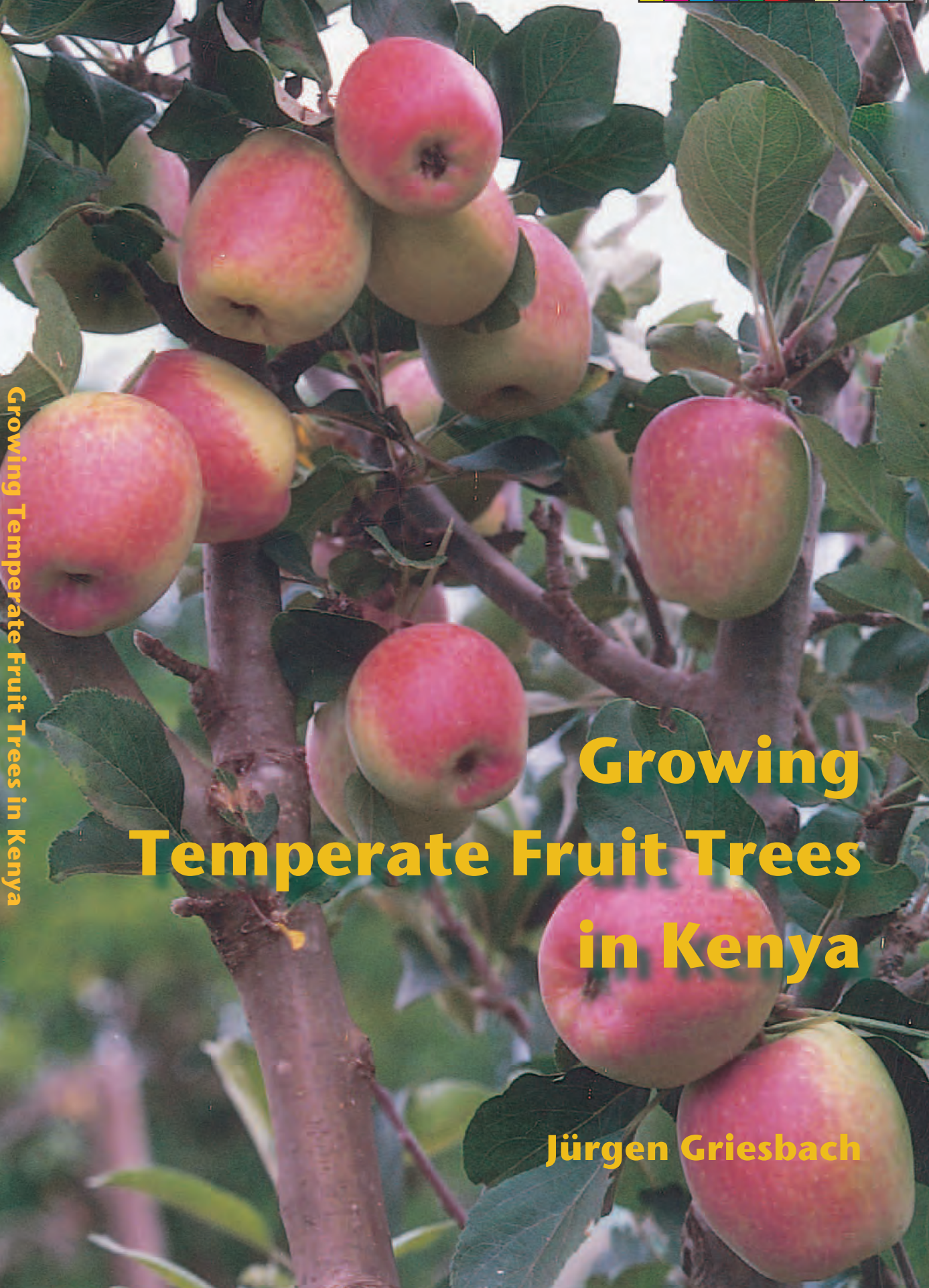

Growing Temperate Fruit Trees in Kenya

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WORLD AGROFORESTRY CENTRE

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Contents

Foreword

Global production of fruit has tripled over the past 40 years, with most of the increases being recorded in the temperate regions. These production increases partly reflect rising demand, but there has also been a strong push from improved varieties and advances in fruit tree husbandry. Notwithstanding significant advances in some tropical fruits (e.g. mangoes and avocados) the opportunities to grow, consume and export more fruit from tropical regions remain under-exploited compared to temperate regions. A somewhat surprising but often neglected aspect to addressing this imbalance is the cultivation of temperate fruits in tropical regions.

This volume describes the cultivation in Kenya of the world's four major temperate fruits, namely apple, pear, plum and peach. Together, these fruits account for 15% of all world fruit production, yet currently in the East African region they account for just a very small fraction of regional fruit production. The four key reasons identified through regional stakeholder surveys centre around (a) lack of awareness, (b) lack of elite planting materials and propagation knowledge, (c) lack of effective dissemination methods for cultivar multiplication and delivery, and (d) absence of market value chains. *Growing Temperate Fruit Trees in Kenya* will be highly instrumental in addressing the first two constraints, which are linked to market development.

The author, who is an expert with more than 40 years of experience in horticulture in East Africa, including Kenya, Uganda, Rwanda, Tanzania and Congo, brings a practical flair to a wide range of topics from the history of temperate fruit tree cultivation to botany, propagation, establishment and maintenance. The recommendations, guidelines and illustrations in the book are the platform for the author's detailed varietal descriptions complemented by colour photographs of more than 50 varieties.

Fruit preferences are as much of a cultural phenomenon as they are an agroclimatic or a physiological one. Even though most of the information on temperate fruit growing contained in this publication is based on experiences gained in Kenya, a lot of it will also apply to highland areas in other East African countries. However, adaptive research will be needed to validate these recommendations in similar agroecological zones before embarking on large-scale production by smallholder or commercial growers.

We are confident that the practical information contained in this book will engender a greater temperate fruit growing culture in East Africa. This in turn may benefit local household nutrition, rural incomes and export opportunities.

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TEMPERATE FRUIT TREES IN KENYA

The cultivation of temperate fruit trees in Kenya dates back to the arrival of European settlers who brought with them the species they grew and consumed in Europe. Efforts to grow temperate fruit trees—which include apples, plums, peaches/nectarines and pears—can thus be traced back over a century. Many cultivars, as well as different types of rootstock, were introduced, observed and evaluated. Although the cooler highlands with a climate more-or-less similar to that of the temperate zones were an obvious choice for the cultivation of temperate fruit trees, soon a number of problems emerged:

- Insufficient chilling in most locations resulted in poor bud-break;
- Lack of temperate-zone seasonality resulted in a deficiency in the heat units needed for the production of good quality fruits;
- In some locations, high humidity promoted the spread of fungal and bacterial diseases as well as the proliferation of lichens and parasitic plants.

Despite these constraints, over the years it has been demonstrated that—within certain limitations—temperate fruit trees, including grapes, can be grown quite successfully in the cool, tropical highlands in Kenya. However, the further removed a crop is grown from its optimum environment, the greater is the skill required in the fruit grower. Local observation and experience have indicated the types/cultivars of temperate fruits best adaptated to specific local environments—indeed, some cultivars have shown themselves to be satisfactory under quite diverse ecologies.

Temperate fruits contribute to the horticulture industry by providing an alternative to the tropical and subtropical fruits normally grown in Kenya, which do well only in lower-elevation, warm ecologies.

At present, the supply of locally produced temperate fruits in Kenya is limited in quantity, quality and seasonality. According to figures published by the Kenya Revenue Authority, Kenya imported 2,581 tonnes of apples in 2005, representing an expenditure of KShs. 109.5 million (approx. US$ 1.5 million) If other temperate fruit species are included, the total average expenditure was about KShs. 139 million (see **Appendix 1**).

In 2005, local annual production of apples was approximately 1,431 tonnes (**Appendices 2a and 2b**). Pear, plum and peach production in 2005 was 7,929, 5,845 and 526 tonnes respectively (**Appendices 3–5**). Clearly, there is a large gap before local demand is met. The local cultivation of these fruits presents an opportunity to reduce imports, saving the country's foreign exchange.

In order to promote the local fruit-growing industry, the following issues should be addressed:

- Specialized training of horticultural extension officers;
- Continuous research on imported horticultural crops;
- Establishing and supervising recognized fruit tree nurseries;
- Better grading, packing and general handling of produce;
- Narrowing the wide gap between producer and consumer prices; and
- Improving and maintaining competitiveness in export markets.

Among the benefits of a strengthened fruit-growing industry will be improved nutritional status of the local population and the generation of income and employment. It will also serve to provide the processing industry with an increased and dependable supply of suitable, good quality produce, since careful selection of the proper species and varieties can give a succession of fruits ripening throughout the year.

The following information is more-or-less valid for all the temperate fruit species covered in this volume, and will therefore not be repeated in detail under individual species descriptions.

Uses and Food Value

It has long been recognized that fruits provide many of the vitamins and minerals required for the maintenance of human health **(Table 1)**. Besides, fruits make an excellent and flavourful addition to the diet. Fruits like banana and dates are a rich source of energy, whereas avocados are known to be a good source of protein and fats. Other fruit species are more valuable as sources of minerals, vitamins and enzymes, which help regulate the chemical reactions occurring in the human body and fight disease (**Table 2)**.

Fresh raw fruits are generally more nutritious than cooked or processed ones, in which especially the vitamin C and B complexes are lost. However,

Table 1. Average daily vitamin and mineral requirements for healthy people

Minerals (mg)				
Natrium	Calcium	Potassium	Magnesium	Phosphorus
2000–3000	800	3000–4000	300–350	800

Vitamins (mg)				
E	B_1	B_2	C	Niacin
12	12	16	76	15–18

Source: Deutsche Gesellschaft für Ernährung, 1991; 'Empfehlungen für die Nährstoffzufuhr'

Table 2. Calories and nutrients per 100 g edible portion of various fruit types

Type	Water %	Nutrients				Minerals (mg)					Vitamins (mg)				
		Calories	Protein	Carbohydrates	Fats		Calcium	Potassium	Magnesium	Phosphorus	E	B_1	B_2	C	Mean
Apple	55	54	0.2	12	0	3	7	144	6	12	0.49	0.04	0.03	12	1
Pear	87	55	0.5	8	0	2	10	125	8	15	0.43	0.03	0.04	2	0.22
Plum	89	48	0.5	15	0	2	14	221	10	18	0.66	0.07	0.04	54	0.44
Peach	90	41	0.8	13	0	1	8	205	9	23	0.97	0.03	0.05	9.5	0.85
Strawberry	88	32	1	6	0	3	28	147	15	29	0.12	0.03	0.05	64	0.51
Orange	88	42	0.6	8	0	1	42	177	14	23	0.32	0.08	0.04	9.4	0.30
Banana	79	88	1	18	0	1	9	393	36	28	0.27	0.06	0.06	12	0.65
Avocado	74	221	0.6–4.4	12–10	5–32	3	10	603	29	38	1.30	0.08	0.15	13	1.10
Cashewnut	6	572	12	10	22	14	31	373	257	373	0.78	0.63	0.26	1	2

Source: Deutsche Gesellschaft für Ernährung, 1991; 'Empfehlungen für die Nährstoffzufuhr'

fresh fruits perish quickly and require specialised storage or processing to avoid wastage. This can be achieved by following recommended storage conditions (see **Appendix 6**) or by processing the fruits into products such as juice, jam, jelly, marmalade, puree, pickles, wine, vinegar, and confectionary. Fruit may also be dried, canned or frozen. Other important uses are flavouring for ice cream and as a base for milk shakes and soups. Moreover, there is a great demand for fruit for use in the preparation of a wide range of cosmetics.

Propagation

There are two basic methods of producing a fruit tree: by **using seed (sexual)** or **vegetatively (asexual)**, using, for example, cuttings, grafts and layers.

The most common method of multiplying plants is by seed, but most seeded fruit trees do not produce progeny exactly like the parent, and are generally disappointing when they finally mature and produce fruit. In most cases it is therefore best to avoid using seedling plants for the establishment of a commercial orchard. Seedlings are normally grown as a rootstock onto which the desired fruit cultivars are budded or grafted.

Asexual propagation is achieved by taking some vegetative portion of the mother plant and placing it on a suitable rootstock, or by inducing the vegetative portion (the scion) to produce roots. This type of propagation has many advantages, among them uniformity of yield and fruit quality, shortening of the juvenile phase, resistance to diseases/pests of the aerial parts, and easier maintenance and management. Furthermore, unfavourable growing conditions may be overcome by choosing suitable combinations of rootstock and scion, whereby the rootstock can influence the vigour of the plant, the development of the root system and resistance to diseases and pests of the tree trunk and roots, while the graft is chosen for benefits in the vegetative parts.

However, one disadvantage of vegetative propagation is that systemic diseases, unwanted mutations, chimeras and bud sports can be readily transmitted through living plant tissues. For this reason it is essential that quality-controlled foundation and multiplication blocks of the various fruit species and their respective cultivars be established. These should be the only sources from which nursery owners receive certified propagation material.

The most common methods of asexual propagation practised in fruit tree nurseries are as follows[1]:

- **Cuttings** are made from roots and shoots, which are either softwood or hardwood. Breadfruit, kiwi, mulberry, guava, fig, raspberry, crab apple, and oriental pear are commonly propagated from softwood root cuttings. Hardwood cuttings are successful for fig, grape, quince, gooseberry, pomegranate, mulberry, and some Japanese plum and pear cultivars. Root

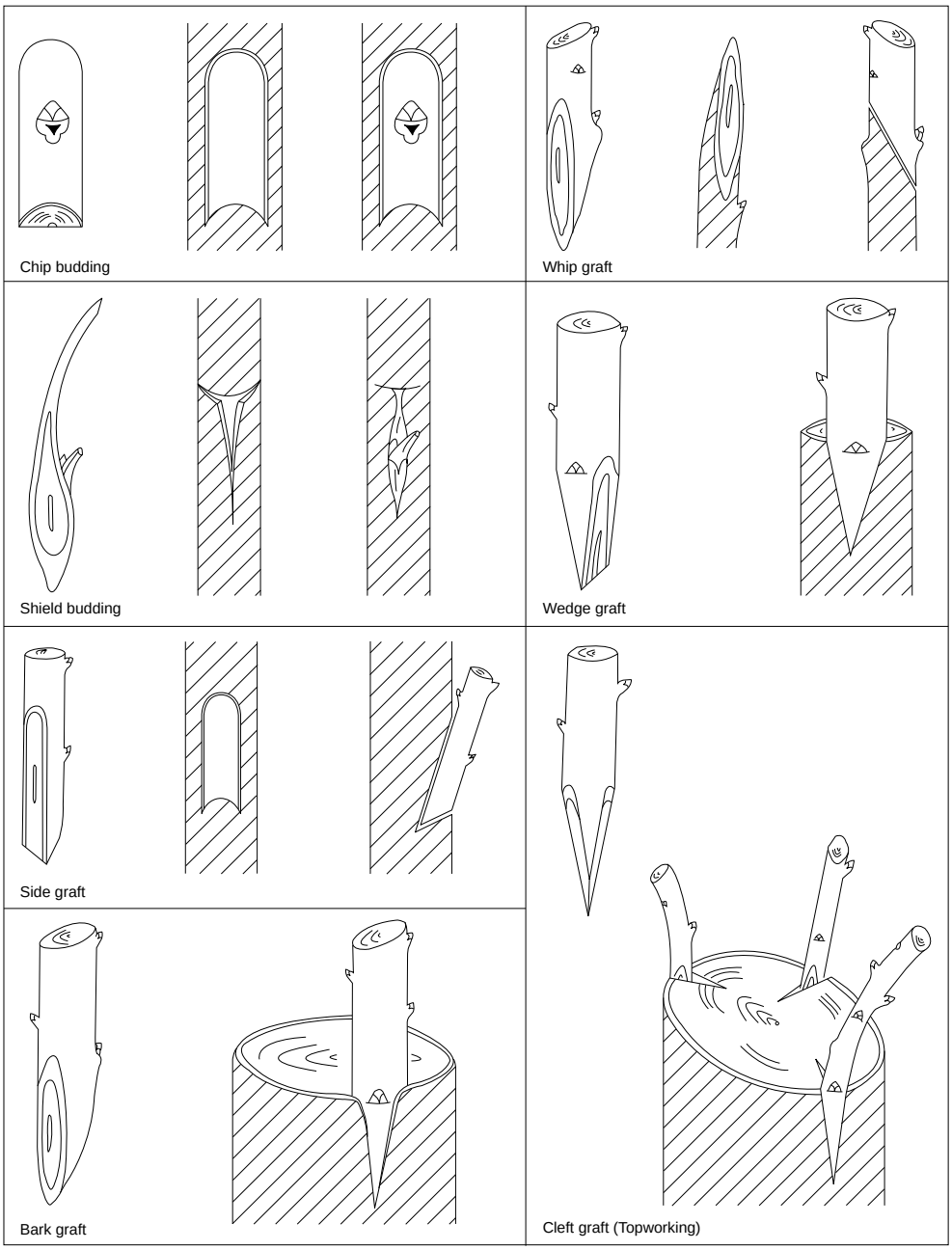
[1]More detailed information on vegetative propagation can be found in the World Agroforestry Centre (ICRAF) manual *Vegetative Tree Propagation in Agroforestry: Training Guidelines and References.*

development in many species can be promoted by using growth regulators and hormones.

