PLANT ESTABLISHMENT

Vegetables are propagated either by vegetative methods or by means of seed, depending on the crop. Examples of those usually propagated vegetatively are potato (“seed” tubers), sweet potato generally vine cuttings), garlic (the bulbs are divided into cloves, with the larger ones being used for planting), Jerusalem artichokes (the edible tubers), globe artichokes and rhubarb (division of existing plants), horseradish (root cuttings), amadumbe (corms), and so on.

However, most vegetables are produced from true seed, and it is this aspect which will be dealt with in this chapter only.

Most plants can be successfully transplanted at a very young age. However, this period is short for certain crops, such as various beans, carrot, cucurbits, parsnip, peas, sweet corn and so on, that the disadvantages of transplants usually far outweigh the advantages, and transplanting is seldom a practical consideration. Such crops are thus sown directly into the production field in their paramount positions. Even those crops which may be successfully transplanted are, at times, seeded directly into the production field.

Seed quality

It is important to use quality seed that is true to type, has a high germination percentage, has a high vigour, has no dormancy, is free of foreign matter and has no disease contamination. Two types of seed are available: open-pollinated and hybrid seed. Hybrid seed is more expensive, but an improved crop uniformity can be expected due to the selection of favourable characteristics. Hybrid seed is a combination of two or more genetically distinct parental inbred lines. Open-pollinated (OP) seed is cheaper and does require the same management practices as needed to produce hybrid seed. On-farm trials should commence in order to determine what cultivar is best suited to that particular region and time of season. It is important to take note of the batch number or reference number of all seed used so that any problems which may arise can be discussed with the relevant seed supplier.

Direct seeding

The land preparation for direct seeding should be at least as good if not better than that used for transplants. It should be close to that used for open seedbeds, particularly when small seeded crops are to be sown. The field should have a good tilth without any large clods, should be firm and as level as possible. An uneven surface leads to an eneven depth of planting, resulting in less uniform emergence, growth and maturity. Obviously any basal fertilizer dressings should be worked in before sowing.

Small seeds, such as carrot, cole crops, lettuce and tomato, are generally drilled to a depth of 10 mm to 15 mm, occasionally up to 20 mm or 25 mm. Shallower sowing is seldom used because the surface layers of the soil dry out too rapidly, and it is difficult to keep the seed moist enough for successful germination and emergence. Sowing will generally be deeper on sandy soils than on heavy soils. Planting depth for larger seeds, such as bean, pea or sweet corn, may also be shallow, but it is usually more common for them to be drilled one-and-a-half times as deep as small seeds. Firm down the soil down over the seed after planting to ensure good seed-to-soil contact. It is usually better to plant into moist soil, which had been wetted to the rooting depth of the crop a few days previously, and then to give a light irrigation soon after planting to settle the soil around the seed. Make sure that the soil around the seeds remains moist by frequent light irrigations until the plants emerge - remember that the top layers of soil can dry out rapidly.

Apart from the crops discussed above, there is another group which transplant comparatively easily and successfully, even at a more advanced age. These include crops such as brinjal, broccoli, Brussels sprouts, cabbage, cauliflower, celery, chilli, leek, lettuce, onion, sweet pepper and tomato. It is common practice to raise them in seedbeds or seedrtays, for later establishment in their permanent positions in the field. The main advantages of transplanting revolve around the fact that the area used for growing transplants is small in comparison with the size of the production fields. This results in:

Better utilization of available ground, because the larger fields may be used for crop production while the seedlings are being produced.
Better germination, seedling growth, and plant survival, resulting in lower usage of seed, because the small seedbed can be cared for better than the large fields.
Better, quicker and cheaper control of pests, diseases and weeds on a small area.
Better control of irrigation, with a saving in water usage, and more frequent watering, ensuring consistent seedling growth.
Easier and cheaper protection of seedlings against wind, hail, rain, heat and, cold.
Earlier cropping is possible in areas with cold winters by producing seedlings under cover, or in a warmer area, and transplanting when outside conditions become favourable for growth.
More uniform plant spacing, as well as replacement of "missing" plants when established in the production field.

