TOMATO

INTRODUCTION

The tomato *Lycopersicon esculentum* Mill., belongs to the family Solanaceae. Other useful members of this family include bell (or sweet) pepper, chilli, cape gooseberry, eggplant, pepino and potato. Several important weeds, such as the thorn apples ("stinkblaar"), apple of Peru, wild gooseberry, black nightshade and bugweed, also belong to this family. The plant originated in the Andes mountains of Peru, from where it spread as a weed to extensive areas in South and Central America. An intensive breeding programme has since produced the wide range of tomato cultivars available throughout the world today.

The tomato is a very important vegetable crop in South Africa. In terms of area planted, only potatoes, onions and cabbages are more important. In KZN it is probably third in line after potatoes and cabbages.

Most of the fruit is sold fresh, but large tonnages are also processed. In KZN fresh sales are by far the most important. The fruit is used as a fresh salad vegetable, and is also a popular ingredient in soups, stews, sauces and various other dishes.

ENVIRONMENTAL REQUIREMENTS

Climate

This annual plant is classified as a warm-season crop. Temperatures even a few degrees above freezing may cause serious damage to both plant and fruit. The optimum temperature for growth, yield and fruit quality of tomatoes is an average daily mean of 20°C to 24°C. At temperatures below 12°C or above 35°C, flowers are often shed, with a consequent poor fruit set; the quality of the fruits produced under such conditions may also be detrimentally affected. Even in frost-free areas, winter production of tomatoes should not be attempted where mean temperatures frequently drop below the critical margin of 12°C.

The best soil temperature for germination of tomato seed is from 15°C to 30°C. At such temperatures plant emergence occurs in about 7 to 10 days. At temperatures of only 10°C this period may extend to three weeks or longer, and emergence tends to be more uneven and poorer. The germination capacity is detrimentally affected at soil temperatures of over 35°C.

Hot, dry winds may cause an excessive flower-drop, even when soils are moist. Strong winds can cause serious mechanical damage.

Continuous moist, rainy weather promotes the occurrence and spread of leaf diseases, and also makes their control more difficult. For best results, tomatoes should be grown in relatively dry areas under irrigation.

Soils

Tomatoes should ideally be grown in deep, fertile, humus-rich, free-draining, but moisture-retentive soils, which are free of nematodes. Sandy loam to clay loam soils, with a clay content of between 15 and 35 percent, are considered to be the most suitable. Sandy or gravelly soils are acceptable, provided the soil moisture content can be kept at the desired high level. Heavy clay soils are less suitable because the slower drainage can cause unfavourable water-logging during prolonged or heavy rainy spells, particularly where these occur just after a good irrigation.

In entirely unrestricted soils, a few tomato roots may penetrate to a depth of over 2 m, but the greatest concentration of roots occurs in the top 600 mm of soil, which is considered to be the effective rooting depth of this plant. Soils with a minimum depth of 600

mm should thus be selected, with even deeper soils receiving preference. The tomato does well in humus-rich soils and will respond well if grown after a green manure or soil-improving crop.

Cultivar choice

There is a very wide range of cultivars available for planting. New cultivars are constantly being released by plant breeders. Growers are strongly advised to test any proposed new cultivar on a small scale, together with a proven one, for purposes of comparison. Should the new cultivar appear to have some advantage over the other one, the proportion of the planting made with the new cultivar could be increased. Such changes in cultivar composition of plantings should normally be gradual. Bear in mind that different cultivars may respond differently to changes in planting times, cultural practices and environmental conditions.

Various factors need to be considered when selecting cultivars for planting.

Probably the most important single factor is fruit quality.

The specific requirements of the proposed market need to be met. Here factors such as fruit firmness, size, shape, colour and uniformity, must be considered.

Adaptability and reliability of the cultivar are important.

One should be able to rely on fairly consistent high yields of a good quality, even under slightly less favourable growing conditions, which are likely to occur from time to time in any production area.

Susceptibility to various diseases and nematodes.

Many of the popular cultivars have some resistance or tolerance to one or more diseases or nematodes. The selection for resistance/tolerance to certain diseases can have important implications for successful tomato production in certain cases, and may also affect costs of production. No other vegetable crop is as subject to such a variety of diseases, control of which is required during the whole production season.

Plant growth habit.

A determinate growth habit indicates that the growing points of the plant, after some time, terminate in an inflorescence (flower cluster), thus restricting further growth. Such cultivars do not grow as tall as indeterminate types, where this growth restriction does not occur. They usually start bearing earlier, and the harvesting period is more concentrated than indeterminate cultivars. The final size of plants is dependent on environmental and cultural conditions, as well as on the specific cultivar grown.

This difference in growth between cultivars has very important implications. Determinate cultivars, with their shorter plants, can result in savings on trellising and spray costs, and will generally produce an earlier and more concentrated crop. The yield per unit of time is often greater than from indeterminate types (a more concentrated yield over a shorter period), which may be a disadvantage if prices drop to low levels at peak harvest. It also means that, where continuity of supply is important, follow-up plantings need to be made at shorter intervals than with indeterminate cultivars.

The specific market.

Processing cultivars possess certain qualities required for processing, such as high solids content. Apart from this, however, some communities prefer these cultivars for table use. Preferences may vary with regard to firmness, flavour, colour, shape, and so on, from one market to another.

Even with the so-called fresh market, or table cultivars, specifications may vary between markets. For example, the pre-pack market demands fairly small fruit,

whereas medium to large fruit are usually more popular in most retail outlets.

The planting time.
Apart from adaptability, it is frequently found that certain cultivars do better than others at particular times of the year. There is also a tendency for some otherwise very good cultivars to produce more defects, such as catface, under certain conditions (usually cool, moist conditions), whereas other cultivars may be relatively free of such defects. The larger-fruited cultivars generally show more catface than smaller fruited ones do.

Before making a decision on which cultivar(s) to grow, one should consult the local seedsman for advice, taking the above factors into account. Some popular cultivars grown in KZN are listed below.

Fresh market tomatoes
Florodade, Heinz 1370, Karino and Rodade are popular cultivars in the relatively cheap seed price range. Popular newer hybrids are Fortress, Hytec, Star 9001, Star 9003, Sundance and Zeal.

The new long-shelf life tomatoes, which are becoming popular, include Baldo, Blockbuster, Disco, P 747 and Shirley.

"Jam" or preserving tomatoes
HTX 14, Legato, RomaVF, Rossol, Star 9056F, Sun 6216 and UC 82B.
Cherry Tomatoes
Bamby, Josephine.
Tunnel Tomatoes
Atletico, Daniella, Gabriella

CULTURAL ASPECTS

The production of plants
The seed required, to plant one hectare varies from about 100 g to 200 g when using seedtrays, to 250 g if grown in seedbeds and up to about 2 kg if directly sown in the production field.

Tomatoes are, however, seldom direct seeded in the land. Plants are either raised in seedbeds or, more commonly these days, particularly when using expensive hybrid seed, in seedtrays.

Seedlings will emerge within 6 to 9 days after sowing at suitable temperatures of 20°C to 35°C.

Sowing times

cold areas	(heavy frost)	Sept - Nov
warm areas	(light frost)	Aug-Dec
hot areas	(no frost)	Dec-Mar, Jul - Sept

Seedbeds
Sites for seedbeds should not be exposed to strong winds, but there should be good air movement to reduce disease incidence. The site should be fully exposed to the sun. It should also be isolated from existing tomato fields, as these are a possible source of pest or disease problems.