- **Marcottage**, also known as air-layering, is a method of inducing root formation on a branch still attached to the parent plant. A ring of bark that is 1 to 2 cm in height is removed from a terminal growth approximately 20–30 cm from the tip end. The injured portion is then covered with a handful of moist moss or peat, which in turn is covered tightly with clear polythene. Once root development can be seen through the polythene, the branch is cut off and planted into a container where it will remain until sufficiently strong for transplanting. This procedure is also useful for breadfruit, rambutan, litchi and lemon.
- **Stool-layering** is mainly used for the multiplication of clonal rootstocks. Well developed mother plants are cut back to ground level to enforce the sprouting of new shoots. After these have reached a height of 20 cm, their base is covered with fertile, moist soil to encourage root formation. The rooted shoots are then removed from the mother plants and transferred into containers or into the open field, where they are grafted at a later stage of development.
- **Grafting / budding**: Grafting is the technique of joining parts of plants—such as a bud or twig (scion)—together in such a manner that they will unite with another plant (rootstock) and continue their growth as one plant. When a scion is used, the process is termed ‘grafting’, and when only one bud is used one speaks of ‘budding’. Many methods of grafting and budding have been developed, but in all of them the critical factor for a successful graft union is that the cambium of the scion or single bud is placed in close contact with the cambium of the rootstock. The tissues which form the union are called the callus. The union is only successful if the plants are compatible with each other. A grafted tree can be identified by the presence of the swollen callus tissues. The most commonly used techniques are chip and shield budding, whip (tongue) graft, wedge graft, side (veneer) graft, and cleft graft. Top working of older trees is mainly done by bark and cleft grafting. The different techniques are illustrated overleaf **(Fig. 1)**.

Dormancy and Climatic Conditions

One of the major factors leading to the poor development and yield of temperate fruit trees in equatorial regions is the lack of a sufficiently cold period to break the trees’ dormancy period. As this is a key factor in any evaluation of potential growth of these species, it is appropriate to describe the climatic requirements according to recent findings.



Source: Author's own illustrations

Fig. 1. Budding and grafting techniques

The two natural factors with an effect on breaking dormancy are low temperature and low light irradiance. In general, the number of hours below 7° C required to terminate the rest period has been used as an index for the classification of various temperate fruit tree species. Recent research, however, has shown that even temperatures at, or just below, 13 ° C are sufficient to break the bud rest in peaches, and one would expect other temperate fruit trees to behave similarly. The chilling requirement increases with the kind of fruit as follows: loquat, grape, peach, apple, Japanese plum, pear and cherry. **Table 3** should serve as a rough guide, as even cultivars of the same species can show marked variations in chilling requirements.

Reduction of light intensity was found to have a positive effect on breaking dormancy; shade, cloudiness, fog, etc. are more beneficial than bright conditions.

Dormancy is not uniform on all buds on the same tree; the lateral vegetative buds always have the deepest dormancy. The terminal buds – either mixed (apple) or simple vegetative (plum / peach) – and the flower buds in most species show a more shallow dormancy.

Temperate fruit trees grown in the medium-altitude areas and left without attention develop long, whippy branches, which, apart from terminal clusters of leaves, are almost devoid of lateral branches and leaves. However, at altitudes higher than approx. 1,800 m, temperatures can be low enough to induce seasonal growth, but are usually not low enough to satisfy the crop's chilling requirements. As a result, the trees are harmed by the prolonged rest (see **Appendices 7 and 8**).

Table 3. Chilling requirements by species

Species	Approx. no. of hours below 7 °C
Figs	0–300
Almonds	0–800
Peaches	100–1,250
Grapes	100–1,500
Japanese plums	100–800
Apples/pears	200–1,400
European plums	800–1,500
Sweet cherries	900–1,700

Source: Ruck, 1975

When chilling during the dormancy period does not meet the requirement of the lateral vegetative buds, a typical response will result. The response differs between pome fruits and stone fruits and will therefore be described separately.

Pome fruits (apple / pear)

Most of the lateral vegetative buds will not break and only the terminal ones will develop, resulting in bare twigs showing only apical development. In a few cultivars such as Granny Smith and Winter Banana, the terminal bud is a mixed one bearing a cluster. With the weight of the growing fruits the year-old twigs will bend over, exposing the fruit and bark to the sun and thus risking sunscald damage. This change of orientation of the one-year-old twig may give rise to new growth, starting from the upper part of the concave branch. The presence of terminal clusters assures some yield even under extreme adverse conditions. Normally, when lateral vegetative buds do break, many spurs (short, horizontal growths) will be produced. These spurs will differentiate to flower clusters and the potential number of fruits produced will increase many times.

Stone fruits (plum / peach / apricot)

In these species, flower buds are always found laterally on one-year-old twigs or on short spurs. Under insufficient chilling conditions, terminal buds may sprout, most of the lateral flower buds will abort, and the lateral vegetative buds will remain dormant. In some cases, the upper part of the tree will not produce any new growth. This will appear on lower limbs only.

Methods of Overcoming Dormancy

Apart from breeding fruit cultivars which have low winter chilling requirements, it is also possible to overcome bud rest under tropical conditions by using cultural techniques such as defoliation and desiccation, followed by pruning, application of rest-breaking chemicals and irrigation to initiate a new growth cycle.

These techniques need to be applied where there is no temperate-zone seasonality. Since the buds are forced to develop before entering dormancy, cultivars with a range of chilling requirements may be tried.

Defoliation (leaf stripping) will create an artificial resting period, which is later broken with a chemical spray. The proper timing of leaf stripping, which is easily done by hand, can be determined from climatic conditions, leaf orientation and appearance. For Kenya it is recommended that this is

done approximately during the second half of August for plums and peaches/ nectarines, and in the first week of September for apples and pears. Lately a new approach has been developed where a harvesting cycle of 6 to 7 months for selected apple cultivars is feasible, which means that almost two crops can be obtained per year. Normally, stripping of leaves is performed one month after harvest but may be varied to alter the sequence of ripening in the same region. Twenty to 30 days after defoliation, pruning, and training (bending) of shoots, mature trees will start flowering, and after a further 5 months the fruits will start maturing.

Depending on the size of an orchard, hand defoliation may not always be feasible and chemical defoliation may be appropriate. Many of the preparations below have been applied with varying success depending on local conditions, but should be tested on site to assess their effectiveness:

a) combination of 5 % urea + 5 % zinc sulphate
b) 3 – 4 % urea
c) 1 % Copper chelate
d) 0.75 % Magnesium chlorate

As a rough guide the following activities are advisable:

1st week: hand or chemical defoliation;
2nd week: pruning of trees;
3rd week: application of spray to overcome prolonged dormancy.

Desiccation: It is possible to counteract a lack of winter chilling to some extent by using cultural techniques. The practice of withholding irrigation water in the dry season following harvest to induce early dormancy is fairly widespread.

Chemicals: The problem of prolonged dormancy can be minimized significantly by using chemicals like dinitro-orthocresol (DNOC), thiourea, potassium nitrate (KNO_3) and, more recently, hydrogen cynamide (Dormex™).

Spraying of trees causes flowers and leaf buds to open more evenly and at the right time. The use of tar oil or DNOC does not permit the growing of cultivars entirely out of their climatic range, but its effect on borderline cases is quite remarkable; certain cultivars that would not have grown properly unless sprayed do in fact bear good crops after treatment. In trials, pome fruit trees responded better to chemical treatment than stone fruit trees. Furthermore, it seems that thiourea influences mainly the opening of leaf buds, whereas potassium nitrate affects primarily flower buds.

In general, beneficial effects leading to increased yield have been detected by using combinations of various chemicals, especially thiourea (2%) plus oil, and KNO_3 (10%) plus oil. The timing of application is critical: trees will not

respond if sprayed too early in the dormant season, whilst late spraying may damage any buds that have already broken or are at the stage of bud break.

When spraying, it is important to wet the whole tree thoroughly. The most popular treatment used commercially to break dormancy of temperate fruit trees following warm winters in South Africa is a 0.25 % DNOC–6 % mineral oil emulsion. Results obtained in practice are, however, often unsatisfactory due to incorrect timing and phytotoxicity.

In order to overcome these and other shortcomings extensive research with hydrogen cyanamide (Dormex), a plant growth regulator, has been undertaken. Because of the exceptional results obtained Dormex has been used commercially since 1984 in tropical and subtropical countries the world over. Dormex can overcome the lack of winter chilling, induce uniform bud break and increase yield. Its effectiveness seems less sensitive to the time of application and the interval between treatment and bud break than DNOC–oil. The following Dormex application dosages for selected fruits are recommended:

Grapes / kiwi	5 %
Apple / pear	2 – 4 %
Peach / plum	1 – 3 %
Cherry / nectarine	1 – 3 %

A spreader/sticker should be added to increase effectiveness.

Because of the widely variable agro-climatic zones in which temperate fruit are being grown in regions close to the equator, the recommendations concerning the use and the appropriate timing of any methods for inducing bud break must not be generalized. More research is still needed to compile accurate recommendations for specific growing regions **(Appendix 8)**.

Orchard Establishment

Site selection

Every plant has specific needs with regard to drainage, soil type, soil fertility, light and moisture. As such, the siting of an orchard should be considered extremely carefully; a wrong location for the orchard could have disastrous consequences for a fruit growing enterprise.

In general, fruit trees require soils that are well drained, deep, fertile and well aerated. The most successful soils fall into the sandy loam to loamy clay categories. Poorly drained shallow soils have only a limited area in which the roots can develop, which inhibits tree growth and leads to lower yields. Poor sub-soils of any kind result in unsatisfactory growth, affecting the tree's anchorage and its ability to withstand drought. Fertile soils with a depth of more than 1.5 metres and pH range of 5.8–6.6 are ideal for growing fruit trees.

Furthermore, good orchard soils should take up water readily. This is equally important whether the orchard is to be irrigated or rain fed. In soils that absorb water very slowly, not only does the danger of erosion exist, but due to reduced penetration, part of the water does not benefit the orchard.

Although it is desirable that the orchard be located on a site sufficiently elevated to ensure good drainage, locations on the tops of ridges may be unsatisfactory for a number of reasons, including exposure to strong/cold winds, which can result in injury to fruits and trees, interfere with normal tree development and hamper plant protection operations. For this reason the chosen site should have protection against strong wind. If there is none, early establishment of windbreak plants is a must—even years before the planting of the orchard itself.

The gentle slopes along the sides of ridges are normally more desirable than the tops. Given a choice, level or slightly sloping land is advantageous; otherwise contour cultivation or terracing is necessary in order to control soil erosion.

For successful fruit production, some species need additional irrigation, especially during the season following flowering and fruit development. Therefore, an adequate supply of good quality water is vital.

The proposed orchard's site has to be cleared as thoroughly as possible of perennial weeds, undergrowth, trees, stumps, roots, trash and debris. This should be followed by levelling of unwanted anthills and the elimination of their destructive inhabitants. To achieve a good tilth of the cleared land, fruit growers are advised to plant an annual crop a year before starting fruit cultivation. After this annual crop has been harvested, the final re-ploughing, harrowing and levelling is carried out.

Selection of suitable fruit species/cultivars

The choice of suitable fruit species and cultivars to grow is one of the most important prerequisites for successful fruit farming. A cultivar must be adapted to the environmental conditions of the locality in which it is to be grown, and there should be a good market demand for it. For many fruits there is an extended list from which to choose. In several districts, there usually exist cultivars that have been satisfactory for a long time, but oversupply, declining markets and competition from other sources may make any additional plantings of these questionable. As such, growers nowadays have to be flexible and enterprising, and assess newly available and approved cultivars for their market potential for fresh or processed utilization.

Generally, the task of selecting the right cultivar for a specific area will require long-term research and effort. And there is usually no shortcut—results from other parts of the world cannot be transferred neatly to local conditions.

Orchard layout

The first step in the planting operation is the proper layout of the planned orchard. A grower must make decisions about such things as the selection of cultivars and rootstocks, tree size and spacing, pollination, and planting procedures. If possible, trees should be planted in straight lines to facilitate crop husbandry and picking. Trees today are planted closer together than they were in the past, in an effort to increase production per hectare. There are different systems of layout, including the rectangular, hexagonal or square system. The proper spacing for the trees will depend on the fruit species/ cultivar, soil fertility, and water retention of the soil. The closer the trees are planted together, the more carefully they must be trained to make the planting successful. Overcrowding leads to increased pest infestation and disease, reducing fruit quality and yields.

Wider spacing than normal is necessary if the soil's fertility is poor, maintenance inputs are limited and/or the plants depend mainly on rainfall. For recommended planting distances see the chapters on the specific tree crops. The number of plants required in relation to different spacings are found in **Appendix 9**.

Preparing planting holes

In order to be well prepared, growers should dig the planting holes 2 to 4 weeks before the planting operations begin. This is normally carried out at the beginning of the rainy season. Usually the size of the planting holes—which are normally dug manually—will depend on the soil conditions of the site and on whether the planting material has been raised bare-rooted or in containers. As a general rule, the holes should be large enough to accommodate the natural spread of the roots, usually 50 – 60 cm square and up to 80 cm deep. If compacted layers (hardpans) of gravel or murram outcrops are present, it is essential that these be broken up so as to allow free drainage and undisturbed development of the root system. When digging, keep the topsoil and subsoil separate.

This is the right time to take soil samples for analysis. To achieve the best results, take about 10–12 topsoil samples (5–15 cm depth) from different locations in the field, place them in a bucket, mix thoroughly and put about 1 kg of this representative mixture into a properly labelled delivery container. Repeat the procedure with subsoil from a depth of 16 cm downwards and fill a separate container. The containers and a completed 'Soil Sampling Information Sheet' should now be delivered for examination to the National Agricultural Laboratories or equivalent facility. The labs are able to provide the farmer detailed information about the status of the soil, and advice concerning proper fertilization of the crop.

As a rule, one should always try to supplement the topsoil taken from the planting hole with an application of manure, phosphate and, if necessary, a soil insecticide. About 5 kg of well rotted cattle manure and 250 g of Double Super Phosphate, well mixed with the top-soil, will significantly improve the structure and fertility of the filling medium. One-third of this mixture is then returned into the planting hole; the remainder will later be used to refill the planting hole during the planting operation. The sub-soil is used to construct a basin around the young, newly planted tree.

Planting operation

To utilize seasonal rainfall to the full, trees should be planted as soon as the rain has penetrated deeply into the soil. Planting holes must be large enough to ensure that the root system is neither crowded nor bent. Extra-long or damaged roots have to be pruned before planting. Bare-rooted tree planting material, i.e. young trees that have been defoliated and pruned, is obtained from good tree nurseries ready for planting. The plants should then be placed into the planting hole in an upright position and planted at approximately the same depth or better still slightly higher than they were grown in the nursery, thus making sure that the grafting/budding spot will never have any contact with the soil. The planting hole is then filled with the remaining topsoil mixture, taking great care that no cavities are left between the roots. Potted plants must be removed from their containers right at the planting hole to ensure that the soil around the roots is not disturbed. After planting, the reserved subsoil is used to build a basin around each tree in order to collect water from rain or irrigation. It is essential thereafter that each tree is given 15–20 litres of water. Depending on rainfall this watering has to be continued until the first young shoots appear. In order to minimise moisture loss and sun scorch, growers are advised to whitewash their young trees with a 10% solution of agricultural lime. Furthermore, each tree must be mulched. Mulching, among other things, helps to control weeds and evaporation.

Finally, the young orchard must be protected against livestock and wild animals, which may damage leaves, shoots, blossoms and fruits, preventing proper plant development.

Orchard Maintenance

Mulching

Mulching has proved to be a very effective measure for improving the performance of many fruit crops. Mulching means covering the soil surface by spreading layers of leaf litter, grass, straw, compost/manure and other plant matter in order to:

- control wind and water erosion, especially from rain splash;
- improve water infiltration and moisture holding capacity;
- conserve soil moisture by preventing desiccation through surface evaporation;
- increase the activity of beneficial soil micro-organisms; and
- improve soil structure and feeder-root development near the surface.

To be effective, such mulch layers must be heavy enough to prevent the growth of weeds or other vegetation around the tree and should be renewed often, since most of the organic cover material decomposes very rapidly.

Mulching is particularly valuable for orchards located on steep slopes or in rocky soils where cultivation is difficult or likely to cause erosion. The greatest benefits from mulching are usually obtained in areas of relatively low rainfall where mulch has been applied during the rainy season. In order to avoid the transmission of fungal diseases the mulching material should never have any contact with the tree trunk. It is, however, important to cover the ground area under the tree, which is exposed to sunshine.

Irrigation

In general, irrigation means any process, other than natural precipitation, which supplies water to crops, orchards or any other cultivated plants. There is usually little doubt as to the need for irrigation in arid and semi-arid regions. Irrigation also can be used to guard against failure of rainfall, or to alter the cultivation season. Potential increases in productivity have to be weighed against the extra expenditure required to irrigate.

There are three main ways of capturing irrigation water, namely

- catching streams and flood water by dam construction;
- pumping or diverting water from rivers and lakes; and
- pumping underground water.

Irrigation programmes vary, depending on orchard location, climate, soil type, and the kind of fruit to be grown. No standard recommendations can be given, and each grower must find out the requirements of his/her own farm. Before heavy investments in irrigation facilities are made, hydrological, economic and financial aspects have to be considered, among other factors.

Any tree nursery or orchard project is bound to fail if it is discovered at a later stage that the water source is only seasonal or insufficient, that the water quality is poor, that fertilizer and crop protection inputs are not affordable, or that there is no market for the produce.

Until recently, most of the locally grown horticultural crops were non-irrigated. But in recent years there has been a steady increase in the use of irrigation water to supplement unpredictable rainfall. Irrigation also requires

some knowledge of the amount of water a tree removes from the soil. This again is influenced by factors like sun, wind, temperature, and humidity. More frequent irrigation will be required on sandy soils than on clay or loam soils. After irrigation the area beneath the canopy of the tree should be wet to a depth of up to one metre—which may require more than 200 litres of water for a large tree or about 20–50 litres for younger trees. Under extremely dry conditions an irrigation interval of 7–14 days may be necessary.