The disadvantages include:

The unavailability, or high cost, of labour needed for transplanting.
Transplanting losses may, under favourable conditions, result in a poor stand and low yields.
The time taken from sowing to harvesting is normally extended because plant growth may be set back to some extent by transplanting.

Transplants are usually raised in seedtrays or in open seedbeds. Seedtrays are normally used by speacialized nurserymen producing plants for sale to growers. Although a few vegetable growers do make use of this system for the production of their seedlings, the majority of producers who grow their own transplants, use open seedbeds for this purpose.

The quality, including age, of transplants plays a large role in determining the potential yield of the resultant crop. Seedling production should, therefore, receive special attention from each grower, because poorly grown seedlings can never produce the yields, nor the quality, that can be achieved with young, strong, healthy transplants.

In commercial prectice there are two main methods of producing transplants. The first is to produce the seedlings in seedling trays, usually using composted pine-bark as a growing medium, and usually under cover, and the other is to grow the seedlings in soil in seedbeds situated in the open.

Seedling trays

In KZN most transplants are produced in seedling trays and mostly by specialised commercial nurserymen. The most commonly used structures in which the seedlings are produced are shade-houses, which make use of shadecloth. Different colours, as well as different percentage shade, are available. Consult with a Knittex or Alnet agent as to which is the most suitable for the particular crop. These houses should not be shaded or exposed to high winds.

Should the seedlings be grown in trays placed directly on the ground, or any other solid surface, their roots will tend to grow out of the drainage holes at the bottom of the growing

cavities (or cells). At transplanting this would cause difficulty in removing the seedlings, would damage the roots, causing a greater transplanting shock and plant setback., and would negate most of the advantages of raising plants in such containers. If the trays were to be raised about 60 cm above ground, with the drainage holes exposed to the air, roots do not grow out of them and would remain within the cell cavity, with much better transplanting results. To achieve this, two parallel lengths of 16 guage wire (60 cm apart) are drawn taut over a pole structure about 60 cm high and spaced 3.8 m apart down the rows. The ends of the seedling trays rest on these wires, thus allowing a free flow of air past the bottoms of the trays.

The trays used for large scale production are usually about 670 mm long, 340 mm wide and 50 or 60 mm deep. The number of cavities per tray vary. The fewer the cavities per tray, the larger the cells are, and the longer the seedling can be kept before becoming root-bound. He cost of producing each seedling is appreciably higher, as fewer seedlings are produced over time per unit area, and more growing medium is used per plant in large cavities. Because of this cost factor, commercial nurseries favour the use of trays with many small cavities, say a count of 300 per tray, whereas growers often prefer those with larger cavities, say 200 cells, or even 128 cells for certain crops such as tomato.

The trays are available in plastic or polystyrene. Plastic trays are heavier, making movement in the nursery more onerous, but they are less prone to breakage. Ploystyrene trays are lighter but not as durable. The higher price of plastic trays is recovered by their longer life span. One should remember that most nurseries will sell their seedlings in bulk in plastic packages, and not in the trays in which they are produced. The production fields must be prepared for the plantlets before they are received.

Seeding

Well decomposed pine bark medium that is weed free is recommended for seedling trays.

Seed is normally planted mechanically into the tray cavities. The trays are then lightly irrigated and placed in germination rooms with high humidity and moderate temperature. About 3 days later the trays are removed and placed in the nursery where they are irrigated, often several times a day during hot weather. Nutrients are added to this irrigation water. It is essential that the runoff water is drained from the nursery, as pooled water is ultimately detrimental to the health of the growing plants.

To prevent disease the trays are sterilised before planting, either by means of steam or chemical means such as plazdip, sporekill and pathoclen. It is essential with seedling production to maintain good sanitation in the nursery.

The copper in products like plazdip helps with root pruning and prevents what is called root caging. Root caging occurs when the roots reach the cavity wall and grow down, which will reduce the plants rooting volume. The copper on the other hand cauterizes the roots causing a pruning effect when it reaches the cavity wall; subsequent lateral growth of the roots results in increased root volume of the plant. Most trays also taper and are open at the base of each cavity, which causes air pruning.