As with the main production fields, a three-year rotation should be practised.

Well-drained, sandy loam soils are preferred. The soil needs to be well-prepared, relatively loose and in good tilth.

In many instances soil fumigation with registered compounds may be required for the control of nematodes; certain weeds and other pests and diseases may also be controlled with some of these chemicals. The soil should be limed if necessary, and should be well-fertilized.
Beds are usually made about 1 m wide, and about 150 mm higher than the pathways between them, to facilitate drainage. The beds should be level across their width, with no high spots (too dry) or low spots (too wet).

The seed is sown thinly, in shallow furrows drawn 100 mm to 150 mm apart, and covered to a depth of 10 mm to 15 mm. Frequent light irrigations are necessary to prevent drying out of top of the soil in which the seed is planted. Gradually increase the interval between irrigations to about 7 days when the plants are well-established.

About 250 g of seed, sown on 100 to 150 square metres of seedbed, should provide sufficient plants for one hectare.

Reduce watering over the last 7 to 10 days (but do not allow the plants to wilt severely), in order to harden them. 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.

Short, sturdy, slightly hardened seedlings, 100 to 150 mm tall, 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 fertilizer and over-watering. Under warm conditions, tomato seedlings may take only about 30 days to reach the transplanting stage, but this may extend to 60 days or more under colder conditions. Younger plants of the required size perform better than older ones. Only those seedlings which have reached the desired size are used for transplanting. Those developing more slowly may be transplanted slightly later, when they are more developed, but are less likely to perform quite as well.

Any weak, diseased or abnormal plants should be discarded. Lift the plants carefully, with as little root damage as possible, and cover them with moist sacks until transplanted. Lift only sufficient plants at a time to keep the planters busy.

Plant into moist soil for preference. Set the plants slightly deeper than they were in the seedbed, firm the soil around the roots and irrigate again as soon as possible after transplanting.

Spacing and plant populations
Processing crops are seldom trellised and row widths are determined by the straddle of the tractor and spray-rig, as well as the vigour and vine length of the cultivar used. In order to prevent trampling during spraying and harvesting operations, ensure that plant growth is confined to the tops of the bed, and does not spill over into the tractor wheelings, which are used to gain access for spraying and harvesting. A plant spacing of 300 mm to 500 mm in rows drawn 1,2 m apart will give a plant population of between about 16 000 and 28 000 plants per hectare.

If direct seeding is practised, it is common to drop 20 to 25 seeds per metre of row length, i.e. a 40 mm to 50 mm seed spacing down the rows. Thin out the plants to a spacing of 300 mm to 500 mm in the rows. Thinning is often unnecessary unless the stand is very thick, or in moister areas where diseases are encouraged by dense plantings.

For table tomatoes plants are invariably trellised. In this case, rows are generally spaced between 1,4 m and 2,0 m, occasionally even up to 3,0 m, apart.Plant spacing within

the rows varies from 300 mm to 500 mm. Populations of about 12 000 to 16 000 plants per hectare are commonly adopted. Row spacing is generally determined by the size of tractor and equipment which must move between the rows. It should be no greater than that needed for adequate access.

Rotational cropping

A three- , or even four-year rotation is advisable, mainly to reduce the risk of disease build-up. Related crops, such as potato, chilli, eggplant, sweet pepper, cape gooseberry, and tobacco, should not be included in this rotation, as they are often alternative hosts to some of the important tomato diseases and pests.

Trellising

It is generally accepted that there is seldom a marked difference between the total yields of trellised and untrellised tomatoes. However, there is frequently a very significant improvement in the marketable yield, and usually the quality, when the tomato plants are raised above the ground. The incidence of various diseases, pests and sunburn is invariably appreciably lower with trellised tomatoes. Plant parts and fruits touching wet ground remain moist longer, which favours the development of various diseases; such plant parts cannot be adequately covered by pest control chemicals, and many soil organisms or insects can easily damage them.

Staking, trellising or otherwise training tomato plants off the ground thus has many advantages. It is, however, an expensive practice in terms of both materials and, to some extent, labour. However, these costs are usually off-set against higher marketable yields, easier harvesting, less disease, insect and sunburn problems, and reduced injury to both plants and fruits during harvesting and other operations in the field. The practice of training is likely to be most profitable when a long harvest season is possible, fairly uniform production over the season is desired, and in areas where pests and diseases are more prevalent.

The major differences between fresh market and some of the newer processing cultivars is that the latter are generally shorter vined, have a more concentrated harvest and bear fruits with a thicker and tougher skin, which are less easily damaged. Trellising of the latter is then often not economically justifiable.

Trellising of the normal table cultivars is a standard practice. Many growers who produce processing cultivars for fresh use also resort to trellising but, when produced for processing, trellising is seldom practised.

Those growers considering the production of untrellised processing cultivars for the fresh market should take note of the following points:

A sound rotation system should be implemented to reduce the general disease and pest pressure.
All practical methods of pest and disease control should be implemented.
Routine spray control programmes for disease control should, if anything, be intensified rather than slackened.
Growing the crop over the cooler, drier periods of the year, particularly where there are no heavy dews, should reduce incidence of diseases, and also reduce sunburn.
Training the plants to lie on top of raised beds, rather than in furrows, will reduce fruit rot.
Plant spacing should be widened to about 500 mm between plants in the row when more vigorous growth is expected (warmer conditions), whereas a spacing of 300 mm to 450 mm may be adopted over the cooler season, when growth is not so rampant.
Select the more determinate cultivars, with good foliage cover but a relatively short top growth, early maturity and with as wide a disease resistance/tolerance as possible, especially to leaf diseases and fruit rots.
Consider direct sowing in the land, because it shortens the growing season, eliminates

the cost of transplanting and reduces disease problems because of the greater vigour of seedlings, as well as less root damage. However, greater attention to weeding and watering becomes necessary.

Once the plants are well established, avoid sprinkler irrigation and resort to drip or furrow irrigation, particularly when high atmospheric humidity is common. Keeping the foliage and bed surface as dry as possible, while maintaining a good moisture regime in the root-zone, is most important.

The training method most used by producers of fresh table tomatoes is briefly as follows:

Poles 2,0 m to 2,5 m long and 50 mm to 70 mm in diameter are planted in the rows to a depth of 600 mm, usually at a spacing of about 3 m. Poles at the ends of the row may be slightly larger, and should be well buttressed and/or anchored to prevent them being pulled over later, by the weight of vine growth in the rows.

When the plants are 300 mm to 400 mm tall, a 14 to 16 gauge wire is tautly stretched on either side of the plants down the row, at a height of about 300 mm. These two horizontal parallel wires are attached to the inner poles by means of baling wire. As the plants grow, additional pairs of wires are stretched along the rows and attached higher up the poles at intervals of about 300 mm to 400 mm. Altogether, four to seven pairs of wires may be needed, depending on the vigour and length of plant. Indeterminate cultivars will generally need more wires than determinate cultivars. Any plant growth is simply trained to grow between the sets of parallel wires. It is most important to attach the wires timeously; plants should never be allowed to hang down over the previously erected wire.