Whatever the conditions, a good fruit-grower will constantly assess his or her trees during the dry season. A prolonged wilting of leaves, or even in some cases shrinking of fruit, signals that irrigation is overdue.

In general the closer the orchard is to the source of water, the more economical irrigation will be. Irrigation water is normally drawn from lakes, reservoirs, rivers, wells, or boreholes. There are different methods of irrigation, depending on orchard size, topography, soil, climate, and capital available. The basin method of irrigation is the most widely used and easiest to operate. Basins are constructed around the base of each tree and are gradually enlarged each year to cover the expanding root system. In order to avoid trunk diseases, irrigation water should never come into direct contact with the tree trunk.

It is therefore strongly recommended that a protective inner earth wall is constructed around the inside edge of the basin and approximately 25 cm away from the trunk. The basins are flooded by means of buckets, hoses, pipes, channels, etc. Once the trees are fully grown and their demand for water is increasing, the basin irrigation may be replaced by other methods like channel, flood, sprinkler or drip irrigation.

Fertilization

Proper fertilization is essential for plant development, health and productivity. The major elements required in relatively large amounts include nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. Minor elements are required in extremely small quantities and include boron, iron, manganese, zinc, molybdenum, copper, and chlorine.

Specific fertilizer recommendations cannot be given here because of the great variation in the physical and chemical composition of soils in different locations. Some soils may be deficient in one or more of the elements. In others these may be present but not readily available to plants. It is therefore important to have soil samples analyzed for pH, nutrients, and organic matter. Corrective fertilizer treatments can be used to rectify unfavourable soil conditions. To determine the ideal fertilization programme, both the soil and the leaves of the established fruit crop have to be analyzed. Leaf analysis is used to assess the nutritional status of the plants. For many fruit species, standard figures have now been tentatively defined for those elements that are important to the nutrition of the particular crop.

Element deficiencies show fairly characteristic symptoms and are therefore relatively easy for the grower to detect and identify. They are an aid in prescribing curative fertilizer treatments. In order to obtain an accurate diagnosis, leaf samples of a specific age and position on the tree are taken and analysed. A horticulture extension officer should be consulted for assistance on how to take soil and/or leaf samples. Depending on the results of the analyses, farmers receive advice on the kind and quantity of fertilizer to use. It is essential that the required nutrients be made available to the trees during the individual flowering seasons. Nitrogen should preferably be given in two applications at the beginning of the rainy season. The fertilizer itself is always spread around the tree in such a way that it covers the so-called drip-line area. It should, however, never come into contact with the tree trunk. All fertilizers containing phosphate have to be worked into the soil using a forked hoe. Micronutrient deficiencies can be corrected by using foliar sprays containing the required element.

The pH value describes the acidity or alkalinity of the soil. pH values of around 6.5–7.0 are the most favourable for the uptake of plant nutrients (see **Appendix 10**). Agricultural lime and Magmax are used to adjust the pH value.

Commonly used fertilizers in East Africa are

- Sulphate of ammonia (SA)
- Calcium ammonium nitrate (CAN)
- Ammonium sulphate nitrate (ASN)
- Urea
- Double super phosphate (DSP)
- Triple super phosphate (TSP)
- Muriate of potash
- Sulphate of potash
- Diammonium phosphate (DAP)
- NPK compound fertilizers like 20:10:10, 20:20:0 and 10:30:0.

Organic fertilizers like sewage sludge, animal manure, green manure, and compost should be used whenever available. Their mineral content is rather low but they are high in organic matter which is necessary for maintaining or improving the soil structure. Depending on the soil's organic matter content, a rough guide for a year's application would be approximately one full 15-litre container per tree for each year of its age.

In general, small amounts of an inorganic fertilizer applied several times during the year will result in more efficient use and better plant response than the same amount applied all at once.

Pruning

Pruning is undertaken to achieve one or more of the following objectives:

- modify the shape or habit of the plant in order to facilitate cultivation, spraying and picking of the crop;
- influence the size, quality and quantity of fruit; and
- remove, renew, promote or retard the growth of parts of the plant.

In a young orchard the primary aim of pruning is to develop a tree shape that will lend itself to economical culture. The fruit grower in East Africa cannot follow an orthodox European/American pruning programme, as the growth of temperate fruit trees—with the exception of peaches—is quite different under prevailing local conditions. In East Africa the trees have a tendency to grow more upright with strong, branchless shoots. In view of this difficult habit, it is no use carrying out the well known cold winter pruning of temperate countries, as this would only result in more upright sprouting from any part of the tree. The only way to govern this tendency is by summer pruning, or bending of the immature shoots during the growing season.

Summer pruning consists of, among other activities, pinching off the tip of a shoot at a length of about 25 cm. Under normal circumstances this will lead to multi-branching—but not so in East Africa. Here, the tipped shoot will usually continue growing with one, seldom two, buds only. In order to achieve more branching, development of flower buds and branch sturdiness, it is necessary to pinch off the young sprouting shoots again and again. The same results may be attained by bending shoots horizontally.

The only dormant pruning necessary after this is the removal of undesired shoots within the canopy to prevent crowding, pruning of broken and/or diseased branches, and shortening of those branches touching the ground. Excessive pruning should be avoided since it will affect the yield and may cause sun scorching on the fruits, leaves and branches. It should be kept in mind that the higher the temperature and sunshine intensity, the denser the tree should be.

There are two locally modified systems in the way young trees are pruned to establish their future structure and shape **(Fig. 2)**.

The **'open centre'**, also called the '**vase shape'** tree consists of a relatively short trunk which has been created by pruning the young single-stemmed ('whip') tree at a height of approx. 60–70 cm from soil level. This stimulates side branching below the point of cutting. From among these side branches, select 3 or 4 shoots of roughly equal vigour which are well spread both up and down and around the trunk. These will form the future scaffold's main branches. Wide angles and strong unions are preferred. Removal of the topmost shoots—which will tend to be too upright—will result in a well shaped vase tree. Any suckers arising from the rootstock should be removed.

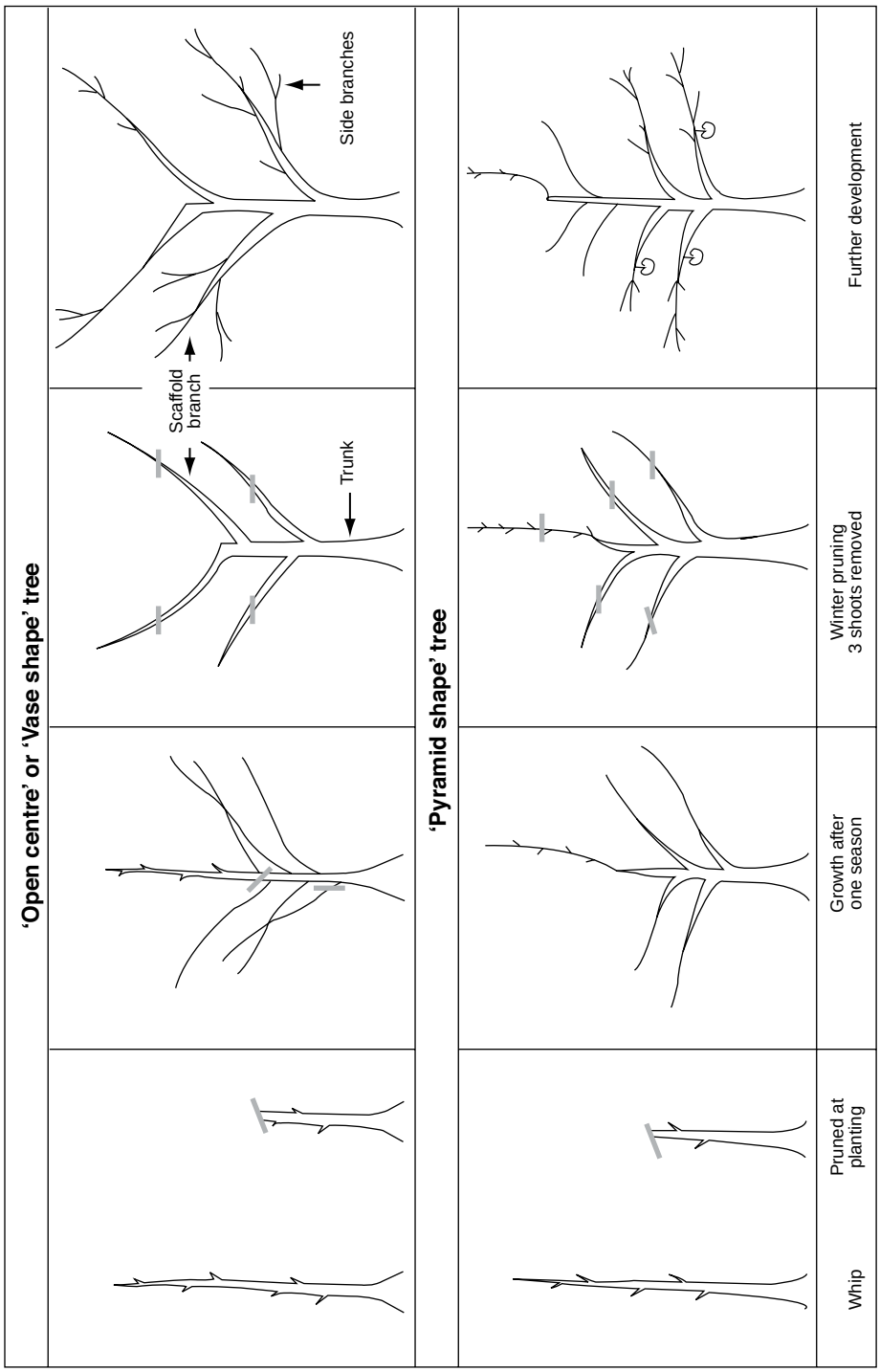


Fig. 2. 'Open centre' and 'pyramid shape' pruning

During the next season the selected scaffold branches are pruned back by up to half of their length, which induces the development of side branches, known as laterals. Spacing of side branches should be 40–50 cm apart on both sides of the scaffold branches. Vigorous competing shoots which cannot be used should be removed. Retain as many short shoots and spurs as possible and thin only where overcrowded.

When fruiting starts, the growth of the tree will be slowed down, and pruning will change to judicious thinning of shoots and spurs, heading back of branches that are too long and whippy, and spacing of new shoots to obtain optimum lighting, stimulating growth where necessary, and keeping the size of the tree within the optimum planting distance. Keep scaffold and side branches dominant by removing vigorous and competitive growth and shorten old spurs when growth becomes poor. In order to avoid infection and promote healing of pruning wounds, cover them with a suitable protectant.

The **'pyramid shape'** tree consists of a single vertical trunk with main branches spread evenly up and around it and becoming less vigorous towards the top of the tree. The trunk ends in a single vertical shoot. The height and spread of trees will depend on the rootstock, cultivar, soil, and spacing, but the height is normally limited to 2.5–3 metres.

After planting, head the whip (single-stemmed tree) back to about 90 cm above soil level. If the tree has already produced side branches prune the leader approx. 25–30 cm above the side branches. The buds below the heading are the ones to grow, and once these side shoots are about 25 cm long, tie them into a horizontal position—the same way as was previously done with the existing ones. During the following year, again head back the leader 25 cm above the first tier of branches, and develop the second tier the same way as was done a year before. Any shoot which might compete with the trunk and alter the shape of the pyramid should be removed. Manipulation of the height of trees is done when a height of approximately 3 metres is reached, by heading back the vertical elongation to a lower side shoot. Main branches that become too long or whippy should be headed back to suitable side shoots. Growth in the upper part of trees must not be allowed to become too strong; judicious pruning of such shoots should be done annually together with fruit thinning to obtain regular crops of good quality fruit.

Finally, **rejuvenation pruning** has to be mentioned because it is often used to bring declining trees back into full production. Old branches are severely pruned to promote the sprouting of dormant buds. These will normally produce plenty of young shoots but only the best placed and most vigorous ones should be retained for the development of a new tree. Rejuvenation can be carried out all year round.

Many wounds are caused to the trees through pruning and at least the larger of these must be treated with a suitable sealing compound to avoid fungal infection and decay. Sunburn protection by white-washing the exposed trunks and branches is also advisable.

Plant protection

Disease and insect pests constitute a major constraint to the production of horticultural crops. They can cause severe losses in quantity and seriously lower quality, and therefore, preventive measures are essential.

Cultural control. Good agriculture practices are vital to establishing and maintaining a healthy tree crop and include:

- choice of a suitable orchard site,
- proper site preparation,
- wise choice of cultivars,
- appropriate plant density,
- correct depth of planting
- proper fertilization, and
- crop sanitation and weed control.

Biological control utilises pathogenic bacteria and fungi, predators or parasites, either naturally present or deliberately introduced, to control pests.

Mechanical control includes burning, hand-picking, uprooting, glue-banding and bagging affected plants.

Legislative control means adherence to established government laws concerning quarantine regulations, whose objectives are to prevent the introduction of pests and diseases from foreign countries/localities.

However, where the above measures are inadequate and **chemical control** has to be used, it is essential that correct diagnosis and proper choice of farm chemicals are made. The disadvantages of improperly used chemicals are known and include pollution, toxicity, phytotoxicity, residues, drift damage, and resistance. In order to avoid these dangers, the following general considerations should be kept in mind:

- Do not apply chemicals unless they are needed.
- Apply only recommended chemicals in suitable concentrations for a specific pest, disease or weed.
- Use appropriate spraying techniques and apply spray at the correct time.

- Carefully follow the directions given on the container labels.
- Follow the recommended pre-harvest intervals.

Some common farm chemicals are listed in **Appendices 11, 12, and 13**.

Pesticides are grouped into insecticides, fungicides, nematicides, acaricides, molluscicides, herbicides, and disinfectants. Their effectiveness depends largely on their application. Insecticides act on pests in various ways as stomach, contact or systemic toxicants and are available in powder, liquid or gaseous form. In general, it is important to cover the plant surface thoroughly; this can be aided by adding a spreader/sticker agent, regardless of whether a curative or protective spray is used.

Pesticides are generally poisonous to humans and should therefore be treated as dangerous chemicals. They must be handled and used with utmost care, and stored only in their original packaging in a locked room away from foodstuffs.

Fruit thinning

Experience in growing fruits for the fresh market shows that in most seasons a reduction in the number of fruits per tree or vine is necessary in order to produce fruit which satisfies consumer requirements. Therefore, fruit thinning is well recognized as one of the most important orchard operations. It results in improved fruit size and uniformity, reduces competition between the fruit and other growing parts of plants such as shoots and roots, promotes regular bearing, reduces limb breakage, permits culling of undesirable fruits, assists in maintaining general tree vigour, and decreases the labour requirements of crop picking.

Species such as peaches, nectarines, plums, apricots, and apples should be thinned to meet market demand. Pears, sweet cherries and grapes also benefit from thinning, although with these species thinning is mostly used in young plants in order to avoid over-cropping. Fruits are normally thinned as early as practical, but generally only after the first fruit-drop—through lack of pollination—has taken place. Spacing of fruit is essentially a manual operation. Usually it is done more-or-less in proportion to the final fruit size desired—between 5 and 20 cm from fruit to fruit. Excess fruits are removed by twisting, pulling or pinching them off.

Since fruit thinning by hand is one of the most expensive orchard operations, any alternative method to reduce this expense would be most welcome. In recent years the advent of chemical thinning agents has provided growers with an economical means of partially thinning their crop. One of the techniques to consider is blossom spray thinning, in which flowers are sprayed when trees are 80–95% in full bloom.

New compounds like 3-chloroproprionic acid (3CP), naphthylacetamide (NAAmide) or Sevin (an insecticide), among others, have been used quite

successfully, but the grower should have good knowledge of the trees, the climatic situation, and any other factors that may affect the results obtained.

Picking and handling

Providing that the ecological requirements of the fruit species selected are met and the recommended crop husbandry measures are carried out, Kenya has excellent potential for producing fruit in sufficient quantity and good quality for both the local and export markets. According to the overall production figures for 2005 published by the Ministry of Agriculture more than 5.85 million tons of horticultural produce were traded, and export figures are rising (**Appendices 14, 15**).

Because most importing countries are amply supplied with prime quality produce and serious competition exists for this lucrative market, only produce of superior quality will have a chance of retaining its market share. In order to avoid disappointment exporters must be sure to meet international export standards for fruits, vegetables, and flowers. However, the marketing of produce for local consumption and processing should not be neglected. Constraints with regard to pricing, grading, maturity, packing, distribution, wastage control, etc. have to be taken into consideration. Farmers should always be keen to learn more about the elements of efficient fruit production in order to improve their yields, quality and competitiveness. Unfortunately, it has been observed that farmers very often diminish their profits by not observing the following points:

- Each type of fruit develops basic internal and external signs of ripening which indicate the proper time of picking. Fruits must only be picked when they have attained a sufficient size, attractive colour and internal maturity. There are other specific ripening criteria like oil/juice contents, sugar to acid ratio, change of flavour, resistance to pressure, appearance of seed coat, and dropping of sound fruit. Because of the lower juice content of unripe fruits, premature picking will lead to a decreased yield performance (kg/tree) and consequently reduce the producer's expected revenue. By rejecting unripe or poorly handled fruits, the consumer can do a lot to influence the quality of fruit delivered by farmers for sale.
- The presentation (grading, waxing, packing, etc.) of the fruits imported into Kenya and the ever-increasing demand for them as a result of their unblemished and attractive appearance ought to be an eye-opener and should lead to the requirement of higher standards in local produce.
- Picking and handling of fruits should be done with the utmost care because it determines their shelf life and the condition in which the fruit reaches the market. Most kinds of fruit must never be pulled from the branches as

this will very often rupture the skin. Even very slight peel injuries, bruises or scratches may result in losses because fungi and moulds can enter more easily at such spots and cause decay of the whole fruit. Once the fruit has been removed from the tree, it must not be dropped on the ground; it should be placed into picking bags or baskets. After these are filled they are carefully emptied into appropriate field containers such as boxes, crates or strong baskets **(Fig. 3)**. The sides and bottoms of these containers should be clean, smooth and free of anything that might injure the fruit. Also, the containers must never be filled above the top.