OPEN SEEDBED

Site selection

The site for a seedbed must be carefully selected. It should be easily accessible, because the seedbeds should be inspected and attended to daily, in order to make management decisions on irrigation, pest and disease control. Avoid using soils subject to capping (crusting). Preferably, select lighter soil types, such as sandy-loam to loam soils. These soils warm up quickly, generally drain well, are easier to cultivate, and most seedlings will emerge more easily,

and grow better. Frequent light irrigations are required for optimum germination and growth making a good water source essential. The site should be protected from cold and wind. However, be careful of windbreaks, or other trees possibly shading the seedlings or competing for root space. A good air circulation is advisable in order to reduce disease incidence. Avoid hollows where cold air drains. Virgin land would be preferable, followed by a three year rotation.

Soil preparation

The soil needs to be well-prepared, and in good tilth. As most transplanted vegetables have relatively small seeds, the soil surface should be fine, but not pulverised. In many instances, soil fumigation may be advisable for the control of nematodes; certain weeds, and other pests or diseases, may also be controlled with some of these chemicals. A soil test would be advisable. The soils should be limed if necessary, and should be well fertilised. On soils of low fertility, a pre-plant incorporation of about 10 kg per 100 m² of a general fertiliser mixture such as 2:3:4(30) should be adequate for most crops.

The beds are usually made about 1,0 m wide, and of any convenient length. They should be level across their width, with no high spots (too dry) or low spots (too wet). The beds are usually raised about 150 mm above the access pathways between them, to facilitate drainage.

Sowing

The seed is sown thinly, usually in shallow furrows drawn 100 mm to 150 mm apart, and covered to a depth of 10 mm to 20 mm for most vegetables. In order to prevent over-crowding of seedlings, rather err by sowing too thinly than too densely. As a general rule, sow about 100 to 150 seeds per running metre of plant row.

The seedling rate for any crop will obviously vary, depending on the number of seeds per gram of the particular seed lot, its germination ability, the growing conditions to which it is subjected, and the plant population desired on the land. Common seeding rates for a hectare are 300 g to 400 g for most cole crops (cabbage family), 250 g to 350 g for capsicums (chillies and sweet peppers), 250 g for tomatoes, 500 g for brinjals (eggplant) and lettuce, and 3,0 kg to 5,0 kg for onions. Many growers customarily sow 10% to 15% more seed than is considered necessary, to ensure that there are sufficient plants, even after fairly stringent selection.

Table 5.
Seed count, seeding rate, sowing depth and spacing of selected vegetable crops.

Vegetable	Seed/g	Seeding Rate/ha			Sowing	Usual Range of Spacings	
		Seedtray	Seedbed	Direct	depth mm	Plant mm	Rows mm
Asparagus	40 - 60	300 - 500 g	1 kg	7 kg	15 - 20	400	1800
Bean, broad	0,5 - 1	-	-	75 kg	40 - 50	200	800
Bean, bush	2 - 5	-	-	50 - 100 kg	20 - 40	50 - 80	45 - 60
Bean, runner	2 - 4	-	-	50 kg	20 - 40	100	1 000