Cultivation

Cultivation between rows of young plants is done to keep the soil loose and to control weeds. However, the lateral spread of roots of the tomato is quite shallow and extensive. Mechanical cultivation should cease as soon as it becomes evident that roots may be damaged. Thereafter only shallow hoeing is recommended to control weeds.

Earthing-up of the soil against the stems of the plant is usually done when the plants are about 200 mm tall. Although there is little evidence of improved performance, this ridging does promote the development of additional roots from the stem and also reduces lodging due to strong winds, especially from untrained plants.

Pruning

The pruning of tomatoes is a general practice in some European countries. Trials done in South Africa, as well as reports from some states in the United States of America, indicate that, apart from the high cost aspect, pruning often reduces both early and total yield, as well as detrimentally affecting fruit quality and often increasing the incidence of virus diseases and other disorders.

Pruning is thus not recommended for outdoor culture of tomatoes.

Fertilizers

Most cultivars have the potential of producing yields in excess of 100 tons per hectare and thus have a fairly high nutritional requirement. They respond particularly well to organic manuring. In order to achieve satisfactory yields of an acceptable quality, balanced nutrition is very important. A suitable fertilizer programme, based on reliable soil analyses, should be developed for each field. In many areas of KZN, the main factors that limit yield and quality of tomatoes are high soil acidity, low soil phosphorus status, low soil nitrogen and potassium levels, and low soil magnesium or calcium content.

Soil acidity

Tomatoes are sensitive to high soil acidity. Soils of low pH often contain high levels of soluble manganese and aluminium, both of which can reach toxic levels, which adversely

affect growth and yield. Under such conditions soil phosphorus may be immobilised, rendering it unavailable to the plant, thus giving rise to phosphorus deficiency. Calcium, magnesium, nitrogen, potassium, sulphur and molybdenum also become less available under very acid soil conditions. Under alkaline conditions phosphorus, as well as boron, copper, zinc and manganese become less available.

While tomatoes prefer a pH (KC1) ranging from about 5 to 6, they can normally be grown fairly successfully even when the soils are slightly alkaline. They are only moderately sensitive to soil salinity and will perform better under such conditions than many other vegetable crops (beetroot and some cucurbits excepted). The pH of acid soils should preferably be raised to at least 5, and the acid saturation of the soil should ideally be less than 2% by adequate liming some while before planting.

Liming of acid soils will aid in reducing the possible toxic effects of elements such as manganese, will increase the tempo of decomposition of plant residues in the soil, thus releasing more nutrients, will increase the availability of nutrients such as phosphorus, and will supply nutrients, such as calcium and magnesium, for which the tomato has a fairly high demand.

MACRO-NUTRIENTS

Nitrogen (N)

The nitrogen requirement of tomatoes is generally considered to be moderately high, with some authorities suggesting only about 150 kg N per hectare, reducing this to 125 kg for certain cultivars such as Zest, which have a particularly good root system. However, in high rainfall areas, or for high production, a minimum of 250 kg N per hectare should be considered, for target yields of about 50 tons per hectare. Where higher target yields are expected, increase N by about 5 kg for every 2 tons over 50.

Usually about a quarter of the N is applied at planting. Much of the remainder is applied in the first 6 to 8 weeks of growth, at 2 to 3 week intervals, with further light dressings over the next six weeks or so. In order to maintain a balance with potassium (K), the use of potassium nitrate for some of these side-dressings is suggested.

Adequate nitrogen promotes better growth and better flower and fruit set. Deficiencies lead to poor uptake of other nutrients. Growth of shoots and roots is restricted. The first sign of nitrogen deficiency in tomatoes is a retardation of growth, followed by a change in the normal green colour, first noticeable in the tips of the younger leaves on the tops of the plants. These leaves remain small and thin and the entire plant gradually becomes light green to pale yellow in colour.

The veins of the leaves soon turn purplish, especially on the underside of the leaf. The stems become hard and fibrous, and may take on the deep purple colour found in the veins. Flower buds turn yellow and are shed; fruits are small and yields greatly reduced.

Nitrogen deficiencies most frequently occur in colder soils and after heavy rains which leach N. Deficiency symptoms are often seen towards the end of the season, especially under cool night temperatures, and during periods of drought.

Excess nitrogen delays maturity, favours disease development and reduces fruit size and fruit quality.

Phosphorus (P)

Phosphorus promotes root development and ensures more vigorous growth, especially of young plants. It also promotes early flowering and fruit set.

Where the phosphorus status of the soil has been built up over several years, 40 kg to 60 kg of applied P per hectare should be adequate. On the more acid soils, best results are

obtained by banding the fertilizer. An early symptom of phosphorus deficiency in tomatoes is the development of a purplish colour on the undersides of the leaves. The foliage eventually assumes a purplish tint, particularly at the tips of the leaves. The stems are slender and fibrous, leaves are small and the plants are late in setting and maturing fruit.

Potassium (K)
The potassium requirement of tomatoes is high. Plant analyses indicate that the plants take up about 50% more potassium than nitrogen. The major effect of high potassium is its influence on fruit quality, rather than on yield. The colour, taste, firmness, sugars, acids and solids of the fruit are all improved with adequate levels of potassium. It also strengthens plant cells and makes the plant less susceptible to attacks by many diseases. As chloride tends to reduce fruit quality, rather use chlorine-free fertilizers. A minimum of 100 kg K should be applied per hectare. Where target yields are greater than 40 tons per hectare, apply a further 10 kg K for each 2 tons extra.

A severe soil deficiency of potassium will result in symptoms showing up first on the older leaves at the base of the plant. With only moderate supplies of potassium, the deficiency symptoms may first occur in the middle of the plants and then move upwards to younger growth. Plants will grow slowly, be stunted and produce low yields of a poorer quality. The older leaves will have a dark bluish-green cast at first and develop a yellow-green tint along their edges. The leaf margins later become brittle, turn brown and finally die. The entire leaf may bronze and develop large yellow areas between the veins. Fruits ripen unevenly, often have a "blotchy" colour and lack solidity.

An excess of potassium, on the other hand, leads to a reduced uptake of, especially, magnesium. This can result in a magnesium deficiency.

The figures, supplied in Table 28 , give some indication of the N, P and K absorption by a good crop of tomatoes.

Table 28.
The absorption of N, P and K by a good crop of tomatoes.

	N	P	K
67 tons fruit	112	11	202
Plants	90	13	112
Total	202	24	314

SECONDARY AND MICRO-NUTRIENTS

Calcium (Ca)
Tomatoes have a high calcium requirement. Deficiencies may occur on acid soils, on soils with very high potassium levels, or under conditions of poor calcium uptake and translocation, such as drought conditions. The major symptom is that of blossom-end rot of the fruit, where there is a breakdown of the tissues, resulting in dark sunken areas on the blossom-end of the fruit. The use of calcium nitrate sprays will reduce the incidence of this condition.

Magnesium (Mg)
Magnesium deficiencies occur mainly on acid soils, on light soils subject to leaching, or on soils with high levels of potassium. Leaves of deficient plants tend to be brittle and curve upwards. The veins remain dark green, while the areas between them become yellow, generally from the base of the leaves. The yellow areas may finally turn brown and break down. Symptoms are most common on the older leaves of mature plants.

Sulphur (S)
Sulphur deficiency symptoms are similar to those of nitrogen. The lower leaves become yellowish-green, and stems are spindly, hard and woody. Unlike nitrogen (or phosphate or potassium), the increase in length of stems of sulphur-deficient plants is not reduced to any marked degree. Deficiencies are unlikely in industrial areas, but may occur in more isolated areas unless fertilizers such as ammonium or potassium sulphate, superphosphate or saaifos, which all supply sulphur, are used.