- In order to minimize sunburn, loss of moisture and dust accumulation, field storage should be as brief as possible. After the produce has been cleaned and graded in a sheltered place it has to reach the local market outlet without delay.
- The produce of a grower intending to join the sophisticated export market will require additional special treatment after picking and prior to marketing. Furthermore, mastery of the relevant export regulations and requirements takes time and patience.
- It is imperative to finalise arrangements for marketing before harvesting the crop. Once harvested, horticultural produce is highly perishable and will not last long. It has to be sold regardless of prevailing market conditions, and without forward planning, the farmer has little bargaining power and will most likely be the loser.

Fig. 3. Appropriate fruit picking/transportation containers

Storage

Fresh fruit is alive and will remain so during storage and marketing. High temperatures will promote deterioration, and farmers are strongly advised to protect their fruits against overheating and sunshine. Reduction of field heat can be achieved either by immediate transfer to a cool store or by stacking bins outside overnight to lose heat by radiation. In order to realise optimum returns, small-scale farmers should ship their produce as soon as possible to regional or local distributors such as terminal markets, independent wholesalers or chain-store distribution centres.

In optimal growing areas with a concentration of fruit growers there is often a temporal overproduction of certain commodities. This leads to an oversupply to, and saturation of the market, and the collapse of producer prices. Well-planned and coordinated planting of early and late varieties of certain fruit species that will extend the picking season can safeguard the availability of certain varieties for a longer period, as can controlled storage of fruit. This point is highly pertinent if the objective is to promote local production and at the same time reduce expenditure of foreign currency for imports.

Cold storage for fruits is used to retard deteriorating effects, reduce decay from pathogens, and minimise shrivel from water loss. The best storage temperature is generally the lowest the fruit will withstand without freezing. The data given on recommended storage conditions of fresh fruits is only intended as a quick reference guide (see **Appendix 6**). Storage requirements at a particular temperature may vary depending on numerous factors, including cultivar, maturity, nutritional status, pre-treatments and the condition of the crop prior to storage. It is therefore not possible to recommend a single storage temperature for a given commodity without taking these factors into consideration.

Essentials for rapid cooling and good cold storage are adequate refrigeration, sufficient air circulation, and proper stacking to permit optimal exposure of fruit to cold moving air.

For longer storage, deterioration may also be retarded by using controlled-atmosphere storage in which carbon dioxide, oxygen, temperature and humidity are controlled in airtight chambers.

Why Fruit Trees Fail to Bear

Not without reason do fruit growers become worried if their fruit trees do not start bearing at the time expected, or if fruit does not set even after abundant flowering. There are many factors which may cause this problem, including the following:

a) **Age.** Grafted fruit trees will normally begin bearing soon after they have become old enough to blossom freely. The length of time from planting to fruit bearing varies with the type of species as follows (in years): Apple: 2–5; Plum: 3–6; Pear: 4–6; Peach: 2–4; Fig: 2–3.

b) **Excessive fertilisation or pruning.** The onset of flowering indicates the beginning of the generative phase which can be delayed by heavy fertilization or excessive pruning.

c) **Weather.** Trees may flower but produce little or no fruit. One reason for this might be that unfavourable weather conditions prevailed during blossoming. Frost will kill the flowers, and low temperatures can adversely affect the pollen germination and consequently the fertilization of flowers, leading to non-viable seeds/fruits. Cross pollination, required by many fruit cultivars, is curtailed by heavy rain or strong winds, which affect the activity of pollinators. In addition, pollen may be spoiled or washed away. Flower drop has also been observed due to moisture stress.

d) **Pollination.** Most fruit trees need to be pollinated. Without sufficient pollination, they may blossom abundantly but bear no fruit. Some fruit species have perfect flowers. Both the anthers, which contain pollen, and the pistils, which develop into fruit, are located in the same blossom and will bear fruits by self-pollination. However, there are many types of fruit varieties that are self-infertile, i.e. they have perfect flowers that cannot produce fruit from their own pollen. In such cases, cross-pollination with the pollen from an entirely different variety of the same kind of fruit species is required. Self-infertility is very common and occurs in many varieties of apples, pears, plums, peaches and grapes.

e) **Infestation.** Another serious problem which reduces fruit set is the infestation of flowers with pests and diseases. Losses can be tremendous and only timely crop protection measures will save the crop.

f) **Biennial bearing.** Occasionally, certain fruit trees bear heavily in one year and sparsely the next. This is called biennial bearing. A particularly heavy crop in one year may prevent adequate flower bud formation in the following one. Biennial bearing is difficult to alter; the farmer can, however, induce a return to normal annual fruit production by early and thorough thinning during the year in which the trees produce their large yield.

g) Premature fruit drop. Farmers are often distressed by premature fruit drop, which occurs in definite waves and decreases their expected revenue. Fruit drop can be observed soon after fruit set and again later when the fruits have already reached a reasonable size (pre-harvest fruit drop). The cause of fruit drop in the first instance is the formation of an abscission layer at the point where the fruit attaches to the twig. Abnormally high pre-harvest fruit drop can be controled with chemicals. Before resorting to chemical means, however, growers should make sure that other factors like drought, over-bearing, pest and disease infestation, or adverse weather conditions, are not responsible.

Apple

APPLE *(Malus domestica)*

History

The origins of the domestic apple are uncertain, but it is usually believed to have derived from *Malus pumila,* a small-fruited species that occurs naturally in eastern Europe and western Asia. However, the apple may well have originated from *M. sieversii,* a diverse species from the mountains of central Asia.

Although some historians are in dispute over exactly who first domesticated the wild apple, many believe it was the Romans who discovered that they could cultivate wild apples into fleshy, sweet and juicy fruits. Pliny the Elder, a Roman statesman, *circa* 23 AD, described 37 different cultivars of apples in '*Historia naturalis*'. By the 1st Century AD apples were being cultivated in every region throughout the Rhine Valley, and apple cultivation was gathering momentum. By 1640, the horticulturist Parkinson noted 60 cultivars; in 1669 the count was up to 92; and in 1866 *Downing's Fruits* recorded 643 different apple cultivars. At present, apples are cultivated the world over. The main producers include Europe, United States, Russia, China, Iran, Japan, and Argentina.

According to FAO statistics, overall world apple production in 2001 totalled 63 million metric tonnes. Only a few of the more than 1,000 cultivars that have been described over the centuries are grown extensively at present. Breeding projects in several producing countries are continuously developing new apple cultivars with improved quality and other characteristics such as disease resistance and low chilling requirements.

Botany

Together with its relatives the plum, peach and pear, the apple belongs to the family Rosaceae. Under normal growing conditions an apple will develop into a small to medium-sized tree, of 5–10 m height, freely branching with long shoots and various types of short spurs. When growing unattended in the tropics it will revert to a stiff, overcrowded upright bush of 2–4 m in height. The leaves are elliptic-ovate, rounded at the base, and often tomentose. Apple trees produce flowers and fruits from mixed buds which are usually formed only on the ends of short spurs or tips. An inflorescence contains 5 to 7 individual flowers; the centre bloom opens first, and later produces the largest fruit which may be round or conical in shape, usually more than 5 cm in diameter **(Fig. 4)**.

Different cultivars may be distinguished by the fruit's flesh colour, juiciness, mealiness, firmness/crispness, and flesh texture. Other fruit characteristics include taste (acidic, aromatic, sweet, etc.) and skin colour (red, yellow, striped, blushing, and russeting).

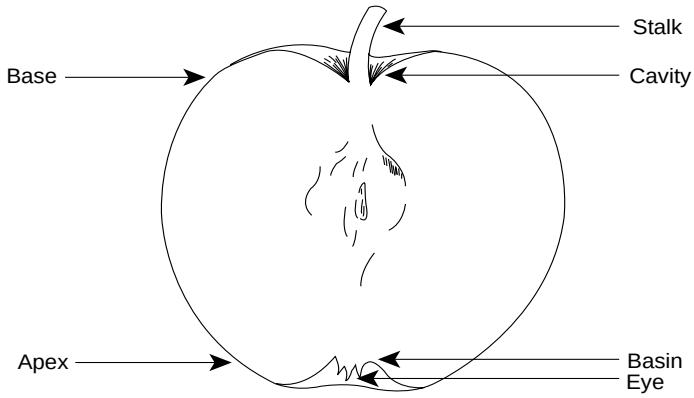


Fig. 4. Cross-section of an apple fruit

Propagation

In order to produce true-to-type apple cultivars, vegetative propagation methods using grafting or, more often, budding techniques are necessary. For this purpose, seedling or clonal stock is needed. Clonal stock availability had been a major obstacle for the speedy extension of the East African apple industry. Experience has shown that only vigorous or moderately vigorous rootstocks should be used.

Clonal stocks

M 25 is the most vigorously growing of all the apple clonal stock in East Africa. It produces large, well anchored trees, induces early fruit bud formation and gives excellent fruit set and yields. It is moderately resistant to woolly aphid.

Alnarp 2 (= A 2). The roots are well anchored and produce vigorous trees, comparable to those of M 25.

M II has been the most commonly used rootstock. Trees on M II tend to be vigorous and fruitful and are smaller than trees on seedling roots. It is moderately susceptible to crown gall but resistant to crown rot.

M XI. The vigour of trees on this rootstock is comparable to that on M II or MM 111 but the trees grow better when young, start bearing earlier and are more drought-resistant.

M VII. A stock of medium strength which develops a stronger, deeper root system than the dwarfing M 9 and starts bearing early. It is tolerant of excessive soil moisture but susceptible to crown gall, and it produces lots of root suckers.

MM 106 is promising as a replacement for M 7; it produces a tree 65 to 75% the size of that on seedling. The roots are well anchored and do not sucker. Trees are more productive and crop earlier. Plants are resistant to woolly aphid.

All the above-mentioned clonal stocks are multiplied by stooling, and after about a year under local field conditions the following average output results of suitable rooted plants have been achieved per mother plant:

A 2 and MM 106	7
M II	6
M VII	5
M II and M IV	4

Appendix 16 shows details of one of the rootstock/cultivar performance trials carried out in Kenya, whose goal was to obtain relevant local information.

Seedling stock

Bittenfelder seedling, which is propagated generatively, is known for its vigorous growth, even development and drought resistance. Prior to planting seeds require moist chilling (= stratification) for about 65–80 days at a temperature of 2–6 °C to promote germination. For more detailed information, see ‘Propagation’, page 85.

Establishment

Growing apples for commercial production should only be attempted in locations recognized as feasible growing areas. An ideal location with optimum natural growing conditions is difficult to find in East Africa, because it has to combine two essential preconditions: cold winters and relatively hot summers. Since cultivars with low chilling requirements are available, and dormancy and dormancy break can be induced artificially, elevations of approx. 1,500–2,200 m are the most suitable for this type of tree crop. Depending on cultivar, apple trees require 200–1,400 hours below 7 °C for optimal development. Ideal orchard locations have deep, fertile, properly aerated and well drained soils. The optimum pH range appears to be between 5.5 and 6.5. Generally apples grow well in areas with an annual rainfall of 800 to 1,100 mm. It is essential that sufficient soil moisture is available during the time of bud break, flowering,

fruit set and fruit development. Moisture deficiency may seriously affect yield and fruit quality.

The choice of cultivar should depend not only upon where one will grow it but also upon the end use of the produce. If destined for the fresh market, the fruits must handle and ship well and have an attractive appearance. Fruits for canning or other processing, on the other hand, are selected with other specific characteristics. From among the cultivars recommended for Kenya in the 1960s, only Winter Banana and Rome Beauty have survived for commercial use and further extension.

After the country's independence from British rule in 1963, many additional cultivars were introduced into Kenya. Those that have already been evaluated and included in the propagation programme are, among others: Ana, Golden Dorsett, Grand, Acpye, Alexander, Ein Shemer, Cowin, Glocken, Law, Granny Smith, Red Rome, Mutsu, Gloster, Starking, Golden Delicious, Jonagold, and White Winter Permain.

In most instances apple cultivars are not sufficiently self pollinating and it is therefore advisable to have cross-pollination from other suitable cultivars, which have been interplanted. These include: Winter Banana, Jonathan, Golden Dorsett, Ein Shemer, etc. Honeybees are the most important carriers of pollen amongst temperate fruit trees, and bee keeping in the orchard is therefore essential.

The proper spacing of apple trees is directly associated with region, altitude, type and fertility of soil, cultivar, and rootstock. Usually 2–3 m within the row and 3–4 m from row to row are advisable. The trees must be sufficiently far apart to allow the sun to hit the lower branches if fruit of satisfactory quality is to be grown on the lower parts of the trees. The closer the trees are planted together, the more carefully they must be trained to make the planting successful. Spacings of rows and trees should be altered independently to suit particular circumstances (see **Appendix 9**).

Maintenance

In Kenya, growers must deal with the tendency of apple trees to produce upright, strong and sparsely foliated unbranched shoots that are very limited in their productivity. The most common pruning procedure is to create the so-called 'open centre tree', but sometimes the 'pyramid shape' tree is preferred (for details, see 'Pruning', page 17).

Trees that are properly cared for during their formative period will be well shaped and able to support heavy crops. Once fruiting starts, the primary consideration becomes striking a balance between vegetative growth and fruit production by controlling tree height and spread, exposure to light, renewal of fruiting wood, etc.

The two most important measures for successful local apple growing are the creation of an artificial resting period (dormancy) and the breaking of prolonged dormancy (for details, see 'Methods of Overcoming Dormancy', page 8).

To stimulate dormancy, it is common to defoliate apple trees at the beginning of September in order to let the crop mature during the dry season. This also results in a superior crop as compared with the harvest gained by defoliation in March, at the end of the dry season.

Sufficient fertilization is needed to achieve high yields and good fruit quality. The most effective fertilizer programme can best be determined on the basis of leaf and soil analysis **(Table 4)**. Numerous apple tree leaf samples taken for examination have shown that deficiencies of trace element (like zinc, copper and manganese) are very common in Kenya.

Serving as a rough guideline, the following annual CAN (26 % N) application per tree is recommended: 150 g in the first year after planting, increased by 125 g per subsequent year to a maximum of 1.5 kg/tree/year. Also, 150 g of Double Super Phosphate (DSP) are given in the second year after planting, increased each year by 150 g up to a maximum of 2.5 kg DSP per tree. The nutrient requirement is highest after dormancy when flowers, shoots, leaves and fruit are developing.

Very little thinning of apples is done in Kenya. Thinning improves fruit size,

Table 4. Tentative leaf analysis guide for diagnosing nutrient status in apple leaves

Element	Desirable range
Nitrogen	2.3–2.5%
Phosphorous	0.25–0.30%
Potassium	1.2 –1.5%
Calcium	1.0%
Magnesium	0.25–0.4%
Copper	8 ppm
Zinc	20 ppm
Manganese	80 ppm
Boron	30 ppm
Sulphur	150 ppm

Source: Childers, N.F. (1966) Nutrition of Fruit Crops

quality and regularity of crops and should be carried out as soon as it can be established with certainty what fruit is going to remain on the tree. The stalks of the fruit that will drop turn yellow, usually about 50 days after full bloom. The severity of hand thinning will depend upon market preferences for specific sizes of the cultivar. According to prevailing circumstances, flower/fruit clusters can be spread approx. 12–15 cm apart, or alternatively whole clusters are removed. The following may serve as an indication of the maximum number of fruits that can be left per cluster of some selected cultivars after the final hand thinning has been done:

Winter Permain	one
Jonathan, Starking	two
Golden Delicious	two – three
Granny Smith	three

Weeds or interplanted crops should not compete with the orchard trees for moisture and nutrients. Cultivation is usually necessary only for weed control and should be done as shallow as possible to avoid damaging the root system.

Depending on the age of a tree, an area of approximately 60–180 cm from the trunk should be maintained weed-free. Chemical weed killers are often practical, but also mulch should be used to control weeds and conserve moisture, although the mulch must not come into contact with the trunk.

Apples ripen satisfactorily on the tree and should be picked when they have reached optimum colour and size. Depending on cultivar, this will occur 5–7 months after flowering. In Kenya, there are two main picking seasons: around February and around August. However, trials have shown that the picking time can be controlled by the timing of leaf stripping. This means that a year-round supply of fresh fruit could be feasible.

As apples appear to be hard at picking time there is a tendency to handle them in a rougher manner than more perishable soft fruits **(Fig. 5)**. All apples for the fresh market are picked by hand, and this should be done taking care to avoid bruising and stalk punctures, which damage the appearance of the fruit and also provide entry points for fungi, which cause storage and shelf rot.

If not consumed or delivered to the market immediately, apples can usually be stored for 3–6 months at a constant temperature of –1° to 4° C and 85–95% relative humidity. Cold storage duration differs according to cultivar: for example, even under refrigeration Ein Shemer does not store for more than two weeks, while Ana has been kept satisfactorily for 6–8 weeks, Jonathan/Golden Delicious for 3–4 months and Granny Smith for 4–5 months.

Yields depend largely on the type of rootstock used, age and cultivar combination, and certainly on the applied crop husbandry measures. For more detailed yield figures from a rootstock/cultivar combination trial, see **Appendix 16**.