Vegetable	Seed/g	Seeding Rate/ha			Sowing	Usual Range of Spacings	
		Seedtray	Seedbed	Direct	depth mm	Plant mm	Rows mm
Bean, Lima	0,5 - 1	-	-	30 - 50 kg	30 - 40	300 - 400	1 000 - 1 500
Beetroot	4,5 - 6	-	-	10 kg	15 - 20	50 - 70	200 - 300
Brinjal (Eggplant)	215 - 250	140-200g	300 - 500 g	3 kg	15 - 20	500	700 - 800
Broccoli	175 - 330	150 - 250 g	300 - 500 g	-	15 - 20	300 - 450	600 - 700
Brussels sprout	225 - 350	70 - 150 g	250 - 350 g	-	15 - 20	400 - 500	900 - 1 000
Cabbage	200 - 350	120 - 200 g	300 g	0,5 - 2 kg	15 - 20	350 - 450	500 - 600
Chinese cabbage	250 - 350	200 - 250 g	250 - 300 g	-	15 - 20	300 - 400	500 - 600
Carrot	600 - 1 200	-	-	2 - 3 kg	15 - 20	20 - 50	200 - 400
Cauli-flower	200 - 400	120 - 200 g	250 - 500 g	-	15 - 20	400 - 500	600 - 700
Celery	1800 - 3000	-	500 g	-	10	150 - 200	200 - 300
Chilli	150 - 175	150 - 200 g	250 g	-	15 - 20	400 - 500	600 - 800
Cucumber	30 - 55	(1 - 1,5 kg)	-	2 kg	20 - 30	350 - 500	1 200 - 1 400
Leek	280 - 400	0,7 - 1,5 kg	4 kg	8 kg	15 - 20	100	300
Lettuce	600 - 1 200	300 - 500 g	500 g	1,5 - 3 kg	15 - 20	250 - 350	400 - 500
Marrow, bush	4 - 10	2 - 4 kg	-	4 - 6 kg	20 - 30	350 - 500	800 - 1 200
Melon	20 - 40	-	-	3 kg	20 - 30	250 - 350	1 500
Onion	225 - 300	2 - 2,5 kg	3 - 5 kg	7 kg	15 - 20	60 - 80	200 - 300

Vegetable	Seed/g	Seeding Rate/ha			Sowing	Usual Range of Spacings	
		Seedtray	Seedbed	Direct	depth mm	Plant mm	Rows mm
Parsley	550 - 800			3 kg	15 - 20	100	300
Parsnip	250 - 400	-	-	3 - 4 kg	15 - 20	150	300
Pea	3 - 10	-	-	50 - 75 kg	30 - 60	50 - 80	600
Potato	tubers	-	-	about 3 tons	70 - 100	300 - 400	900 - 1000
Pumpkin	4 - 5	-	-	4 kg	20 - 30	600 - 700	2500
Radish	75 - 110	-	-	6 kg	15 - 20	40 - 60	150 - 200
Spinach	100 - 140	-	-	10 kg	15 - 20	70 - 80	200
Sweet pepper	150 - 175	150 - 200 g	250 g	-	15 - 20	400 - 500	600 - 800
Sweet potato	300 - 400 mm cuttings /slips	-	-	30 000 - 35 000 cutting		on ridges 250 - 400	900 - 1 000
Swiss chard	40 - 50	-	-	8 - 10 kg	15 - 20	200 - 400	400 - 600
Squash, trailing	4 - 10	(1 - 3 kg)	-	2 - 3 kg	20 - 30	400 - 500	1 000 - 1 500
Sweet corn	3 - 8	-	-	12 - 15 kg	25 - 40	250 - 350	700 - 800
Tomato, table	200 - 350	100 - 200 g	250 - 300 g	-	15 - 20	350 - 500	1 400 - 2 400
Tomato, processing	200 - 350	100 - 200 g	250 - 300 g	0,5 - 1 kg	15 - 20	450 - 550	1 000 - 1 400
Turnip	300 - 500	-	-	4 kg	15 - 20	80	400 - 600
Water-melon	10 - 20	-	-	3 - 4 kg	40 - 60	500 - 600	1 700 - 2 000

Note : Super Sweet sweet-corn has a shrunken seed and would have nearly double the seed count per kg seed than that of standard sweet corn. Seeding rates are thus likely to be about half that shown above.

Table 6.
Sowing times for certain selected vegetable crops.