Boron (B)
Tomatoes are not often affected by a deficiency of this element. Where it does occur, the growing point of the stem has a blackened appearance. The plant appears bushy due to the growth of new leaves below the growing point.

Iron (Fe)
Iron deficiencies tend to occur only on calcareous, alkaline soils, or after heavy lime applications. The first symptoms occur in the younger leaves, and consist of a yellow mottling between the leaf veins. Tomatoes are not very prone to iron deficiency.

Copper (Cu)
Copper deficiencies are very seldom found in tomatoes, partly because of the emphasis on copper-containing chemicals in a disease control programme.

Zinc (Zn)
As with many other plants, zinc deficiency is characterised by poor development of leaves. Leaf petioles may be full size, but the leaves tend to be small. Fertilizers containing zinc should be used in areas where zinc deficiency is common.

Manganese (Mn)
Manganese deficiencies occur primarily in calcareous soils. It shows as a lightening of the green colour in the leaf areas furtherest from the main veins. This yellowing becomes more marked and extensive, and leaves may later die. Growth is spindly, little or no blossoming occurs, and no fruit forms, in severe cases.

Molybdenum (Mo)
Molybdenum deficiencies are common on very acid soils, but may occur even on calcareous soils. The older leaves become mottled, with pale green veins. The mottled areas often have a puffed appearance. New leaves are at first green but become mottled with age. Leaves tend to curl inwards.

IRRIGATION

Tomatoes can seldom be grown successfully without irrigation. The total water usage of a crop of tomatoes will vary tremendously, depending on the prevailing climatic conditions during growth. Thus, under hot and relatively dry summer conditions, 550 mm to 600 mm of water may be needed. In cooler and moister regions, the requirement for a summer crop may lie between 400 mm and 500 mm. However, in the frost-free coastal areas, a winter crop may need only 250 mm to 350 mm of water.

It is important that the root-zone be kept moist throughout growth. During the first two or three weeks after transplanting, wetting the soil to a depth of 400 mm should be practised as soon as about 25% of the available soil moisture has been utilised. From about three to nine weeks, the soil should be wet to a depth of 500 mm; the allowable depletion of soil moisture is about 40%. Thereafter, allow a depletion of, at most, 50% of available soil moisture, before irrigating to a depth of 600 mm.

The crop factors for tomatoes are 0,3 for the first 20% of the growing season, i.e. the first four to five weeks, 0,4 for the next 20% of growth, and 0,7 thereafter.

The lateral spread of roots can be up to 1 m or more. Irrigating the entire soil surface

area is advisable, except during the first month or so, when the plants are relatively small, and the roots have not yet spread to their full extent. During this initial stage, irrigation water may be confined to the planting furrows without any ill effects.

The use of sprinkler irrigation during the drier months, especially before the fruiting stage is reached, normally has no harmful effect. However, when the summer rains have started, and the plants come into bearing, sprinkler irrigation can increase the incidence of various diseases, especially in high rainfall or misty areas. Any method of irrigation which avoids wetting of foliage would then be preferred.

Good results have been obtained with drip irrigation, on the heavier soils at least, even though wetting is confined to a relatively small area of the potential root-zone.

WEED CONTROL

Weeds need to be adequately controlled because they are efficient competitors with the crop for nutrients, moisture and sunlight. Some of them might be hosts of pests and diseases of tomatoes, or they might provide shelter for insect pests. It is very important that weeds be controlled in the early stages of crop development, because early competition can more seriously affect plant growth, and result in the lowering of crop yields. Weed growth can also hinder the correct application of pest and disease chemicals, which are usually necessary in the production of tomatoes.

In most instances, weeds are controlled by means of mechanical and/or hand cultivation. Such cultivation needs to be started timeously, before any damage to the crop results from competition. The row spacing selected, especially in the larger plantings, is often such that mechanical weed control can be practised in the inter-row area during the initial stages of growth, with hand-hoeing or hand-pulling of weeds being applied in the plant rows. Because tomato feeding roots are wide-spreading and shallow, mechanical cultivation should preferably be discontinued in well-established plantings.

Chemical weed control is not normally practised in KZN. Nevertheless, there are a number of herbicides which are registered for use in tomato plantings

Pre-plant - trifluralin (sold as Trifluralin, Triflurex 480 and Digermin) sprayed onto well-prepared soil and incorporated immediately, for control of annual grasses and some broadleaved weeds.
Early post-emergence - metribuzin (Sable 480, Sencor 480 and Contrast Turfgrass) applied between rows a fortnight after transplanting, against annual grasses and broad-leaved weeds.
Haloxyfop - R - methyl ester (Gallant Super and Verdict Super); control grasses when young
Rimsulfuron (Cato); against young annual grasses and broad-leaved weeds.
Cycloxydim (Focus Ultra); against grasses

PESTS

Tomatoes are attacked by a very wide range of pests. The severity of attack will vary from place to place, and from season to season, but some form of pest control will generally be necessary on virtually every planting. The most important pests of tomatoes in KZN are the larvae of various moths (such as American bollworm, cutworms and Plusia looper), leaf miners, various mites , especially red spider mite, and root-knot nematodes. Several other mites, aphids, thrips and white fly can cause problems at times. See Table 29 for chemicals registered for their control.

American bollworm (*Helicoverpa armigera*)
The American bollworm is a major pest of many crops. On tomatoes, the larvae feed mainly on the flowers and fruit, and can cause tremendous losses if not controlled.

The creamy-white eggs, about 0,5 mm in diameter, are laid singly on the flowers and

leaves. They hatch within 3 to 5 days under good conditions. Young caterpillars are hairy and vary from black to dark beige in colour. When fully grown (after 2 to 3 weeks) the larvae are up to 40 mm long, and have a characteristic broad, white to pale yellow stripe on either side of the body. On the upper side are small black spots. Mature larval colours range from shades of green and reddish yellow, to reddish brown and black. The underside is greyish white. Pupation takes place in the soil. The adult moth has a wingspan of 40 mm, and a body length of 18 mm. The forewings have two characteristic brown markings, while the hindwings have two distinct pale spots. In the warmer parts of KZN bollworm is present throughout the year, although populations and damage are usually lower during the cooler months (with temperatures below 18°C).

Cutworm (*Agrotis* spp.)
The major damage is caused when the stems of young plants are cut off at or near ground level. Cutworms feed at night, and during the day can be found just below the surface of the soil next to the damaged plants. The caterpillars, which may reach a length of up to 35 mm, are usually a greasy-looking, grey to dark brown, almost black, colour with several black bumps (tubercles) on each segment. The nocturnal moth has brown or greyish forewings, and light brown hindwings.

Plusia looper (*Chrysodeixis acuta*)
The caterpillars are pale green, with a narrow white stripe along each side, and grow to a length of about 30 mm. They move around, in the characteristic manner of loopers, by arching their backs as they propel themselves forwards. The young larvae feed on the undersides of leaves, skeletonising them. Older larvae attack the fruit, eating shallow and often extensive cavities in them. The larvae pupate in frail cocoons. The forewings of adult moths are patterned with different shades of brown, and there are two distinct, oval, yellow spots near the middle of each wing. The wingspan is approximately 30 mm.