Fig. 5. Do not treat apples like potatoes.

Average yield performance figures of Rome Beauty in combination with various types of rootstock are presented in **Table 5** (Author's own recordings).

Preventive control of insects and fungal diseases keeps trees healthy and is an important aspect of successful apple production.

Table 5. Average yield performance of apple var. Rome Beauty

Rootstock	kg/tree in year after planting					
	2nd	3rd	4th	5th	6th	10th
MM 106	1.0	2.7	4.2	5.8	8.6	N/A
A 2	0.3	1.4	2.8	6.3	13.7	24.3
Bittenfelder	0.7	1.8	4.0	2.0	6.6	15.8
M II	–	0.9	2.8	2.8	4.6	12.1
M VII	–	0.9	8.5	5.1	3.9	16.5
M XI	–	0.8	4.6	3.2	3.9	14.3

Major Pests of Apple

Aphids. These colony dwellers suck on leaves, flowers and young shoots, causing them to curl and become stunted. Aphids may also transmit viral diseases and the honeydew they produce develops into sooty mould.

Woolly aphids. Attack the aerial and underground parts of fruit trees. A white, woolly, waxy secretion and the formation of galls on branches and roots are characteristic of this insect's damage.

*Thrips.*Very small, slender insects which suck on young leaves, flowers and fruits.

Scale insects. There are different types which cause serious damage or die-back of fruit trees. Infested trees show a general decrease of vigour as well as leaf discolouration.

Spider mites. Tiny, mobile, reddish-brown, sucking insects which cover the leaves with a fine web system. They are very active during long dry spells when they puncture and destroy the leaves.

Systates weevils. Can occasionally be very troublesome by typically chewing leaf edges and ruining flower setting.

Chafer grubs. Live underground and can cause considerable damage to the root system. Attacked plants whither, may be stunted and often die. At the beginning of the rains, flying adults feed on flowers, fruits and leaves during the night.

Codling moth. Damage to the fruit is caused by the larvae, which upon hatching chew tunnels through the fruit during its development, particularly in the core area. Young, damaged fruits drop off the trees or become grossly malformed. Fruit at different stages of development may be attacked by several generations of moths.

Fruit flies.The most important and damaging species in Kenya are *Ceratitis capitata* and *C. rosa*. The adult female punctures and lays eggs within the skin of ripening fruits, and this often leads to rotting. The hatching white maggots burrow further into the fruit, feeding on the rotting pulp. Attacked fruits rot and usually drop prematurely.

Important Diseases

Apple scab. This fungus attacks leaves and fruit. Lesions develop on both leaf surfaces, causing distortion. Scabby dark spots are clearly seen on infested fruit; immature fruit growth is distorted and the surface may crack.

Powdery mildew. In highly susceptible cultivars like Rome Beauty or Jonathan, infection starts as white felty patches especially at the leaf margin, later extending over the entire shoot. In serious infection all parts of the blossom too may be covered with the fungus and very often fail to set fruit.

Armillaria root rot. A fungal disease that attacks the roots and can result in the death of the tree. A white layer of fungal growth can be seen under the bark of roots and trunk, and the foliage of infected trees turns from yellow to brown. It is especially problematic in recently cleared land that contains residual tree roots which serve as a source of inoculum.

Suitable insecticides/fungicides for use in apple cultivation are listed in **Appendices 11, 12 and 13.**

A note on apple cultivars. In addition to those shown here, further apple varieties grown that have shown promising results in Kenya include

Acpye	Red Jonathan
Alexander	Schweizer Orangenapfel
Ein Shemer	Shlomit
Grand	Starking
Maayan	Vered
Michal	Winter Glockenapfel
Orleans	

APPLE CULTIVARS

Gloster 69

History: Raised in 1951 from Winter Glockenapfel x Richard Delicious at Fruit Research Station Jork, Germany.

Tree: Vigorous, upright-spreading. Produces spurs fairly freely.

Fruit: Ground colour pale greenish yellow, flushed almost overall with a dull deep red. Numerous small, pale russet lenticels. Oblong-conical, sometimes waisted; often flat-sided and irregular. Stalks are 24–45 mm long, thin, reddish and fairly stout; always bent to one side. Medium to large size: height 65–85 mm, diameter 70–90 mm. Flesh is creamy white, fine-textured, juicy, sweet with briskly pleasant flavour. Excellent for dessert.

Mutsu (syn. Crispin)

History: Raised at Aomori Research Station, Kurioshi, Japan, in 1937 from a cross between Golden Delicious and Indo.

Tree: Particularly vigorous, and therefore a dwarfing rootstock is recommended for the home garden. Mutsu spurs freely and sets heavily. It is self-infertile and needs a pollinator. Its chilling requirement is 967 hours.

Fruit: Yellow-green, shiny-skinned fruit, blushed and with pronounced lenticels, somewhat similar to Golden Delicious. Large, oblong, and irregular in shape; the skin is waxy and clear with a copper blush. Flesh is very crisp, juicy and coarse-grained with a sprightly flavour. Excellent both for dessert and cooking. The fruit is free from russeting and will not shrivel in storage.

Winter Banana

History: Originated around 1876 on the D. Flory Farm in Case County, Indiana, USA. Today there are a number of strains.

Tree: A very vigorous grower that bears alternatively heavy and light crops. It has a low chilling requirement and is recommended both for production and as a pollinator.

Fruit: Has an attractive appearance—pale yellow blushed pink with a waxy finish. The skin is shiny, smooth and greasy with a distinct suture line. Medium to large and mainly round to conical in shape. The yellowish-white flesh is crisp and juicy with a distinctive aroma; its flavour, however, is only fair.

Golden Delicious

History: A chance seedling found by A.H. Mullins, Clay County, West Virginia, USA, in 1912. It probably resulted from open-pollinated (speculated to be by Golden Reinette) seed of Grimes Golden. Today, there exist many strains, sports and cultivars.

Tree: Moderately vigorous, low and spreading with wide-angled crotches. Will bear young and annually. Self-fertile, it is also an excellent pollinator for other cultivars. Thinning is necessary to produce large fruits. The tree is highly productive, bearing on spurs, laterals and tips.

Fruit: Greenish-yellow, becoming golden-yellow. No stripes; lenticels russet and fairly large, occasionally tinged red. Usually large, round-conical to oblong. Rather more tapered to apex than to base. Cream, slightly green-tinged flesh. Crisp, fine-textured, juicy, sweet and a little acidic with good to very good aromatic flavour. The skin is dry and bruises easily. An excellent multi-purpose apple with very good storage qualities.

Jonagold

History: A cross of Jonathan and Golden Delicious developed in 1943 at the New York State Fruit Test Station, Geneva (New York, USA).

Tree: Moderately vigorous, fairly wide-spreading. Produces spurs very freely.

Fruit: Ground colour bright yellow with some green tinges. Up to one-half flushed and mottled bright red. Lenticels inconspicuous. Slight grey russet. Dry skin. The large fruit is round to conical. Stalk is fairly long and curved to one side. Broad at the base, moderately flattened at base and apex. Creamy white flesh that is firm, sub-acid, and juicy with a good rich flavour. Excellent dessert and processing quality. Fruit keeps well in storage for up to 5 months.

Rome Beauty

History: Originated around 1817 at H.N. Gillet in Lawrence County, Ohio, USA. For many years it was one of the most important commercial varieties in Kenya. Parentage is unknown.

Tree: Requires a vigorous rootstock for good performance. Upright-spreading, becoming round-headed. Does not produce spurs very readily.

Fruit: Ground colour greenish-yellow, up to one half flushed dull red. Some broken red stripes and mottling. Lenticels are moderately conspicuous. Several highly coloured strains exist.Medium-large round to round-conical; sometimes a little lopsided, flattened at base. Skin slightly greasy, a little bumpy and pitted. Rather coarse-textured creamy white flesh. Initially crisp, juicy, tart-sweet but lacking in flavour under certain conditions. Good for eating raw and for all-purpose cooking. Keeps well but loses snap.

Granny Smith

History: Originated about 1868 from a chance seedling grown by M.A. Smith, Ryde, Paramatta River, Australia. It is thought by some to be a seedling of French Crab.

Tree: The upright growing tree is vigorous and bears early and heavily. It requires a long growing season to mature, is an excellent pollen source for other varieties and is known as a tip bearer.

Fruit: Waxy, smooth-skinned and bright green, sometimes flushed purplish-brown. The lenticels are conspicuous large white dots. Medium to large in size and globose-conical shaped. The white flesh is hard, crisp and juicy. It is resistant to bruising. This outstanding multi-purpose apple has a tart flavour, becoming very sweet if tree-ripened. The fruit will store for several months without needing refrigeration.

White Winter Pearmain

Also known as Cambellite, White Pearmain and Griffin's Pearmain.

History: There is confusion about its history and uncertainty on its American origin and distribution. It is speculated to be of Eastern United States origin and was recorded in 1849, but it is also claimed to be an English apple dating back to 1200 A.D.

Tree: The moderately vigorous tree has oval, medium-sized and light green leaves folded and reflexed. The tree grows tall and upright, and the bark is a dark-red on new growth with numerous lenticels. An excellent pollinator for other varieties.

Fruit: Medium in size and round to conical in shape. Pale yellow skin is flushed irregularly with a brownish-red and covered with russet dots. The skin is waxy and tough. The yellowish-white flesh is crisp, juicy and tender with a sub-acid flavour that approaches sweetness. A good all-round apple with low chill requirements

Gravenstein

History — This is likely to be an Italian variety. However, because of 'bitter pit' and physiological cracking it is not recommended for Kenya.

Tree: — The tree is very vigorous with an upright spreading habit. Chilling requirements are low to medium. The tree is a spur and tip bearer. To obtain a good fruit-set, a pollinator is needed.

Fruit: — The medium to large roundish fruits tend to be a bit lopsided. Striped with red over a greenish-yellow skin. Soon after ripening the skin develops a waxy or greasy feel. The creamy yellow flesh is very juicy, crisp, fine-textured, markedly aromatic and slightly acidic. A multi-purpose variety, but the storage life of its fruits is very limited.

Golden Dorsett

History: This variety originates from Nassau in the Bahamas.

Tree: The plants are medium in height, upright and semi-spreading, developing into large, vigorous trees. This is a low-chilling apple that does well in warm winter climates. An ideal pollinator for var. Ana.

Fruit: The fruit resembles Golden Delicious with a yellow skin and red cheek but is slightly smaller than Ana. Firm, smooth and crisp flesh with a sweet, tart flavour. Fruits have been stored satisfactorily for several weeks under refrigeration.

Ana

History: A low-chilling cross between Golden Delicious and Red Hadassiya developed in Israel and very well adapted to Kenyan conditions.

Tree: The trees are vigorous, upright, and of medium height.

Fruit: Fruits are medium to large and round-conical or conical. Resembles Red Delicious but with approximately 30 to 40% red blush. There are plenty of red stripes on a green-yellow background and lenticels are conspicuous. Flesh has a good mild flavour that is sweet to semi-acidic, and the texture of fruits is crisp to soft. The storage ability is only poor, and therefore—and also to avoid mealiness—fruits have to be consumed soon after harvest.

Jonathan (*syn.* King Phillip, Ulster)

History: Seedling from Esopus Spitzburg, found on P. Rick's farm, Woodstock, Ulster County, New York, USA and first described in 1826.

Tree: Moderately vigorous, bears early on spurs and shoots, annually and heavily. The tree remains fairly small with slender, delicate growth and is very prone to mildew.

Fruit: The yellow skin is almost covered with bright red stripes and blush. Lenticels are inconspicuous as green or white dots. The skin is fairly smooth and dry. There are several highly coloured sports and strains. Round to round-conical, and medium in size. A little irregular, flattened at base and apex. White, slightly green-tinged flesh. Firm, fine-textured, fairly juicy, sweet with a faint, pleasant flavour. Fruit stores only for a short period.

Pear

PEAR *(Pyrus communis; Pyrus serotina)*

History

All the known species of pears are native to Europe or Asia. The European pear *(Pyrus communis)*, indigenous to the region from the Caspian Sea westward into Europe, was used as food even before agriculture was developed as an industry. A few pear cultivars were known prior to the Christian era, but there was little progress on this tree crop before about the beginning of the 16th century, when plant breeders started to grow plenty of seedlings in the hope of discovering better cultivars.

Pyrus serotina, the Asian pear, is one of a number of *Pyrus* species originating in North-East and East Asia; wild groves are still found in the Szechuan region of southern China. *Pyrus serotina* has been grown in China, Japan and other Asian countries for at least 3000 years, and these regions are still its centres of production. Chinese immigrants introduced Asian pears, also called oriental pear, apple pear, sand pear, and Nashi, to the west coast of the United States during the 1800s. Hundreds of cultivars have been developed in Japan and Taiwan, and future breeding work aims to develop cultivars that combine excellent fruit quality with a wide range of maturity periods, resistance to pests and diseases, and low chilling requirements.

The Asian pear appears to be an under-utilised fruit crop in the tropics. A number of improved low-chilling cultivars have been introduced to East Africa. Some of them will replace the overpopulation of the Kieffer cultivar; others might widen the scope for pears in the highlands where—particularly at higher elevations—the choice of suitable fruit crops is rather limited.

Pears rank second in importance among temperate fruit trees in the world. World production for 2004 was 19.2 million tonnes (FAO statistics).

Botany

Like the apple, the pear is a pome fruit and belongs to the Rosaceae family. Pear cultivars can be divided into 3 main groups originating from 3 species: *Pyrus serotina, P. ussuriensis,* and *P. communis*. Their hybrids are of increasing importance as indicated by the wide distribution of the cultivar Kieffer. Asian pears may be divided into the Japanese cultivars which have more-or-less round fruits, and Chinese cultivars which produce more pear-shaped fruit similar to European cultivars. Japanese cultivars may further be divided on the basis of fruit skin texture—smooth or russet. European pears may be harvested for ripening off the tree in storage, while Asian pears are allowed to ripen on the

tree before being picked. A ripe European pear has a soft, melting texture and creamy, aromatic flesh, while Asian pear fruits are very firm, crisp, juicy and very sweet.

The descriptions given here cover Asian pears and their hybrids, which appear to be better adapted to the Kenya highlands than European pears.

Asian pears generally have an upright growth habit and may grow to 10 m tall. Shoots grow in flushes, the number of leaves being limited in spurs, and indeterminate in long shoots. The annual cycle of growth is similar to that described for apple. Flowering takes place before or together with unfolding of leaves. Self-incompatibility is common but parthenocarpic (i.e. seedless) fruit set occurs. Fruit ripens after 4 to 5 months.

Propagation

Pear cultivars are not true to type when grown from seed. Therefore, vegetative propagation has to be used. The most common method of pear cultivar propagation is grafting and budding, in which regard the following has been observed:

- Hardwood cuttings are successful for such cultivars as Bartlett, Old Home and Kieffer. The latter may also be used as a rootstock for most other Asian pear cultivars.
- All Asian pear cultivars will grow on *Pyrus betulaefolia*, *P. calleryana*, *P. serotina* and *P. ussuriensis* rootstock. Seedlings of the common pear (*P. communis*) are generally grown from seeds of Kirchensaller, Winter Nelis, and Bartlett, and are used for the multiplication of European cultivars.
- For good germination pear seeds have to be stratified for 60 to 110 days at about 4º C. The choice of rootstock plays a key role in the pear tree's productivity, longevity and hardiness. Incompatibility of rootstock and cultivar can result in poor growth and declining crops.
- Quince *(Cydonia oblonga)* has been used for centuries as a dwarfing stock for pear. Several dwarfing clones of quinces have been selected, and 'Quince A' has proved to be the most satisfactory stock for European pears. Some cultivars, however, fail to make a strong union and hence double working with an intermediate stock is necessary. Most Asian pears appear to be incompatible with quinces.

Establishment

The pear thrives on a variety of soils but it does best in fairly rich, well drained loam soils of moderate depth underlying a porous subsoil with sufficient organic matter. Pear trees are reasonably tolerant to drought and excess soil

moisture during the rest season, and can tolerate slightly acidic soil, with an optimum pH of about 6.0–7.0.

Depending on their chilling requirement pears do very well at elevations of approximately 1,700–2,700 m, which include famous growing areas like Limuru, Tigoni, Kikuyu and Molo in central Kenya (see **Appendix 7**). Generally, Asian pears and their hybrids can be grown at considerably lower elevations than European pears in tropical regions. A cold season is required to break bud dormancy. Lack of chilling leads to delayed foliation and poor, uneven fruit set. Cultivars differ greatly in their chilling requirements, and in some cases up to 1000 hours below 7 °C are needed. For Kenya, pears with low chilling requirements are necessary; accordingly, appropriate cultivars were introduced not long ago, namely Flordahome, Hood, Tenn, Spadona, Gentil, Shinko, Kosui, Nashpati, Tsuli, New Century, 20th Century, Taiwan Hybrid, and Senseke, among others. Of the Chinese cultivars, Tsuli and Yali show the most promise for East Africa.

The pear is similar to the apple in its cultivation requirements but wider planting distances should be applied; depending on the cultivar and location, spacing of 3–4 m within the row and 4–6 m between the rows should be sufficient. Most pear cultivars are self-infertile (Asian pear cultivars are only partly self-fertile), and cross-pollination is generally required to ensure a commercial crop.