Crop	Cold areas Moderate frosts	Warm areas Light frosts	Hot areas Frost - free
Asparagus	Aug - Sept	Aug - Sept	Aug - Sept
Bean, broad	Apr - May	Apr - May	Apr - May
Bean, bush	Sept - Jan	Aug - Feb/Mar	Feb - Sept
Bean, runner	Sept - Dec	Aug - Jan	Feb - Aug
Bean, Lima	Oct - Dec	Sept - Jan	Feb - Apr, Aug
Beetroot	Aug - Mar	All year	Feb - Sept
Brinjal (Eggplant)	Oct - Nov	Sept - Dec/Jan	Jan - Sept
Broccoli	Sept - Jan	Jan - Sept	Feb - Jun/Jul
Brussels sprout	Nov - Feb	Jan - Mar	Feb - Apr
Cabbage	Sept - Feb	All year	Feb - Jun/Jul
Chinese cabbage	Sept - Feb	All year	Jan - Sept
Capsicum (chilli, green pepper)	Sept - Oct	Aug - Nov/Dec	Jan - Mar, Jul - Dec
Carrot	Aug - Mar	Jan - Nov	Feb - Sept
Cauliflower	Aug - Sept, Dec - Feb/Mar	Jul - Sept, Jan - Apr	Feb - Mar/Apr
Celery	Aug - Oct, Jan - Feb/Mar	Aug - Oct, Feb - Apr	Feb - Aug
Cucurbits	Sept - Dec/Jan	Aug - Jan/Feb	Mar - May, Jul - Oct
Garlic (cloves)	Apr - May	Apr - May	Apr - May
Horseradish (root cuttings)	Aug - Sept	Aug - Sept	Feb - Apr
Leek	Nov - Apr	Sept - Oct, Feb - May	Mar - Apr
Lettuce	Jan - Apr, Jul - Dec	All year	Feb - Aug/Sept

Crop	Cold areas Moderate frosts	Warm areas Light frosts	Hot areas Frost - free
Madumbe (corms)	-	Aug - Nov	Jul - Dec, Mar
Onion	Feb - Mar	Feb - Mar	Feb - Apr
Onion (pickling)	Sept	Sept	Sept
Parsley	Aug - Mar	Jul - Apr	Feb - Sept
Parsnip	Aug - Mar	Jul - Apr	Feb - Apr, Jul - Sept
Pea	Jun/Jul - Sept	Mar - Jul/Aug	Mar - May/Jun
Potato (tubers)	Sept/Oct	June-August	April/May
Radish	Jul -Apr	All year	Mar-Oct
Spinach true	Aug - Mar	Feb - May, Jul - Sept	Mar - Aug
Sweet corn	Sept/Oct - Dec	Aug/Sept - Jan/Feb	Jan - Mar, Jul - Sept
Sweet potato(cuttings)	Nov	Sept/Oct - Dec	Aug - Mar
Swiss chard	Aug - Feb	Jan - Apr, Jul - Sept	Feb - Aug
Tomato	Sept - Nov	Aug - Dec	Dec - Mar, Jul - Sept
Turnip	Aug - Mar	All year	Feb - Sept/Oct

After-care

After sowing, frequent, (daily or even twice daily during hot, dry weather), light irrigations are necessary to prevent the drying out of the top-soil in which the seed is planted. After emergence, gradually increase the interval between irrigations to about 7 days as the plants become stronger. Ensure that the seedbed does not become too wet, because such conditions favour the development of many diseases, especially damping-off and some foliar diseases. Reduce watering over the last 7 to 10 days before transplanting, in order to harden the plants, but do not allow the seedlings to wilt severely. If the plants have been produced under shadecloth or other shelter, the cover should be gradually removed to acclimatize the plants to the outside field conditions. Give the beds a good soaking a day or two before transplanting, in order to restore a good water regime in the seedlings, and to facilitate lifting of the plants with minimal root damage.

During growth in the seedbeds, attention to weed control, as well as the control of pests or diseases, should receive priority.

GENERAL INFORMATION

Transplants

Short, sturdy, slightly hardened seedlings, with a well-developed root system, transplant and perform better than soft, lanky, etiolated plants. The latter are encouraged by sowing too densely (seedbed area is too small), over-use of nitrogen fertilisers, and over-watering. Younger plants of the desired size perform better than older ones. Under warm growing conditions, most of these crops will reach the transplanting stage within 4 to 6 weeks, but this period may be doubled under colder conditions. Traditional transplant size is when the plant is at the 5 or 6 true leaf stage.