American leafminer (*Liriomyza trifolii*)
The bright yellow maggots, up to 3 mm long, make narrow, meandering tunnels between the upper and lower surfaces of leaves, leaving thin, black trails of excrement along the insides of these mines. The tunnels may coalesce when infestation is severe. Damage can be sufficiently serious to affect fruit set, and the incidence of sunburn also increases.
Adult flies are about 2 mm long. They have pale, brownish yellow undersides and black upper-parts, with a yellow spot between the wings.

Leafminer/potato tuber moth (*Phthorimaea operculella*)
The larvae are small caterpillars, which grow to a length of 12 mm. They are pale, creamy grey when young and become greenish white or pink when older, with dark brown heads. The adult moths are pale, silvery grey or silvery brown, with faint, dark speckles on the wings. They are about 8 mm long and have a wingspan of about 15 mm.
On tomatoes, the caterpillars make irregular channels within the leaves and leave brown spots on the leaves. They sometimes also mine in the stems. Breeding takes place throughout the year, slowly in winter but extremely rapidly in summer, when a generation can be completed in less than one month.

Aphids (several kinds)
The green peach aphid (*Myzus persicae*) is probably the most important. These aphids are soft-bodied, slow-moving insects about 1,5 mm to 2,5 mm in length, with long, spindly legs, and may be winged or wingless. Twenty or more generations are completed within a year. They have a wide host range and are present throughout the year. Numbers increase in summer.

Severe aphid infestations under dry conditions can cause early die-back of plants.

However, the direct damage caused by these sap-sucking insects is less important than the transmission of virus diseases by the pest.

Red spider mite (*Tetranychus* spp.)
Females are brownish red, roughly oval, up to 0,5 mm long and eight legged. They are most

numerous and serious in hot, dry weather, with numbers frequently declining after rain. Population numbers can increase dramatically under favourable conditions, especially if their natural enemies are harmed by the use of certain pesticides. Resistance to specific miticides is common and often develops rapidly.

Red spider mites prefer to feed on the lower sides of the leaves but, as populations increase, they spread over the whole plant.

Initially, chlorotic stipples may be observed on the upper side of leaves. Later, leaves may yellow, become bronzed and dry out. Fine webbing is conspicuous and clearly visible when infestation is severe.

Rust mite (*Aculops lycopersici*)
Rust mites are minute, about 0,2 mm long and torpedo-shaped, with cream to orange-yellow bodies.

The first sign of damage is a curling up of the lowest leaves, which show a silvery gloss on their lower surfaces. Later the leaves become bronzed, wither and eventually die. Stems become purplish brown. Fruits become rusty brown and coarse, with surface cracking.

Erinose mite (*Eriophyses lycopersici*)
These mites are microscopically small. They cause the formation of dense patches of fine, white hairs on the younger leaves and stems. They are generally confined to tropical and subtropical areas.

Thrips (several kinds - mainly *Thrips tabaci*)
These are small, quick-moving insects, about 1 mm to 2 mm long, torpedo-shaped, and yellowish in colour.

They feed on flowers and young fruit, by rasping the surfaces and sucking the sap from the broken cells. They cause blossom drop and scarring of the fruit, with some malformation of the leaves.

The pest is most important as a vector of kromnek (spotted wilt virus), which is a serious disease of tomato and potato.

Nematodes
Several different nematodes can attack tomatoes. They are generally more prevalent in the sandier soil types and during warm conditions, with numbers reaching a peak in mid-summer.

The root-knot nematodes (*Meloidogyne* spp.) are probably the most important eelworm affecting tomatoes. They attack the plant roots, causing galls to develop, and reduce the size and efficiency of the root systems. Plant growth is stunted, fruit set is reduced and yields and quality of the crop is affected adversely. Plants show drought symptoms and may sometimes wilt and die, even in the presence of adequate soil moisture. Symptoms are more pronounced in certain patches/areas of the land than in others.

Table 29.
Pesticides registered for use on tomatoes.

Chemical	Formulation		Safe Period (days)	Sold as	1	2	3	4	5	6	7	8	9	10	11
abamectin	EC	18 g/l	3	Abamectin Plus, Affirm, Agrimec, Epimek, Sanamectin, Vertimec											
acephate	SP	750 g/kg	3	Ace, Acephate, Orthene, Racet 750 SP											
aldicarb	GR	150 g/kg	80	Temik											
alphacypermethrin	EC	100 g/l	4	Fastac											
alphacypermethrin	SC	100 g/l	-	Concord, Fastac											
amitraz & bifenthrin	EC EC	200g/l 100g/l	5	Mitac & Talstar											
Bacillus thuringiensis var *aizawai*	WG WG	15000 IU/mg 25000 IU/mg	-	Florbac, XenTari Agree											
Bacillus thuringiensis var. *kurstaki*	WP	16 000 IU/mg	-	Thuricide, Dipel											
Bacillus thuringiensis var. *kurstaki*	WP	32000 IU/mg	-	Biobit, Dipel 2X											
betacyfluthrin	EC	50 g/l	3	Bulldock											
bifenthrin	EC	100 g/l	5	Talstar											
bifenthrin	TB	0.18g/tablet	5	Talstar											
bifenthrin	TB	0.018g/tablet	5	Talstar											
cartap hydrochloride	SP	500g/kg	7	Suntap											
chinomethionat	WP	250 g/kg	3	Morestan											
chloropicrin/EDB	AL AL	1028/250g/l 400/500g/l	-	Bacfume 60 Bacfume 30											
chlorphenapyr	SC	360g/l	3	Hunter											
chlorpirifos	SC	240g/l	4	Dursban											
chlorpirifos	EC	480 g/l	4	Agropyriphos, Clorpirifos, Dursban, Pyrinex, Pyrifos, Lirifos, Avi-Klorpirifos, Phantom, Rochlop											
copper oxychloxide/sulphur	DP	85/900g/kg	3	Coppasulfa, Copper Sulphur, Copsul											
cyfluthrin	EC	50 g/l	3	Baythroid											
cyhexatin	SC	600 g/l	3	Acarstin Flo											
cypermethrin	EC	20g/l	4	Fruitfly, Garden Ripcord, Ripcord 11											
cypermethrin	EC	200 g/l	4	Avi-Sipermethrin, Cymbush, Cypermethrin, Doodskoot, Magnum, Polythrin, Ripcord, Rocyper, Serpa, Sipermethrin, Supermethrin											
cypermethrin-high cis	EC	200 g/l	4	Fenon											
cyromazine	WP	750 g/l	3	Patron											
deltamethrin	EC	25 g/l	2	Decis											
deltamethrin/endosulfan	SC	2.5/475g/l	2	Kracket											
demeton-S-methyl	EC	250 g/l	21	Dematox, Demeton											
diafenthiuron	SC	500g/l	4	Polo											
diazinon	EC	275 g/l	14	Kayazinon											
1,3-dichloropropene	AL	1110 g/l	-	DD92 Soil Fumigant											
dichlorvos	EC	1000 g/l	2	Dichlorvos, Dedevap, Devipan, Nogos,DDVP											
dicofol	WP	185 g/kg	7	Kelthane											
disulfoton	GR	50g/kg	-	Disyston, Diurafton							a				
EDB	AL	1800 g/l		EDB, EDB MO											