Maintenance

Nearly all the maintenance requirements for apples also apply to pears, with a few exceptions. Heavy pruning of pears can produce undesirable excessive, vigorous growth. Most pears trees tend to grow upright, causing the fruit to be difficult to pick. Therefore, pruning the tree to a ‘vase-shape’will help to open the centre and encourage spreading. This may be supported by cutting at outside-facing buds and tying of laterals. Most pear cultivars fruit primarily on spurs. Pears generally tend to spur up more freely than apples, and once the trees have started cropping, it will be necessary to thin the spur system frequently to encourage new wood growth. Kieffer trees are often cut back to two-year-old wood every other year so as to remove about two-thirds of the previous season’s growth. The tree needs this since it is likely to set heavily, producing small fruits.

Pears take longer than apples to begin fruiting, usually 3 to 5 years after planting. Many cultivars tend to set heavy crops of fruit which the tree is unable to develop to a good marketable size. Removing excess fruit ensures satisfactory development of colour, shape, and size of the pears remaining on the tree. Over-cropped trees are also prone to serious limb breakage problems. The earlier thinning is completed, the more effective it is at achieving the

desired results. Leave one pear per cluster and space these about 10–15 cm apart. If fruit set on a tree is not excessive, 2–3 fruits per cluster will reach satisfactory size without thinning.

Precise fertilizer requirements for pears in East Africa are largely unknown. Generally, they are more-or-less the same as those for apple culture. The most effective fertilizer programme can be reached based on leaf and soil analysis **(Table 6)**.

All pear fruits, whether intended for the market or for use at home, should be hand-picked with care. The fruit is ready for harvesting when there is a perceptible change in the skin colour, when the seeds begin to turn brown or when the stalk separates readily from the branch when the fruit is lifted lightly. These tests are an indication of picking maturity only; most pears will need to be store-ripened before they are ready to eat. If not consumed immediately, well treated and packed fruit can be stored for several months at a constant temperature of –1° to 2º C and relative humidity of 85–90 %. Maximum storage life in pears is cultivar-dependent (see **Appendix 6**).

Under US growing conditions, the following storage periods at –1 °C have been published:

Williams	2.5 – 3 months
Bosc	3.5 – 4 months
Comice	4 – 4.5 months
Packham's Triumph	5 – 6 months
Winter Nelis	7 – 8 months

Naturally, pear yields vary according to the age of a tree, the cultivar, crop husbandry and location. There is only little information available on yield levels in Kenya. Expect a healthy young tree to produce 2–7 kg of fruit, a five-year-old tree 13–23 kg and a mature tree 45–180 kg. In Japan, the average commercial production yield is 25–40 tons/ha per year; in South Africa it is 16–20 tons/ha.

Table 6. Pear leaf standards

	%					ppm				
	N	**P**	**K**	**Ca**	**Mg**	**Mn**	**Fe**	**Cu**	**B**	**Zn**
Deficiency	1.9	0.10	0.4	0.5	0.18	20	40	1	25	10
Normal	2.1–2.5	0.60	3.0	2.5	1.0	200	400	50	75	80
Excess	3.0	0.65	4.0	3.0	2.0	450	500	100	100	300

Source: R.L. Stebbins, Oregon State University (1983)

Preventive control of pests and diseases is required to maintain healthy foliage and good fruit quality. Whereas the common Asian pear suffers little from diseases and pests, improved cultivars, and European pears, require fairly intensive crop protection. They may be attacked by black spot disease (*Alternaria* spp.), scab (*Venturia* spp.), rust (*Gymnosporangium* spp.), fire blight (*Erwinia* spp.), root rot (*Armillaria* spp.), and powdery mildew (*Phyllactinia* spp.).

Common pests include aphids, fruit flies, red spider mites, thrips, scales, and false codling moth.

Farmers are strongly advised to contact an extension officer for proper identification of pests and diseases, and to obtain up-to-date information regarding control recommendations.

PEAR CULTIVARS

Shinsui

Origin: Japan (1965)
(Kikusiu x Kimizukawase)

Tree: Medium to vigorous, upright, sparsely branched with long internodes. Broad, round–oval leaf with attenuated tip and medium coarse serrations. Chilling requirements are medium at about 400 hours. Needs pollinators like Shinseiki.

Fruit: An early-maturing (115–125 days after full bloom), russet brown cultivar; flat to globular in shape and of reasonable size (about 130 g). Lenticels are conspicuous. Flesh colour is cream. Juicy, very sweet, crisp and slightly gritty. Medium production but good storability.

Hosui

Origin: Japan (1972)
(Kikisui x Yakumo)

Tree: Vigorous when young but more moderate when mature. Weeping habit with long, floppy limbs. Broad ovate to oval leaf with attenuated tip, medium serrations. Chilling requirements moderate—about 450 hours.

Fruit: Medium to large (about 180 g) round fruit. Juicy, sweet, crisp and full of flavour. Excellent dessert quality. The russet golden brown skin shows plenty of prominent white lenticels. Due to its high sugar-to-acid ratio and fine grained texture this is one of the tastiest Asian pears. Production is medium to high, and fruit stores well for 4 to 6 weeks. Recommended pollinators include Shinko, Barlett and 20th Century.

Shinko

Origin: Japan (1941)
(Nijisseiki x ?)

Tree: Well shaped, low to moderate vigor, very upright and extremely productive. Despite heavy crops, it is an annual bearer. Oval leaf with attenuated tip and small, neat serrations. Moderate chilling requirements; about 450 hours.

Fruit: Large, more round than conical, slightly flattened with a beautiful bronze-russet thick skin. This late-ripening cultivar is of excellent quality and will ripen about 150 to 170 days after full bloom. The fruits are juicy, sweet, refreshing, and crisp like an apple. Shinko is a useful pollinator and is partially self-fertile. Fruit stores well for up to 4–5 months.

Okusankichi

Origin: Old Japanese cultivar
(seedling of Wasesankichi ?)

Tree: Vigorous, very productive, but susceptible to fire blight. Leaves are roundish with attenuated tips and medium serrations. Chilling requirements are medium. Partly self-fertile, but more productive if Hosui is interplanted. A very late cultivar—picking may start 195 to 210 days after full bloom.

Fruit: Large to very large, turbinate or globular and slightly irregular in shape. The fruit is russet brown, dull greenish brown to tan brown. At harvest it has only a fair flavour and moderate quality, but will improve (sugar–acid ratio) during storage. Fruit stores well for up to 6 to 7 months.

Kieffer

Origin: Germany, hybrid of an Asian x European pear. (*Pyrus communis* x *P. serotina*)

Tree: The easiest cultivar to grow. Very vigorous, upright and fruitful. Chilling requirements are low and heat endurance is excellent. Yields are medium to high, and no pollinator is needed. The tree is well adapted to a wide geographical range and to a great diversity of soil and climatic conditions.

Fruit: Medium to large (185–260 g), diameter 7–8 cm, height 6.5–7.5 cm. Oval, narrowing at both ends, with a thick stalk about 2.5 cm long. Flesh is firm, yellowish-white, moderately juicy, tasty but sometimes very granular. The skin is thick, tough, smooth with large lenticels, green-yellow, blushed with dull red on the exposed cheek. Storability is very good and the fruit never becomes soft. Although the dessert quality is low, the canned product is usually good.

Shinseiki (syn.: New Century)

Origin: Japan

Tree: Vigorous, upright, heavy bearer (often starting in its second year), and easy to grow. Self fruitful, with moderate chilling requirements—about 350 to 450 hours.

Fruit: An egg-shaped, bright-yellow-skinned, firm and medium-sized fruit with medium to large brown lenticels freckling the peel. Fruits hold on the tree well and are often colour-picked 2–3 times per season. Heavy thinning is necessary for good fruit size. Fruits have a thin skin and firm, juicy, sweet, and crisp flesh. Mature early and store well for up to 3 months. Resembles 20th Century, but is less flavourful.

Tsuli

Origin: China, old renowned cultivar,
Probably *Pyrus ussurriensis* x *P. bretschneideri*

Tree: Very vigorous, upright, and dense, with low chilling requirement: about 300–350 hours. Leaves are large, oval, with attenuated tip and have very fine, neat serrations. A late cultivar which will ripen 150–190 days after full bloom. It is partly self-fertile.

Fruit: Medium to large (140–310 g), 5–7.5 cm in diameter, pear-shaped, light green to yellow, may have unattractive lenticel spotting. Good eating quality with some stone cells, high sugar and medium acid content, sweet, crisp with a trace of tartness. It has a fairly long storage life of 6–7 months at 0–1 ºC.

Packham's Triumph

Origin: Australia (ca. 1900)
(Bon Chretien x St. Germain)

Tree: Medium to strong vigour, upright growth habit. Chilling requirements are medium to low, and productivity is high.

Fruit: Large (150–200 g) irregularly shaped and short necked fruit with greenish skin, turning yellow when ripe. The flesh is finely textured, creamy white, sweet and juicy. An excellent dessert pear, similar to Bartlett with very good cold storability of up to 4 to 5 months.

Forelle

Origin:	Germany (chance seedling)
Tree:	Strong, upright growth. Low chilling requirements. Medium production. Pollinator: Kieffer. Inclined to produce small fruit, so thinning is advisable.
Fruit:	An attractive green-yellow, red-blushed pear. Medium-sized (ca. 150 g), oblong–pyriform shaped with conspicuous lenticels. Sweet taste but texture is slightly coarse. Very good storability.

Fertility

Origin: Hertfordshire UK (1875)

Tree: Moderate vigour, upright growth; will form a spine-like tree. A very heavily cropping cultivar but only of fair quality. Self-sterile.

Fruit: Small-sized (5–6.5 cm in diameter, height 6–7.5 cm, weight 95–165 g) and round to conical. Skin is rough, dull yellow and almost covered with brown russet. Eye is open and set on surface of fruit. Stalk measures 2.5 to 4 cm, woody, rather stout. Flesh yellowish, very juicy, crisp, half-melting or crackling, but has poor or little flavour. Very short storability.

Spadona

Origin: Ronzone (Italy) – chance seedling

Tree: An old local cultivar, promoted in the region of Trent, and most probably a seedling of the Curato cultivar. The tree is of moderate vigour, a good cropper, and has adapted well to Kenyan highland climatic conditions.

Fruit: Medium-sized: 5–6 cm in diameter, height 5–7 cm, weight 100–210 g, oblong–ovate–pyriform. Skin colour is mainly green-yellowish, but with a reddish blush if exposed to the sun. Waxy skin with conspicuous lenticels. Flesh colour is white, texture fairly melting, and the taste juicy and sweet. Has short to medium storability.

Jargonelle

Origin: France (chance seedling)
An ancient cultivar first recorded in 1629.

Tree: Moderately vigorous with a rather straggling growth habit. It is a heavy cropper and a tip bearer.

Fruit: A medium sized, long conical fruit of good quality, but it must be picked and used as soon as ready because it is prone to rotting from the core. Fairly smooth, greenish-yellow skin with some brownish-red flush and russet patches on the sun-exposed side. Flesh pale yellow, tender, juicy and sweet.

Japanese Plum

JAPANESE PLUM *(Prunus salicina)*

History

This species originated in China, where it was cultivated for thousands of years. It was domesticated in Japan around 400 years ago, and from there it spread around the world being erroneously called the Japanese Plum. Many Japanese plum cultivars are the result of chance seedlings and controlled breeding programmes. Luther Burbank, a famous plant breeder from California, USA, produced some of these, namely Methly, Gold, Shiro, Santa Rosa, and Burbank. They are now grown worldwide, mainly in the subtropics and tropical highlands. According to FAO statistics, world Japanese plum production in 2002 totalled 9.3 million tonnes.

Botany

Plums are placed within the Prunoideae subfamily of the Rosaceae, which contains all of the stone fruits such as peach, cherry and apricot. Plums are the most taxonomically diverse of the stone fruits and are adapted to a broad range of climates and soils.

The Japanese plum tree is a small to medium-sized shrub or tree, but may also grow up to 10 m tall. Twigs are glabrous, becoming lustrous red-brown. The shiny bright green oblong-ovate leaves are carried on 1- to 2-cm-long petioles with several glands. The white flowers are borne on short spurs, mostly in clusters of 2–3 and appearing before or together with the leaves. Honeybees are the major pollinators. The fruit, a drupe, is globose-ovoid, 3–7 cm in diameter, yellow, red or greenish in colour, glabrous, and often pointed at the apex. Fruits are classified as freestone or clingstone type, which indicates whether or not the stone separates easily from the flesh.

Propagation

Plums do not produce true from seed. Consequently, and in order to maintain 'true to type' cultivars, they have to be propagated asexually by using grafting/budding methods (see page 5) or—where feasible—by hardwood cuttings (of cultivars Methly and Settler, among others). Budding or grafting can only be carried out if suitable rootstock material is available. Myrobalan *(Prunus cerasifera)* seedlings have been used as the principal rootstock for Japanese plums. Their roots are adapted to a wide range of soil and climatic conditions. They are resistant to drought and root and crown rot, but susceptible to root knot nematodes and bacterial canker.

To achieve good and uniform germination, the Myrobalan seed requires stratification for about 90 days at between 2° and 4 ºC. Myrobalan B and Myrobalan C are clonal selections and are propagated by hardwood cuttings. Because of their genetic uniformity trees on this rootstock are uniform in size and performance.

In Kenya, plums are usually budded onto preferably nematode-resistant peach seedlings (such as Nemaguard and Lovell) where they tend to produce earlier and set more consistently. Peach seedlings are compatible with most commercial plum cultivars, although a large scion overgrowth may sometimes develop as the tree grows older.

Establishment

Plums are grown on a wide range of soils. However, a deep, well drained, medium-textured soil with a pH of 5.5 – 6.5 is generally best **(**see **Appendix 10**). Plum trees are the most tolerant of all stone fruits with regard to heavy soils and water logging, and they tolerate drought better than do peach trees.

Japanese plums are very productive at altitudes of about 1,700–2,600 m, where their chilling requirements (hours below 7 °C) of around 100–800 are met. Therefore, it is important to choose suitable cultivars adapted to a specific location.

Depending on future market outlet the grower has to decide on such aspects as appearance, storage quality, marketability, palatability, pest/disease resistance, tree growth and productivity. Although it is known that some cultivars like Methly, Beauty and Santa Rosa are self-fertile, adequate cross-pollination is needed for other cultivars to ensure sufficient fruit setting for commercial purposes. Worldwide, many new improved selections are introduced each year and are gradually replacing older and less desirable cultivars.

In most cases a planting distance of 5 m x 6 m is recommended. A spacing of 4 m x 5 m is sufficient if trees are regularly pruned, which is done to maintain a balance between vegetative growth and fruiting. In case cross-pollinating varieties are needed, these should be distributed at a rate of about every 3rd tree in every 3rd row.

Maintenance

The preferred tree shape is the ‘open centre’ with good light distribution even for larger tree sizes. Most of the young plum trees obtained from the nursery will be in the shape of a straight whip without lateral branches. Thus, pruning at planting usually consists of cutting this whip back to 50–60 cm from the ground. This stimulates side branching below the point of cutting. Pruning during the tree’s formative years is light: interior branches and water sprouts are

controlled by pruning or bending, and growing laterals (scaffolds) are headed to induce branching. At maturity, vigorous upright shoots are removed since fruiting occurs mostly on spurs. To maintain fruit size, renewal of fruiting wood is necessary since spurs live for only about 5–8 years. To start a new crop cycle trees should be defoliated. In most locations the leaves do not detach easily, and therefore chemicals like sodium chlorate (0.5–1%), copper or zinc sulphate and, recently, cyanamide (all at about 2% concentration) are used.

To avoid problems associated with heavy crops, it is necessary to thin the fruits. This should be done after natural drop and before seed hardens (about 6 weeks to 2 months after flowering), since thinning at a later stage will have little or no effect on fruit size. Remove all but the best plum per cluster or spur. Depending on cultivar, the remaining fruitlets should be spaced 7–15 cm apart.

Orchards are clean cultivated, preferably with a beneficial mulch cover around the trees. During the rainy season weeds are slashed, or a cover crop may be grown.

The need for nutrients varies from tree to tree depending on, among other factors, the cultivar, age, and soil condition. In this context, leaf analysis will help determine deficiencies and/or excesses of the nutrients needed for good growth and production **(Table 7)**.

In accordance with results received from laboratory analysis, fertilizers are applied at the beginning of the growing season, preferably when the soil is moist and well soaked. The recommended amount of nitrogen should be split into two top dressings, spaced about 2–3 months apart. If the required nutrients are compound NPK fertilizers, and the ratios are, for instance, 15:4:12 or 12:4:17, the application rate should be 200–400 g per tree per year, with a maximum of 3 kg/tree/year. In case fertilizer is not affordable, at least a layer of

Table 7. Optimum nutrient levels of Japanese plums

Element	%	**Element**	ppm
Nitrogen	2.3–3.0	Copper	6–16
Phosphorous	0.1–0.3	Manganese	40–160
Potassium	1.6–3.0	Boron	25–60
Calcium	1.0–1.5	Zinc	20–50
Magnesium	0.3–0.8	Iron	100–250
Chlorine	<0.3		
Sodium	< 0.2		

Source: B. Wolf and H.A. Mills, 1991. Plant Analysis Handbook.

about 10 cm of compost or well decomposed manure should be spread around the trunk.

Depending on cultivar, plums are ready to be picked 80–120 days after flowering. Fruits may be picked before they are completely ripe since they will finish ripening off the tree. Fruit maturity first begins at the top of trees and later at the bottom, which usually necessitates more than one picking stretched over a period of 7–10 days. Plums are highly perishable and must be picked and handled with care. If they are picked to be eaten fresh, leave the stem attached to the fruits and place them in lined buckets. For older cultivars, 4–10 tons/ha is considered to be a fair yield. For the newer ones, such as Harry Pickstone or Reubennel, 20–30 tons/ha may be expected.

Most Japanese plums are marketed as fresh fruit. In order to avoid an oversupply at certain months of the year they may be kept for up to several weeks—depending on cultivar—in controlled cold storage at 0.5º–1 ºC and 90% relative humidity.

