable for the others and competition for light, nutrients and water can easily occur.

In row cropping plants are typically established with a larger distance between rows than within rows. However even spacing should allow uniform development, reduce crop and resource wastage and increase the feasibility of mechanical harvesting. Evenly spaced crops from uniformly sized-graded transplants can produce these effects but direct seeding is the more usual method of vegetable plant establishment.

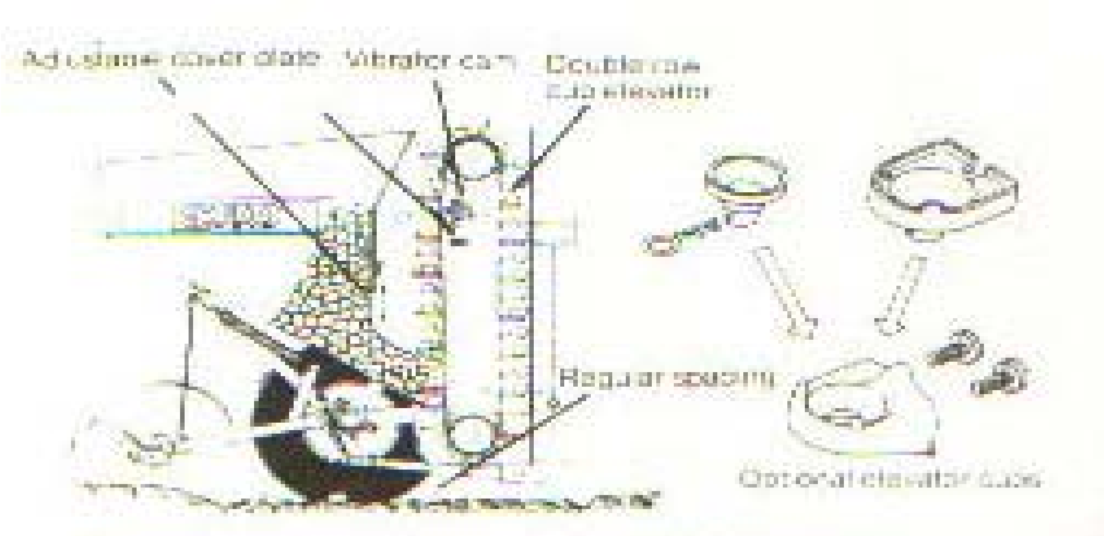
Having decided on the appropriate plant density required, seeding rates can be estimated using the following formula:

$$\text{Weight of seed required (kg/ha)} = \frac{\text{Number of plants required per sq m x 1000}}{\text{No. of seeds per g x \% laboratory germination x field factor}}$$

Seed count and laboratory germination must relate to the particular seed lot. Seed merchants should supply this specific information on request and average figures should never be used as considerable variations are possible. A percentage of the seed that germinates in the laboratory will fail to emerge in the field and the "field factor" is used to take into account this discrepancy. A factor of 0.4 may be used when sowing takes place in poor soil and climatic conditions while a figure of 0.8 is probably the highest that can be achieved.

The planting of vegetables and fruit trees can be undertaken manually or mechanically. The choice depends on the type of crop, the size of the area to be planted, and the availability of labour. Manual planting involves by digging holes that are large enough for the root system of the plants and then planting these by hand into the ground. Mechanized planting involves planters, which open holes in the ground and then automatically place seeds or seedlings in them. Planting distances can generally be regulated according to the species. The following picture shows a traditional automatic planting machine.

***Figure:* Horticultural Seed and Seedling Planting Machine**



Schematic drawing of a two-row EHO planter (without fertilizer attachment).

(Source: EHO, 1993)

In mechanised cultivations crops are grown in cultivated strips or beds that are straddled by tractors, mounted or trailed implements and other equipment. Soil compaction is confined to the wheelways that act like a railway system. It is important that the land is ploughed with a one-way plough to produce a level and even surface. Harrowing and basic fertiliser applications can also be completed before the beds are planted.

Raised beds are sometimes made and help to improve drainage in areas of heavy rainfall or irrigation. Raised beds can also be used on less well drained soils and encourage earlier warming of the soil so permitting earlier sowing or planting.
Vegetable production frequently entails transplanting. This involves raising seedlings under controlled conditions before transplanting into open fields. Transplanting requires more labour than direct seeding but plants occupy their final positions for shorter periods and may allow other crops to be grown beforehand. There are a variety of methods for raising transplants, although most growers prefer plug trays for seedling production. Plants grown in containers or blocks are usually grown in specially prepared growing media and are comparatively expensive to produce. Commercially available organic potting-soil products can be used. This saves the screening and mixing time that is required when making your own soil-blocking mix.

Exercise: Calculating seed requirements

Calculate the weight of seed required (kgs/ha) for carrots to be grown at 108 m2. There are 950 seeds per g, the laboratory germination of the sample is 85% and a field factor of 0.7 is to be used.

Answer: Weight of seed required: 1.91kgs/ha = $\frac{108 \text{ x } 1000}{950 \text{ x } 85 \text{ x } 0.7}$