Chemical	Formulation		Safe Period (days)	Sold as	1	2	3	4	5	6	7	8	9	10	11
endosulfan	WP	475 g/kg	1	Endosulfan, Thionex											
endosulfan	EC	350 g/kg	-	Endosulfan, Sulfan, Thionex											
endosulfan	SC	475 g/kg	1	Thioflo											
endosulfan	DP	50 g/kg	1	Endosulfan,											
esfenvalerate	EC	50 g/l	2	Sumicidin Super											
fenamiphos	EC	400 g/l	-	Nemacur											
fenamiphos	GR	100 g/kg	-	Nemacur											
fenazaquin	SC	200g/l	7	Pride											
fenbutatin oxide	SC	550g/l	3	Torque											
fenpropathrin	EC	200 g/l	4	Meothrin											
fenpyroximate	SC	50g/l	7												
fenvalerate	EC	200 g/l	2	Sumicidin, Agrovate, Fenvalerate, Sanvalerate											
lambda-cyhalothrin	EC	50 g/l	2	Karate											
lufenuron	EC	50g/l	3	Sorba											
mercaptothion	WP	250 g/kg	1	Mercaptothion, Merkaptotoks											
mercaptothion	EC	500 g/l	1	Mercaptothion, Malathion, Datathion, Malasol, Avigard, Garden Insects											
mercaptothion	DP	50 g/kg	1	Kopthion, Avi-Mercaptothion, Stink Powder											
metam-sodium	AL	382-510 g/l	-	Herbifume, Busan											
methamidophos	SL	585 g/l	3	Methamidophos, Tamaron, Midofos, Sniper, Methaphos, Metamidofos, Patrole, Rometa, Thamido									c		
methomyl	SL	200 g/l	2	Methomyl, Lannate, Methomex											
methomyl	SP	900 g/kg	2	Methomyl, Lannate, Kuik, Methomex, Methosan											
methyl bromide/chloropicrin	GA	980-1 000/20 g/kg	-	Methyl bromide, Metabrom											
mevinphos	EC	150 g/l	2	Mevinphos											
oxydemeton-methyl	EC	100g/l	21	Metasystox R liquid											
oxydemeton-methyl	EC	250 g/l	21	Metasystox R											
oxamyl	SL	245 g/l	21	Vydate											
oxamyl	GR	100 g/kg	21	Vydate											
permethrin	EC	500 g/l	3	Sanathrin, Ambush											
profenofos (premium grade)	EC	500 g/l	4	Selecron											
propargite	EC	590 g/l	4	Omite											
propargite	EC	800 g/l	4	Comite											
pyrazophos	EC	295g/l	3	Afugan											
quinalphos	RB	5 g/kg	-	Bonus											
sodium fluosilicate	RB	100 g/kg	-	Cutworm Bait, Cutworms											
sulphur	WP	800 g/kg	-	Wettable Sulphur											
sulphur	DP	980 g/kg	-	Dusting Sulphur, Vine & Dusting Sulphur											
tau-fluvalinate	EW	240 g/l	2	Klartan											
thiometon	EC	250 g/l	7	Ekatin											
tralomethrin	EC	36 g/l	2	Tralate											
trichlorfon	SP	950g/kg	3	Trichlorfon, Dipterex, Dipterex Soluble Powder											

1	=	Cutworm
2	=	Nematode
3	=	American bollworm
4	=	Plusia Looper
5	=	American leafminer
6	=	Leafminer
7	=	Aphids
8	=	Thrips
9	=	Red spider mite
10	=	Rust mite
11	=	Erinose mite

a	=	seedbeds only
b	=	bait
c	=	suppress only

DISEASES

Tomatoes can be affected by many diseases, several of which cause serious losses. Before planting, each grower should be aware of which diseases are most likely to occur locally in any specific planting, so that timeous control measures may be implemented. Select those cultivars or cultural practices that reduce the impact of key diseases.

One should know from where a pathogen originates, how it disperses and infects the plant, and what environmental conditions favour disease development. It is most important to be able to identify the various diseases, particularly in the initial stages of the infection, and to know which methods of control are most likely to be successful.

Disease avoidance is one of the major factors to consider. Here one may consider the selection of cultivars showing resistance or tolerance to specific diseases. Site selection, disease-free seed or transplants, crop rotation, planting times, irrigation practices, good general sanitation, good nutrition, and many other cultural practices, which encourage strong, active growth, should all be taken into account. They lessen the chances of disease infection, and may reduce the impact of diseases, should these occur.

Chemical control of many diseases often becomes essential. Most of these chemicals have a preventative action only, and cannot cure infected plants. They are used by regularly depositing a layer of chemical on the plant parts to prevent initial infection or, where light infections have occurred, to prevent or reduce the spread of the disease from infected to healthy tissue.

A routine preventative spray programme to control early and late blights, as well as certain bacterial diseases, is generally advisable.

SOME IMPORTANT FIELD DISEASES OF TOMATO

Early blight (*Alternaria solani*)

Early blight occurs on leaves, commencing on older leaves. Small dark lesions, enlarging to have concentric rings in the lesions (hence the alternative name target spot), with surrounding areas becoming chlorotic (yellow), are the initial symptoms. With increasing numbers of lesions, leaves die and fruit is exposed to danger of sunscald. If uncontrolled, the plant is defoliated.

On seedlings, stem lesions are small, dark, slightly sunken and may girdle the stem; also dark lesions occur on mature stems and branches.

Fruit is infected at the stem or calyx end, enlarging to show concentric ringing on lesions, which may develop velvety black colouration. Extensive dry infection of inner flesh develops.

The disease is favoured by humid conditions, but can occur in drier situations where heavy dews occur. Setbacks to growth which cause physiological aging or weakness of plant tissues promote disease incidence. Younger plants with vigorous growth which are damaged by hail are also attacked at the damaged marks, if inoculum of the fungus is present.

Some cultivars are less susceptible than others. Keep plants actively growing, with balanced nutrition. Practise crop rotation, and bury crop residue deeply. A regular spray programme, at 7 to 10 day intervals, depending on the season and vigour of plants, is required. If seedbeds are used, transplants should not show collar rot.

Late blight (*Phytophthora infestans*)

This blight is quickly destructive if unprotected plants are infected during prolonged cool, damp spells. Water-soaked, light olive-green lesions changing to dark areas occur on leaves, with white, light mould growth on the underside of leaves, particularly at the edge

of the lesion in moist conditions. Lesions enlarge and the affected area dries. Petioles and stems are also infected, dark in colour; whole plant may die as a result. Fruit lesions are large, may affect the whole fruit, the fruit surface is a greasy, dark, olive colour, slightly rumpled; white mould can be present on infected area in wet, overcast weather.

Infection occurs when foliage is wet during extended cool conditions.

No cultivars show resistance. Use healthy transplants. Follow regular spray programme.

Leaf spot (*Septoria lycopersici*)
This is not as prevalent as the previous fungal diseases described, but this disease can be destructive under prolonged wet conditions and mild temperatures.

Small circular leaf spots, with dark margins and light grey centres with black pinprick markings, appear on the lower leaves, usually after first fruit set. Lesions also develop on stems, leaf petioles and calyx of fruits and are smaller and darker. Not a problem on fruit. Rotation of two years without tomatoes. Time irrigation to allow foliage to dry quickly, or use furrow or drip irrigation. Improve air circulation. Avoid worker and equipment contact with wet foliage. Follow a regular spray programme. Deep ploughing of crop residues will help avoid the disease.