The application of pesticides and/or fungicides is sometimes necessary to control seasonally appearing pests and diseases (**Appendices 11, 12 and 13**). Among these are aphids, beetles, bugs, fruit-piercing moth, nematodes, scale insects, caterpillars, and red spider mites. Common diseases of plums are blossom wilt, brown rot, scab, die back, and rust. These are all fungi which thrive under wet conditions and thus they pose less of a threat if the growing season is not very wet. Outbreaks can be prevented and/or controlled by using appropriate inputs. If in doubt, and to avoid mistakes and unnecessary expenditure, farmers should contact a horticulture extension officer for assistance in diagnosing a particular pest or disease problem, and advice on suitable control measures.

JAPANESE PLUM CULTIVARS

Shiro (syn.: Ogden)

History: Originated in 1899 in California, probably as a chance seedling.

Tree: The vigorous trees have a semi-upright growth habit which means that they are low-growing and spreading rather than upright. They are very hardy and prolific so fruit thinning might be needed. Methly and Santa Rosa will pollinate Shiro, and Shiro will pollinate both.

Fruit: This mid-season, medium to large cultivar bears round to heart-shaped yellow fruits. They are juicy, pleasantly sweet but without a marked flavour. The skin is slightly waxed and the translucent flesh is yellow. The skin and the flesh around the pip are acidic.This clingstone cultivar is suitable for eating fresh, cooking, canning and dessert.

Songold

History: This cultivar—a Golden King x Wickson cross—was bred by the Fruit and Fruit Technology Research Institute (FFTRI) in South Africa, and released in 1970.

Tree: The tree is semi-upright and vigorous with a low chilling requirement. It is precocious and highly productive but needs ample pollination. This cultivar exhibits a high degree of resistance to bacterial spot.

Fruit: Fruits ripen late in the season, and may reach up to 90 g per fruit. They are golden yellow when ripe for picking, developing an amber colour when ready for eating, at which stage the fruit quality is excellent. After cold storage, which is possible for a duration of 4 weeks, the skin turns light red. This clingstone fruit has an excellent keeping quality.

Harry Pickstone

History: A Methly x Wickson cross developed by the Fruit and Fruit Technology Research Institute (FFTRI) in Stellenbosch (South Africa), and released in 1973.

Tree: The tree is moderately spreading, very vigorous and has a very low chilling requirement. This self-fertile cultivar is moderately resistant to bacterial spot and very precocious and productive, bearing heavy crops just two years after planting.

Fruit: This mid-season clingstone plum bears medium to large, cordate shaped, melting, and reasonably sweet fruits. Initially, their skin is green with red but will change to red when ripe for eating. The yellow flesh has a good eating and excellent dessert quality. Fruits can be stored for up to 3 weeks but severe fruit thinning is required to achieve a fruit weight of 70 g.

Reubennel

History: The cultivar resulted from a cross between Gaviota and (Methly x Wickson) developed by the Fruit and Fruit Technology Research Institute (FFTRI) in Stellenbosch (South Africa). It was released in 1978.

Tree: The tree grows moderately upright, has a very low chilling requirement and is very vigorous, bearing heavy crops by its second year. Bacterial spot *(Xanthomonas pruni)* infection has been reported as a serious problem, although Reubennel is considerably less susceptible than older commercial cultivars.

Fruit: The clingstone fruit is medium to large (65 g), sometimes slightly bigger than Harry Pickstone and will ripen a week earlier than the latter. The skin is green with dark red on its suture when picked, but will change to overall red when fully ripe or during cold storage. The flesh is orange/yellow, and the texture firm and non-melting. Fruits have a very good sugar-to-acid ratio and excellent eating and keeping qualities.

Santa Rosa

History: Originated in 1906 as a chance seedling in the USA. It is one of the best cultivars bred by the American plant breeder L. Burbank.

Tree: The tree is hardy, upright, vigorous and highly productive. It is generally regarded as at least partly self-fertile, although a better fruit set will be achieved by interplanting a suitable pollinator like Wickson, Beauty or Gaviota. Santa Rosa is a very important commercial early cultivar with medium chilling requirements.

Fruit: The conical fruit is medium to large (60 g), crimson to purplish red, lightly freckled, and often with a whitish bloom. It is firm, sweet, juicy and aromatic, except near the pit where it is often quite acid. This clingstone dessert cultivar has a dark yellow to orange flesh of a melting texture and may be kept for up to 4 weeks under controlled storage.

Burbank (syn. Wright's Early)

History: Most probably a chance seedling, discovered in the USA in 1888.

Tree: This relatively small, spreading, flat-topped and hardy tree develops drooping limbs. The trees are partially self fertile and often set extremely heavily, which may lead to biennial bearing. Methly and Santa Rosa act as pollinators. The Burbank tree is more widely adapted to Kenyan growing conditions than is Santa Rosa.

Fruit: This semi-clingstone, early midseason plum is medium-sized, roundish/conical and develops a bright red, blushed yellow skin. The yellow to orange flesh is firm, sweet, aromatic, juicy and of a very good flavour. In order to overcome alternate bearing, fruit thinning is strongly recommended.

Satsuma (syn. Red Cardinal; Blood Plum)

History: An L. Burbank (California) introduction (1899) from Japan.

Tree: The tree is a vigorous and upright grower, partially self-fertile, with low chilling requirements. Santa Rosa, Methly and Shiro are known to be suitable pollinators.

Fruit: This semi-freestone cultivar produces medium to large, almost round and dark red fruits with a small pit. The flesh is purplish-red, firm, juicy and has a particularly good flavour. The fruit's keeping quality is only limited but Satsuma is known to be excellent for fresh consumption, cooking, canning, and for making jam.

Methly

History: Originated in South Africa in 1907. Similar cultivars are Settler and Tangazine which should be known as Methly types. Most probably, all three are seedlings and are easily propagated from hardwood cuttings.

Tree: This attractive, vigorous tree bears heavily and its chilling requirements are low.

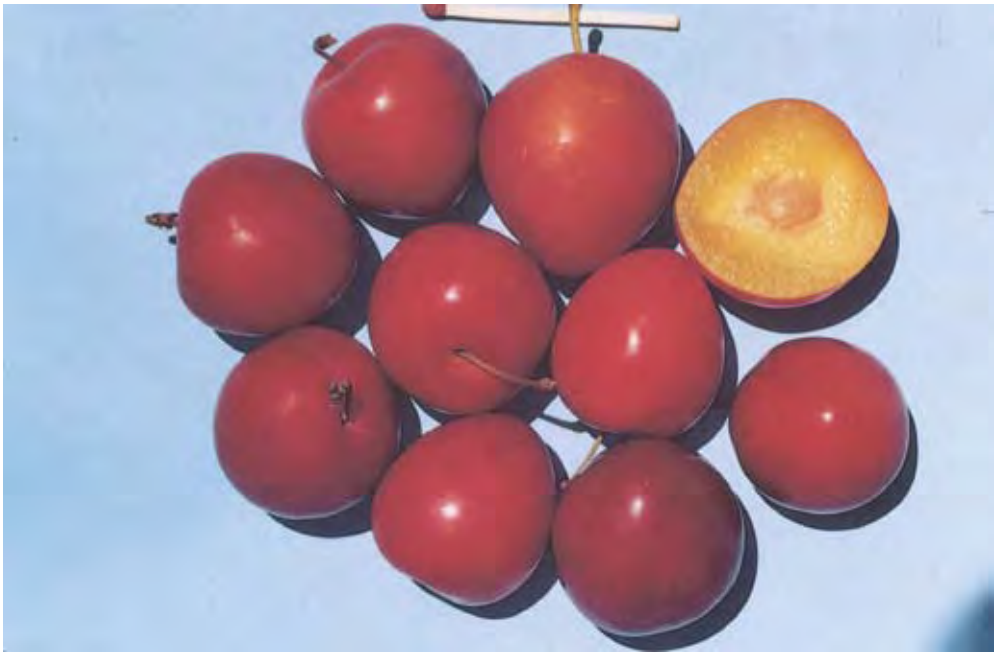
Fruit: Methly is an early season cultivar which produces small to medium-sized, round, reddish-purple fruits with soft, juicy, red flesh of good flavour. It is self-fertile and is a good pollinator for Burbank and Satsuma. Due to its small fruit size and poor keeping quality there is not much demand for this cultivar.

Cherry Plum

History: Cherry Plum is an ancient group of plums closely related to the wild ancestors of the modern domestic plum. They are believed to have originated from the Near East. Most of the original cherry plums were produced by crossing sand cherry *(Prunus besseyi)* with the Japanese plum *(P. salicina)*.

Tree: Many cherry plums are low growing shrubs, but some are vigorous, spreading trees with twiggy branches. There are several selections (Mordena, Convoy, St. Anthony) which mature early or in mid-season and that are highly productive.

Fruit: Small-sized, oval and scarlet red. Their yellow flesh is sweet and juicy and pleasant to eat. The fruits are excellent for canning, and making jam, jelly and juice.



Kelsey

Tree: This vigorous, upright, heavy bearing tree originated in Japan. Its chilling requirements are low, i.e. approximately 400 hours. Good pollinators for this cultivar are Santa Rosa and Beauty.

Fruit: One of the late season's striking free-stone cultivars, the plum is large (100 g), heart shaped, with green to yellow thin skin with a reddish blush. The flesh is bright yellow, firm and juicy, with a particularly small pit. Fully ripe fruits are very sweet and tasty and can be kept for up to 3 weeks under controlled storage.

Peach

PEACH *(Prunus persica)*

The nectarine**,** a close relative of the peach, is included in the following description because its requirements are so similar. Peach and nectarine cultivars are grouped according to a few distinctive fruit characteristics: soft or firm flesh, white or yellow flesh, and freestone or clingstone type (indicates whether or not the stone separates easily from the flesh). The fruits vary in size (3–8 cm diameter), shape and colour, and their very hard stone seeds are deeply pitted and furrowed.

History

Prunus persica is native to China, where it has been cultivated since ancient times. Cultivation spread from China throughout the world, in temperate climates as well as in tropical highlands where in some areas the species has been naturalised. Since then, the temperate zones of the world have been the traditional regions for the production of peach and nectarine. The main peach-producing areas are the United States, the Mediterranean, and China. According to FAO world peach production in 2001 totalled 13.4 million tonnes.

Breeding programmes for low chilling cultivars by the University of Florida and horticulture research institutes in Pretoria, South Africa produced improved cultivars which do quite well in the tropics.

In Kenya, some early settlers introduced peach seed from South Africa in the 1950s. As a result of several generations of selection, both deliberate and natural, some seedlings evolved that were well suited to the climate of locations around Burnt Forest, Londiani and Subukia. Recommended cultivars were as follows: Waldo, Shackleford, Killiecrankie, and Alexander Jewel, all white-fleshed and freestone; and Hall's Yellow, a clingstone with yellow flesh.

Botany

Nectarine (*Prunus persica* var. *nucipersica*) and peach (*P. persica*) are of the same species in the family of Rosaceae. They are called 'stone fruits' because of their central hard pit. The nectarine is actually a smooth and waxy-skinned peach, differing from the peach by just a single gene—the gene that gives peaches their fuzzy skin. Nectarines are also somewhat smaller than peaches, and some say that their taste is sweeter and their flesh a little less melting.

When grafted, peach trees are moderately small, with dense, erect growth, unless pruned to encourage spreading growth. Seedling trees will grow up to 7 metres tall. The lanceolate, glossy bright leaves are 5- to 8-cm-long (can reach 15 cm) with finely serrated edges. Sessile pink flowers appear before the leaves, often flanking the axillary leaf buds.

Propagation

Most peach cultivars are propagated by budding on rootstocks—such as Nemaguard and Okinawa—that are resistant to root-knot nematodes. Generally, peach seedlings are the most satisfactory rootstock for peaches and nectarines, and should be used unless certain special conditions necessitate other stocks. Apricot and almond seedlings are sometimes used, as well as Brompton and St. Julien clones (in Europe). Seedlings of the naturalized peach are normally used by local nurseries in East Africa.

Seeds for rootstock propagation, extracted from fully mature fruits, germinate faster and more uniformly if the stone has been cracked. These freshly obtained seeds should be planted as soon as possible in order to avoid seed dormancy. Seeds that are not removed from the stone must be stratified for about 3–4 months at a temperature of 3–5º C before they are ready to germinate. Dry seeds should be soaked in water for 12–24 hours, then drained and mixed with a moisture-retaining medium like peat moss, vermiculate or well washed sand. A fungicide may be added as a seed protectant. Polyethylene bags make excellent containers; they provide aeration and prevent drying. Under local conditions seed must be stratified in refrigerators and should be examined periodically; if the seed is dry the medium is re-moistened. At the end of the stratification period some of the seeds may begin to germinate in storage. This will be the proper time to transfer the seeds into well prepared seedbeds for their further development.

Establishment

Proper site selection and cultivar choice rank as two important factors in successful peach growing. Peaches can be grown on a wide variety of soils provided there is good internal drainage in the upper soil profile, i.e. from 1.2–1.8 m. Peaches do best in fairly deep sandy loam, a pH of 6.0–6.5, a sunny position, good drainage and an annual rainfall of about 800–1000 mm.

Depending on the cultivar, varying amounts of winter chilling are necessary to provide a good dormancy break. Florda cultivars, for instance, need 50–400 hours below 7º C. Suitable locations for peaches are altitudes of approximately 1,500 to 2,500 m. At higher elevations, summer temperatures are too low for the production of good quality fruit, and ‘leaf curl’ disease may be very troublesome.

In Kenya locally selected cultivars like Waldo, Killiecrankie, Alexander and Jewel have been supplemented by the importation of cultivars like Neethling, Kakamas, Texas, Culemborg, and Flordagold.

Depending on altitude and cultivar, planting distances of 5 m x 6 m and 6 m x 7 m are quite normal. All common peach cultivars are self-fertile and thus trees should be planted in solid blocks for easier spraying and picking.

Maintenance

Peaches are pruned more heavily than any other temperate fruit tree. Pruning is necessary to form a well shaped, strong tree and to maximize production of high quality fruit. Peaches and nectarines should be pruned and trained to an open centre to facilitate the penetration of light and circulation of air. This will take 2–3 years following which the trees should be ready to bear fruit. Peach trees produce fruit on one-year-old wood only, so they must be pruned annnually to remove old wood and allow new growth to develop for the following year's crop. Thus, the terminal and lateral shoots which have developed over the outer surface of the tree are the most important for fruit production. The best and most fruit is produced in the upper third of the tree. To bring overgrown, old trees down to economical range and fruiting, it will be necessary to carry out some heavy rejuvenative pruning (see page 19).

Additional objectives of dormant pruning are to remove dead or diseased shoots, rootstock suckers, and vegetative water sprouts from the centre of the tree. Peach pruning normally removes up to 40% of the tree and will often take 20–30 minutes per mature tree.

Peaches will begin bearing a commercial crop in their 3rd or 4th year. Most cultivars usually set more fruit than can mature to marketable size. Therefore, thinning is necessary for the production of quality peaches, although many growers often do not do this in practice. Thinning is used to control the number of fruits per tree in order to increase fruit size and quality as well as to ensure adequate vegetative growth. Prices of large fruits are usually at least twice those of small fruits, and large fruits are more economical to pick. Depending on the cultivar, fruit should be thinned before pit hardening, leaving about one fruit every 10–20 cm along the branches. The earlier the fruit is thinned, the greater will be the size response of the remaining fruit. As a rule of thumb, fruit should be thinned within 4–6 weeks after bloom. Hand thinning is the most precise and expensive method, but it enables growers to more carefully select the desired fruit and its position.

Historically, weeds were controlled by disc-harrowing and hand-hoeing, but this method is usually not recommended because of the loss of irreplaceable top soil due to erosion, and the danger of damaging the upper layer of shallow roots, which may allow the entry of soil-borne diseases. The most efficient floor management system for most peach orchards consists of a mowed native sod middle with a weed-free strip under the trees. Weeds in this strip are controlled by applying suitable herbicides. For young non-bearing trees the weed control strip should be up to 1.50 m on each side of the row and has to be widened gradually to extend to the drip line as the tree size increases.

Since fruit trees usually require 3-4 years to become productive—and in order to bridge the first few years with little yields—it is advisable to grow

vegetables between the rows at a sufficient distance from the trees. The growing of such crops as beans and peas has proved to be particularly successful and will help provide some welcome income to the farmer.

To keep trees healthy and productive, nutrient levels ought to be maintained within the optimal range (Table 8). The only way of accurately doing this is by monitoring the nutrient availability in both soil and foliage. Soil tests determine the initial nutrient needs and can help a grower maintain soil pH within the desired range (see **Appendix 10**). While applying lime will easily raise the pH in acidic soils, it is more difficult to lower these levels in calcareous soils. Leaf analysis enables the farmer to determine if the tree has obtained the required nutrients from the soil.

Supplementary inputs can normally correct nutrient deficiencies. Maximum growth of newly planted trees is achieved with small, frequent nitrogen applications. Once trees are in full production—usually in the 4th growing season—the grower should base phosphorus and potassium fertilization on soil or leaf tissue tests.