Transplanting

Only those seedlings which have reached the desired size are used for the first planting-out. Those developing more slowly may be transplanted slightly later, when they are more developed, but are less likely to perform as well. Hardening, which is the process of adapting seedlings to field conditions should take place 7-14 days prior to transplanting. Hardening will increase the transplanting success rate, to do this withhold moisture or reduce/increase the temperature to which the plant's are exposed to.

Overcrowding of seedlings is often the main cause of variation in growth and plant size. Lift the plants carefully, with as little root damage as possible, and cover them with moist sacks until transplanted. Transplanting success depends on how rapidly a plant is able to regenerate those areas of the root system that were damaged by there removal from trays / seedbed and from transplanting .

Lift only sufficient plants to keep the planters continually busy. Any weak, diseased or abnormal plants should be discarded.

Transplanting should be done as early in the morning or as late in the afternoon as possible. This is when the humidity is at it's highest, reducing dessication, as well as it being the coolest time of the day. Plant into moist soil, if possible. Set the plants slightly deeper than they were in the seedbeds, firm the soil around the roots, and irrigate again as soon as possible after transplanting. Special attention should be paid to further irrigation, and replacing any dead or weak plants, until the plants have recovered from any transplanting shock.

How to minimise disease in vegetable transplants

Shade house environment: production houses could be located in areas where vegetables are not produced, to prevent the presence of disease- causing agents. Weeds around the shadehouse should be removed, and volunteer or redundant seedlings removed and destroyed.

Media and water	:	all growing media and irrigation water should be pathogen-free. I some instances water pipes should have filters fitted to exclude propagules of known pathogens.
Planting material	:	only certified seed or plant plugs should be used. The grower must not accept seeds or seedlings of unknown quality for use in transplant production.
Cultural practices	:	attention must be given to practices such as fertilization, irrigation and temperature. Free moisture from sprinklers or condensation on plants for prolonged periods should be avoided. Strict sanitation should be followed as well as removing weeds from underneath the benches.

Diagnosis and correction of transplant disorders

Symptoms		Possible causes	Corrective measures
1.	Spindly growth	Shade, cloudy weather, excessive watering, excessive temperature	Provide full sun, reduce temperature, restrict watering, ventilate or reduce night temperature, fertilize less frequently, provide adequate space.
2.	Stunted plants	Low fertility	Apply fertilizer frequently in low concentrations
A.	Purple leaves	Phosphorus deficiency	Apply P-rich fertilizer at 50ppm P every irrigation for up to one week
B.	Yellow leaves	Nitrogen deficiency	Apply N fertilizer solution at 50 - 75 ppm each irrigation for one week. Wash the foliage with water after application.
C.	Wilted shoots	Pythium root rot, flooding damage, soluble salt damage to roots	Check for symptoms of Pythium or other disease organisms. Reduce irrigation amounts and reduce fertilization.
D.	Discolored roots	High soluble salts from over fertilization. High soluble salts from poor soil sterilization	Leach the soil by excess watering. Do not sterilise at temperatures above 160 ^{o} F. Leach soils before planting when soil tests indicate high amounts of soluble salts.
E.	Normal roots	Low temperatures	Maintain suitable day and night temperatures.
3.	Tough, woody plants	Over- hardening	Apply starter solution
4.	Water-soaked and decayed stems near the soil surface	Damping off	Use a sterile, well drained medium. Adjust watering and ventilation practices to provide a less moist environment. Use registered fungicidal drenches.
5.	Green algae or moss growing on soil surface	High soil moisture, especially in shade or during cloudy periods	Adjust watering and ventilation practices to provide a less moist environment. Use a better drained environment.

Symptoms	Possible causes	Corrective measures
6. Poor root growth	Poor soil aeration. Poor soil drainage. Low soil fertility. Excessive soluble salts. Low temperature. Residue from chemical sterilization. Herbicide residue	Determine the cause and take corrective measures