Powdery Mildew (*Oidopsis taurica)*
Although known for some time in South Africa, this disease only recently became a production limiting factor in some areas. Incidence coincides with the increased practice of drip irrigation at the base of rows. More commonly seen on upper areas of plants than at base, it has somewhat inconspicuous symptoms. Small light green to yellow areas, with necrotic spots developing in the centre of the lesions, are seen on the upper surfaces of the leaves. On lower surfaces, a light grey mould develops, coinciding with the chlorosis of upper surface spots. Severely infected leaves die, but do not necessarily drop from the plant.

Commercial cultivars are susceptible. Rotate with crops other than tomatoes. Observe the crop closely for powdery mildew occurrence, then spray several times to check the disease.

Fusarium wilt (*Fusarium oxysporum* f.sp.*lycopersici*)
The disease was important in summer tomatoes in acid, sandy soils. The causal fungus can survive in the soil for lengthy periods.

Infected young plants are stunted and older leaves droop. Later in the season early symptoms are chlorosis of older leaves which gradually affects most of the foliage; plants wilt during the heat of the day and wilting becomes more severe until the plant collapses, with dead leaves. If the lower portion is cut along its length, the exposed vascular system is brown, but the inner pith tissues retain a normal colour.

Various strategies can be used to control the disease - long rotations, raising of soil pH levels and sanitation procedures. However, a number of the commercial cultivars available are resistant to races 1 and 2 of the causal fungus. Race 3 is also present in some areas.

Bacterial wilt (*Pseudomonas solanacearum)*
Prior to the release of cultivars with resistance to bacterial wilt, tomatoes could only be produced in the cool winter soils of the frost free areas of the Lowveld and KZN coast, because the disease survives endemically in infested soils.

The disease is very widespread in tropical, subtropical and warm, temperate regions of the world. Once introduced by infected seedlings, contaminated irrigation water, or on

implements or boots, the pathogen can survive in a soil indefinitely.

First sign of infection is a slight softness and wilting of some of the youngest leaves. This occurs at any stage of growth. With continued warm to hot weather and warm soils, a rapid and complete wilt occurs within a few days of the initial symptoms. Roots do not show obvious signs of infection, but browning of vascular tissues may be seen in roots, but not the stem, at an advanced stage of the disease assault. A clean, freshly-cut stem of a wilted plant will exude a cloudy thread of bacterial cells into water in a clear glass or bottle, provided the container is not shaken or jolted. This phenomenon is characteristic of bacterial wilt.

Bacterial canker (*Clavibacter michiganensis* subsp*.michiganensis)*
This disease can be destructive, but occurrence is sporadic. Use of rotation and healthy seed have reduced its importance and frequency.

Systemic wilting of the plant may be the only external indication of infection. Leaflets wilt, often on one side of the plant, and brown cankers may or may not develop on stems. Internally, vascular tissues change to light to medium brown, and the pith changes slightly in colour and texture when the disease is quite advanced. Fruit symptoms are characteristic but do not always occur. Fruit spots are slight, brown and raised, and surrounded by a white halo.

Control is vested in avoiding the disease. The incidence of canker infection carried on seed is very low, and heat or chemical treatment of the seed is advisable if the seed may have been produced in an area where the disease was present. Wire and stakes, if re-used for tomatoes, should be dipped in a bleach (sodium hypochlorite) solution. Crop rotation is advisable. If the disease has been present in a planting, plant residues should be well incorporated into the soil.

Bacterial spot, Bacterial speck *(Xanthomonas campestris* pv*. vesicatoria, Pseudomonas tomato* pv*.tomato)*
These two diseases are considered together because the symptoms they cause are similar and the spray control programme is the same. One or the other disease is often present at some stage of tomato crop growth, so the diseases cannot be ignored as a minor hazard. The symptoms are found on all above-ground parts of a plant. The lesions are dark in colour and irregularly round. Spots are at first minute, but may develop to about 3mm diameter in the case of bacterial spot, and smaller with speck infection. On fruit, lesions may be flat or slightly raised from the fruit surface and could have a somewhat darker green halo around a lesion. On leaves with a number of lesions there is leaf chlorosis. The dead leaves remain on the plant.

Both diseases are favoured by free moisture. Bacterial speck tends to develop more rapidly at cooler temperatures (18 °C to 24 °C) than those that favour bacterial spot infection (24 °C to 30 ° C). Speck is most commonly spread by the droplets of rain splash (or sprinkle irrigation). Bacterial spot spreads in wind-driven rain droplets or in aerosols, which occurs with very fine, misty conditions.

A two-year rotation is advocated to reduce carryover of infection. The diseases, and especially speck, can be seedborne, so hot water treatment is recommended if there is a possibility of infected seed. If transplants are purchased, check that there is no infection, as it will spread quickly under nursery conditions. Ensure tomato volunteer plants from a nearby field are eliminated. Finally, an appropriate bactericidal programme should be built into the spray programme, and frequency of application increased when one of these diseases is observed in a planting.

TOMATO SPRAY CONTROL PROGRAMME

Regular spraying (4 to 10 day intervals) is a prerequisite with tomato cropping. Even if conditions entirely favour disease-free growth, fortnightly fungicide sprays should be applied. Ensure full coverage and penetration of a bush, but not beyond the drip stage. A routine preventative spray programme would normally contain either chlorothalonil or mancozeb, with a fixed copper fungicide for several weeks included once or twice a month. Under conditions favouring the development of bacterial speck or bacterial spot the copper-containing fungicide should be included with every spray.

A very comprehensive range of fungicides is registered (see Table 30).

Table 30.
Fungicides registered for use on tomatoes.

Chemical	Formulation	Safe Period (days)	Sold as	1	2	3	4	5	6	7
benalaxyl-mancozeb	WP 80/650 g/kg	7	Galben M					a		*
benomyl	WP 500 g/kg	3	Bendazol, Benlate, Benomyl, Pilarben, Spotless							
captab	WP 500 g/kg	7	Captab, Kaptan							
captab	WG 800 g/kg	7	Merpan							
chlorothalonil	WG 750 g/kg	3	Fungistop							
chlorothalonil	SC 500 g/l	3	Bravo, Bravo Plus, Clortosip, Chloronil, Chloroflo, Daconil, Fungistop, Kynothal, Mycoguard							
chlorothalonil/metalaxyl	SC 500/75g/l	7	Folio							
chlorothalnil/metalaxyl-m	SC 500/37.5g/l	7	Folio Gold							
copper-ammonium carbonate	SL 661 g/l	3	Copper Count-N							
copper hydroxide	WG 538 g/kg	3	Kocide 2000							
copper hydroxide	WG 614 g/kg	3	Kocide							
copper hydroxide	WP 770g/kg	3	Funguran-OH, Champion, Hydrox, Kocide, Supacop							
copper oxychloride	WG 850-860g/kg	3	Copperoxychloride, Copper Oxychloride							
copper oxychloride/sulphur	DP 85/900 g/kg	3	Coppasulpha, Copsul							
cymoxanil/mancozeb	WP 40/466g/kg	7	Rimit							
cymoxanil/mancozeb	WP 60/700g/kg	7	Curzate Pro, Fungarrest, Optimo, Zetanil							
cymoxanil/propineb	WP 60/700 g/kg	7	Milraz							
difenoconazole	EC 250g/l	7	Score							
iprodione	SC 255 g/l	3	Rovral Flo							
iprodione + mancozeb	SC + WP	3								
iprodione/mancozeb	WP 200/500g/kg	3	Rovral-M							
mancozeb	WP 750 g/kg	3	Mancozeb, Dithane M45, Penncozeb							
mancozeb	DP 800 g/kg	3	Dithane M45, Mancozeb, Miceb Super, Sancozeb, Tridex							
mancozeb/metalaxyl	WP 600/100 g/kg	7	Expose MZ, Fundi,Milor MZ, Sanlaxil							
mancozeb/ofurace	WP 640/60g/kg	3	Pantafol Plus							
mancozeb/oxadixyl	WP 560/80 g/kg	7	Recoil, Sandofan					* *		
maneb/zinc oxide	SC 435/4.7g/kg	3	Manager,Trimangol,Vondac							

Chemical	Formulation		Safe Period (days)	Sold as	1	2	3	4	5	6	7
metiram	WG	700 g/kg	3	Polyram							
procymidone	SC	250g/l	3	Sumisclex							
procymidone + mancozeb	SC WP	250 g/kg + 800 g/kg	3								
propineb	WP	700 g/kg	3	Antracol							
tebuconazole	EC	250 g/kg	7	Horizon							

1 = Bacterial spot
2 = Bacterial speck
3 = Botrytis
4 = Early blight
5 = Late blight
6 = Powdery mildew
7 = Septoria leaf spot

a. Apply no more than 4 times per season
b. Apply no more than 5 times per season
c. Apply no more than 8 times per season
d. Effective only against light infections

HARVESTING, GRADING, PACKING AND MARKETING

The harvesting, grading, packing and marketing costs of tomato production are generally at least as high as the pre-harvest costs and, with a good crop, may be more than double this figure. A reduction in these costs of only ten cents per standard tray, which is quite possible on the cost of the container alone, will result in an increase in gross margin per hectare of R700.00 from an average yield of 7 000 trays, and double this from a good yield. A ten cent increase in price achieved will have a similar effect on the financial returns. The converse also holds true.

It is thus clear that quite large differences in profitability may be found between producers achieving similar yields, depending on these aspects. The financially more successful growers, apart from producing high yields of good quality, also tend to pay more attention to marketing.

Better supervision of labour during harvesting, grading and packing can improve productivity, thus reducing costs. It can also result in better grading, better presentation of the product and thus better prices being achieved.

Apart from the supply and demand situation, the quality of the fruit offered for sale, as well as its presentation, largely determines the prices achieved. Apart from colour and ripeness, the quality is highest at picking, and every effort should be made to retain this quality for as long as possible. The fruit, especially of the table cultivars, is much more perishable and easily damaged than is generally realised. Bruises or scarring caused by rough handling may not be immediately apparent, but often show up only after the fruit has reached the market, or ripened up fully. This may cause down-grading or reduce "eye-appeal", and result in lower prices being realized.

The fruits should be picked, graded and generally handled with great care, so that as little damage as possible is caused. Growers should, periodically, make a point of inspecting their product **at the point of sale**, and comparing it with other consignments on offer, to assess whether or not they need to pay more attention to any marketing aspect.

Harvesting

The stage of maturity at which the fruit is picked, as well as the intervals between picks, is determined by several factors. For distant markets or where there are large time delays between picking and marketing, the fruit needs to be harvested at a less mature stage. This also applies under high temperature conditions, which hasten fruit ripening and deterioration. The market preference also plays a role; processors and certain communities prefer fully coloured fruits, whereas most retail outlets favour less mature fruits. Tomatoes are picked at the following stages of maturity:

The pale green stage; fruits which have reached this stage of development will continue to ripen internally, as well as develop the characteristic red colour of ripe fruit, whereas less mature fruits will never ripen or colour up properly. These fruits have a pale green colour, particularly around the blossom-end of the fruit, the contents of the seed cavity are jelly-like and fill the entire seed cavity; the hard dry appearance will have disappeared. It should be possible to cut such fruits in half with a **sharp** knife, without cutting the seed which should simply push aside into the softer flesh. By cutting a few fruits occasionally, and noting the difference in skin colour between the pale green stage and less mature fruits, pickers can be taught to recognise fruits that are ready for harvest. Great care must be taken not to harvest immature fruits, as these will not ripen satisfactorily.

The early light-red stage; fruits at this stage have just begun to show a red tint, usually at the bottom end, but sometimes on the sunny side of the fruit.

The light red stage; at this stage of maturity, virtually the entire fruit shows a rosy

or light-red colour. During continuous cool weather it is sometimes advisable to pick tomatoes at this stage for sale at relatively nearby markets. However, colour development is rapid at this stage of development under hot conditions, and the danger exists that a portion of the crop may become over-ripe, particularly during harvest peaks, and over holidays or weekends. Long shelf-life tomatoes are not picked earlier than this stage.

The red or ripe stage; the greater portion of the fruit has developed the full red colour, but should still be firm, without any signs of softening. Daily picking is essential, and should be used only for nearby markets where the demand is for fully coloured fruits.

Fruits of the desired maturity are picked by hand. Lug-boxes, baskets or other suitable containers are used for gathering the tomatoes and transporting them to the grading and packing shed.

Grading

After picking, the fruit is generally graded according to size, either mechanically or by hand, as well as by colour and quality. First grade fruits must be sound, free from diseases, cracks, blemishes, foreign matter or spray residues, and be well-shaped and uniform in size and colour. Well-graded fruits will generally command better prices on average than ungraded fruits. It is usually better to grade too strictly rather than too leniently. Uniformity of the grade is most important.

Packing

Each size, colour and quality grade is packed separately for marketing. The material used for packaging must be new, clean and of such a quality as to properly protect the fruit during transit and marketing. The general appearance of the container should enhance rather than detract from the appearance of the consignment, because price can be affected by eye-appeal.

The better grades of fruit are usually packed tightly in standard tomato trays (wooden boxes or cartons), in a specific pattern determined by fruit size. Lower grades are usually jumble-packed into similar containers.

Marketing

Marketing is one of the most important aspects of production and sales, and yet it often receives the least attention. Market research is essential for successful marketing. One should know which market outlets are financially the most rewarding, the size of the markets, who the potential customers are, what fruit size, colour and general quality they prefer, how they want it presented, whether cartons, wooden trays, lugs or other containers are preferred, whether or not the product needs to be carefully graded or packed, whether or not highly-coloured, attractive labels are likely to command better prices, and so on. One should weigh up the merits of using fully made-up trays or making one's own, or the use of own transport compared with transport contractors. Many aspects need to be considered. Having gathered this information one should concentrate on meeting these needs. This might possibly require a change in cultivar grown, or changes in cultural practices, such as times of planting.

Market research should be on-going. Periodic visits should be made to various market outlets to assess needs, to compare one's standards of quality, grading, packing, trays, and labelling with those of one's competitors, and to try to ascertain whether or not any changes are called for.

Table 31.
Total tonnages sold on Durban National Market per year from 1993 to 1997, and mean annual prices (R per ton obtained).

	1993	1994	1995	1996	1997
Tons sold p.a.	23 231	21 326	22 2664	25 443	27 093
Ave R/ton	956	1199	1304	1430	1394