Peaches are picked when nearly mature but still firm enough to ship well. Change of ground colour can be used to judge the ideal picking stage. Fruits for local markets can be picked more mature than those to be shipped long

Table 8. Leaf analysis levels in peach

	Low Range	Optimum Range
Element	%	
Nitrogen (N)	< 2.8	3.00–3.50
Potassium (K)	< 1.0	1.10–2.00
Phosphorus (P)	< 0.15	0.17–0.29
Calcium (Ca)	< 0.80	0.90–1.50
Magnesium (Mg)	< 0.30	0.35–1.00
	ppm	
Zinc (Zn)	< 16	17–60
Manganese (Mn)	< 30	40–100
Copper (Cu)	< 4	7–18
Iron (Fe)	< 40	50–100
Boron (B)	< 20	25–80

Source: Institute of Food and Agricultural Sciences, University of Florida, Gainesville

distances. Peaches do not ripen uniformly on the tree and it is therefore necessary to carry out several picking operations at 2-day intervals. Ripe fruits will readily detach from the tree with a slight twist. Pick and handle fruit very carefully to prevent bruising. Today's peach market demands large, attractive fruit, preferably 5 cm in diameter or larger, free of insect and disease blemishes, and with good shape, colour and maturity.

A fully productive orchard (about 9–12 years old) should produce around 15 tons per hectare. Under optimal growing conditions and good husbandry this can be increased to 25–30 tons per hectare.

The following yield records (in kg) per tree were published for Tanzania (Igeri Location, 2000 m.a.s.l.):

Cultivar	**3rd year**	**4th year**	**5th year**
Flordabelle	14.8	35.6	21.1
Flordagold	17.5	29.9	38.2
Flordared	3.2	20.2	14.7
Sunred	4.6	47.8	26.9
Sunlite	2.3	35.4	20.9

If the market is oversupplied, fruit may be stored for 1–7 weeks at a constant temperature of 0–1 °C and 85–90% relative humidity.

Peaches are attacked by a large variety of pests and diseases. It is beyond the scope of this publication to give detailed descriptions of common disorders and therefore only basic information will be given. Farmers are strongly advised to keep close contact with their extension officers and relevant institutions in order to obtain up-to-date recommendations for pest and disease control.

Pests

- Dense populations of **sucking aphids** can attack the leaf surface and young shoots. Damage includes poor fruit set, curled, distorted leaves, and die-back of tender young shoots.
- Some peach cultivars may be badly infested with **codling moth** larvae. Eggs are deposited on ripening fruits and the hatching caterpillars penetrate into the pulp. Infested fruit will drop prematurely.
- **Fruit flies** are widespread and peaches are a favourite host. Small, white, legless maggots can be found in the rotting pulp of ripening fruits which usually drop and cause a great financial loss to the farmer.
- Various other insects, including beetles, bugs, nematodes, caterpillars, and grasshoppers, are also likely to be present, though they often do no extensive damage and may escape unnoticed.

Diseases

- **Scab** affects peaches by first causing small brown spots on the fruit skin. The centres of the spots become brown and corky, and deformation or splitting of attacked fruits follows.
- **Mildew** infection starts as white, felty patches especially at the leaf margin, later extending over the whole leaf surface and down over the entire shoot. Young infected leaves and shoots are stunted and often die back.
- **Leaf curl** first appears soon after leaf emergence with the developing leaves showing yellow areas which become dark red, thickened and puckered. Infected leaves fall prematurely; even young shoots are distorted and may die.
- **Rust** (also known as shot hole disease) can be one of the more serious diseases. Many tiny pale yellow/brown spots appear on the upper surface of leaves. In some instances severe defoliation occurs and weakens the trees, and can even result in off-season blooming.
- **Armillaria root rot** is a fungal disease often present in newly cleared land where host plants like eucalyptus, acacia, pine, coffee, etc. had been grown before. Infected peach trees wilt suddenly and die. Cutting through the bark at the base of the trunk will reveal the fungus as a thin white strip.

For the control the above pests and diseases and others, a list of common recommended insecticides/fungicides can be found in **Appendices 11, 12 and 13.**

PEACH CULTIVARS

Killiecrankie

History: Killiecrankie was one of the locally selected and named cultivars from the Plateau–Burnt Forest region of Kenya. Virtually no subsequent breeding was done on the cultivar, which has now lost importance in the local market to imported, improved cultivars.

Tree: A strong grower and prolific bearer.

Fruit: Medium to large fruits of the semi-clingstone type. Round to oval in shape with a pronounced point.The skin is mainly yellow with a fine red blush when mature. The flesh is creamy white to yellowish, sweet, and of good quality.

Flordagold

History: Originated in 1965 from an open-pollinated “Rio Grande” seed in Florida.

Tree: The tree is vigorous but rounded and compact in growth with strong branches. It is highly productive and requires heavy thinning to improve fruit size.

Fruit: A yellow-fleshed, semi-clingstone, firm fruit of medium to large size—up to 6 cm in diameter and 90–100 g in weight. The fruit is roundish oblong with near equal halves. Red skin at picking stage covers about 60% of the fruit’s surface over a bright yellow ground colour, making the fruit very attractive.

Flordaprince

Tree: Vigorous, with semi upright growth. Average yield is up to 100 kg per tree.

Fruit: An early-ripening semi-clingstone cultivar that ripens 70–80 days from full bloom. Medium to large with a small tip or none at all. Pubescent, and fruits reach a weight of up to 90 g. The external surface of fruits is red blush with yellow ground colour. Fruit flesh is yellow and firm with some red colouring near the peel.

Flordaking

Tree: An early maturing variety that requires just 70 days from full bloom to maturity.

Fruit: Averages 6 cm in diameter and weighs around 95 g. This semi-cling cultivar has a beautiful red-blushed skin and golden yellow flesh that is juicy, pleasantly sweet and melting.

Kakamas

History: Originated from a chance seedling of St. Helena peach in 1933 in South Africa and was released in 1938.

Tree: The vigorous tree with a spreading growth habit is a strong grower and its chilling requirements are medium. Produces heavily and regularly.

Fruit: Fruits are round to ovate with a point and a marked suture. Skin and flesh colour ripens to a dull golden yellow. This clingstone cultivar has a fine and firm texture, is non melting and can be stored for 2 weeks at –0.5 °C. Kakamas has outstanding canning qualities but stone residues may be a problem.

Neethling

History: This cultivar was bred in South Africa (Kakamas x Early Dawn) and released in 1961.

Tree: A vigorous tree with a spreading growth and low chilling requirements.

Fruit: The round clingstone fruit has yellow skin and flesh, tastes good and has a non-melting, fine and firm texture. The fruit's canning quality is good.

Sunred

History: The **nectarine** cultivar is the result of breeding work that commenced in 1956 at the Florida Agricultural Experiment Station, Gainesville.

Tree: Has a chilling requirement of about 250–300 hours.

Fruit: A semi-freestone cultivar with small to medium-sized fruit, approx. 4 cm or more in diameter. Fruits are round without a suture, bulge or beak. The external blush is bright red, covering 90–100% of the fruit. The flesh is yellow, firm and of excellent flavour.

Other nectarine cultivars like Sunrich and Sungold were found to be disappointing under local conditions. For additional information regarding Florda peach/nectarine cultivars, see Table 9.

Since 1972 a number of promising peach cultivars such as Summerset, Early Belle, Texas, Almong, Early Amber, and Fradkin have been introduced into an ongoing fruit improvement project.

Table 9. Characteristics of peach and nectarine cultivars recommended for trial in East Africa

Cultivar	Equivalent chilling (hrs)	Days from full bloom to ripe	Flower	Flower* bud set	Stone freeness	% Red Color	Ground colour	Shape*	Firm*	Size (g)	Taste*	Texture*	Browning*
Flordabelle	150	105	Showy	8	Free	60	Greenish yellow	10	8	120	10	9	8
Earli-Grande	200	75	Non showy	6	Semi-cling	40	Yellow	8	6	80	7	7	8
Flordagem	250	90	Showy	9	Semi-free	60	Yellow	8	9	90	9	10	9
Flordagrande	100	105	Showy	9	Free	40	Yellow	8	8	90	7	7	7
Flordaprince	150	80	Showy	7	Semi-cling	80	Yellow	9	8	90	8	7	7
Sunred nectarine	250	90	Showy	8	Semi-free	100	Yellow	9	7	70	10	8	8
Flordagold	325	90	Showy	10	Semi-cling	40	Bright yellow	7	10	90	8	7	9
Sunripe nectarine	375	95	Non showy	8	Semi-free	70	Dull yellow	9	8	90	10	8	6
Flordaking	400	70	Showy	6	Semi-cling	50	Greenish yellow	7	7	95	7	7	9
Sunlite nectarine	450	85	Showy	9	Free	80	Yellow	9	8	80	8	8	9
Rio Grande	450	105	Showy	8	Free	60	Yellow	7	8	120	8	8	7

**Ratings: 1 = lowest or poorest; 10 = highest or best*

Source: Institute of Food and Agricultural Sciences, University of Florida, Gainesville

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Glossary of Terms

abscission ..... Dropping of leaves or fruits as a result of the breakdown of a layer of thin walled cells

acid soil..... A soil having a pH less than 7.0

active ingredient..... The chemical agent in a formulation that produces the desired effect

anther ..... The pollen-bearing part of a stamen

apex (apices) ..... The tips of shoots or of lobes of the leaf

asexual propagation..... Propagation by plant parts other than seeds, such as budding, grafting, layering and cuttings

bloom..... The delicate waxy or powdery substance on the surface of berries

bud..... An undeveloped shoot usually protected by scales; tissues are mainly meristematic

callus..... Parenchyma tissue which grows over a wound or graft and protects it against drying or other injury

cambium..... A very thin layer of undifferentiated meristematic tissue between the bark and wood

cap stem (pedicel)..... The stem of the individual flowers or fruit

chlorophyll..... Green pigment of plants that absorbs light energy for photosynthesis

compatibility..... Ability of the scion and stock to unite in grafting and form a strong union

complete flower..... A flower having sepals, petals, stamens, and a pistil or pistils

dioecious..... Having the male (staminate) and female (pistillate) organs of the flower on separate plants

dormant..... Plants, buds, or seeds which are not actively growing

flower buds..... Buds containing undeveloped flowers; also referred to as fruit buds

fungicide..... A chemical used to control the infection and spread of fungi on crops

genus..... A group of plants comprising a number of closely related species

hybrid..... A cross-breed of two species. Hybridizing refers to the practice of crossing species

internode ..... That portion of a shoot or cane between two adjacent nodes

lateral ..... A branch of the main axis of the cluster; also a shoot arising from the main shoot

latent bud ..... A dormant bud, usually hidden, which is over a year old and may remain dormant indefinitely

lenticel ..... A porelike, slightly raised spot on pedicels and fruits

maturity ..... Stage of fruit development when it has reached the maximum quality for its intended purpose

mutation ..... Genetic change in a mother plant or stock that may influence the characteristics of the offspring, buds, or cuttings from the plant

ovary ..... The enlarged basal portion of the pistil containing ovules or seeds

pedicel ..... A stalk bearing a single flower

pH ..... Refers to acidity or alkalinity on a scale of 1 (very acid) to 14 (very alkaline). pH 7.0 is neutral

phytotoxic ..... Causing injury or death of plants

pollination ..... The transfer of pollen from the anther to the stigma

scion ..... The plant part that is grafted or budded onto the stock

shoot ..... Current season's stem growth that bears leaves and buds

soil texture ..... The relative proportion of the percentage of sand, silt, or clay particles in a soil

spur ..... Basal short shoots, from 1-4 buds long. They usually bear fruits

stock ..... The stem or root onto which the scion is grafted

stratification ..... Subjecting seeds to an after-ripening period to terminate the rest period. The seeds are usually exposed to low temperatures under moist but well aerated conditions.

sunscald ..... Injury to outer tissue due to excess sun heat

tomentose ..... Covered with fine hairs; felty

trunk ..... The main stem between the roots and the place where the trunk divides to form branches

APPENDIX 1.
Temperate fruit imports to Kenya, 2000–2003; 2005

Year	2000		2001		2002		2003		2005		Imported mainly from
Crop	Tons	Value (KShs)	Tons	Value (KShs)	Tons	Value (KShs)	Tons	Value (KShs)	Tons	Value (KShs)	
Apples (fresh)	2,405.053	71,430,759	2,760.052	78,111,375	2,348.060	48,217,189	686.510	15,663,861	2,581,750	109,512,642	China, Egypt, South Africa
Apples (dried)	2.989	271,395	7.928	353,074	1.000	363,022	51.356	886,430	10.060	766,430	Egypt, South Africa
Pears and Quinces (fresh)	122.937	3,634,287	162.066	4,141,765	125.975	2,691,464	62.675	1,434,716	115.053	3,219,680	China, South Africa
Peaches and Nectarines (fresh)	29.597	1,586,052	40.216	1,693,636	48.890	1,812,102	26.667	57,419	74.662	3,000,571	Israel, South Africa
Plums (fresh)	8.591	702,574	20.502	690,051	13.351	1,202,228	9.298	227,245	26.469	2,025,184	South Africa, Israel
Cherries	0.799	73,603	1.184	53,517	1.181	227,743	1.301	289,943	3.185	297,251	Israel, South Africa
Figs (fresh + dried)	3.964	823,858	4.433	707,088	2.525	663,280	0.247	2,921	4.306	773,478	Iran, Israel, Pakistan
Grapes (fresh)	334.320	17,011,571	305.811	15,582,678	2,391.587	16,101,458	166.399	4,538,140	426.896	19,363,758	Egypt, India, Italy, S. Africa
Total	**2,908,250.00**	**95,534,099.0**	**3302.2**	**101,333,184.0**	**4932.6**	**71,278,486.0**	**1,004.453**	**23,100,675.0**	**3,242,361**	**138,959,517**	

Source: Kenya Revenue Authority, Customs Excise Department, Nairobi

US$ 1 = 62 Kenya Shillings (Nov 2007)

APPENDIX 2a.
Production statistics for fresh horticultural produce, 1989–2005

Crop: Apple

Year	Area (ha)	Production (tons)	Yield (tons/ha)
1989	316	3105	9.826
1990	203	3186	15.695
1991	197	2165	10.99
1992	232	2359	10.168
1993	208	1240	5.962
1994	134	1143	8.53
1995	97	593	6.113
1996	108	467	4.324
1997	108	388	3.593
1998	224	1536	6.857
1999	133	632	4.752
2000	179	1035	5.782
2001	156	1038	6.654
2002	224	1371	6.121
2003	220	1442	6.555
2004	226	1379	6.102
2005	239	1431	5.987
Average			**7.295**

Source: Ministry of Agriculture and Rural Development, Nairobi, 1989–2005

APPENDIX 2b.
Provincial apple production statistics, 1995–2005

Province	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005	
	ha	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**	**ha**	**tons**
Central	92	473	100	431	104	368	112	496	110	516	109	536	81	380	111	499	109	533	110	544	112	550
Rift Valley							112	1040	19	115	45	306	53	469	58	419	55	427	61	282	59	229
Coast			4	20	4	20	4	2	4	1	4	13			32	260	32	280	29	335	40	400
Nairobi	5	120	4	16																		
Eastern											21	180	22	189	23	193	24	202	26	218	28	252
Total ha.	97		108		108		228		133		179		156		224		220		226		239	
Total production (tons)		593		467		388		1538		632		1035		1038		1371		1442		1379		1431

Source: Ministry of Agriculture, Horticulture Division, Nairobi, Annual Reports 1995–2005

APPENDIX 3a.
Production statistics for fresh horticultural produce, 1989–2005

Crop: Pear

Year	Area (ha)	Production (tons)	Yield (tons/ha)
1989	431	4777	11.084
1990	498	7056	14.169
1991	521	8059	15.468
1992	528	8102	15.345
1993	569	6685	11.749
1994	570	7429	13.033
1995	446	3971	8.904
1996	489	4885	9.99
1997	472	5232	11.085
1998	541	6245	11.543
1999	804	4115	5.118
2000	913	9702	10.627
2001	561	6914	12.324
2002	653	7685	11.769
2003	708	8455	11.942
2004	735	7420	10.095
2005	751	7929	10.558
Average			**11.459**

Source: Ministry of Agriculture and Rural Development, Nairobi, 1989–2005

APPENDIX 3b.
Provincial pear production statistics, 1995–2005

Province	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005	
	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons
Central	446	3971	489	4885	472	5232	475	5768	478	2465	481	3737	459	5147	532	6564	588	7484	591	6730	493	7065
Rift Valley							61	471	321	1649	424	5957	97	1762	113	1116	112	966	135	684	252	778
Coast							5	6	5	1	8	8	5	5	8	5	8	5	9	6	6	86
Total ha.	446		489		472		541		804		913		561		653		708		735		751	
Total prod'n (tons)		3971		4885		5232		6245		4115		9702		6914		7685		8455		7420		7929

Source: Ministry of Agriculture, Horticulture Division, Nairobi, Annual Reports 1995–2005

APPENDIX 4a.
Production statistics for fresh horticultural produce, 1989–2005

Crop: Plum

Year	Area (ha)	Production (tons)	Yield (tons/ha)
1989	792	3981	5.027
1990	736	3474	4.720
1991	807	5560	6.877
1992	854	8562	10.026
1993	834	6290	7.542
1994	907	8325	9.179
1995	650	3833	5.897
1996	670	2830	4.224
1997	632	4267	6.751
1998	655	5218	7.966
1999	638	4298	6.737
2000	687	3571	5.198
2001	634	5136	8.101
2002	787	5551	7.053
2003	784	6250	7.972
2004	783	4259	5.439
2005	543	5845	10.764
Average			**7.028**

Source: Ministry of Agriculture and Rural Development, Nairobi, 1989–2005

APPENDIX 4b.
Provincial plum production statistics, 1995–2005

Pro-vince	1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005	
	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	tons	ha
Central	650	3833	670	2830	632	4267	615	4905	623	4212	614	2935	543	4251	616	4173	620	5111	621	3199	352	4688
Rift Valley							40	313	15	86	73	636	91	885	84	712	76	466	75	445	99	454
Eastern															87	666	88	673	87	615	92	703
Total ha.	650		670		632		655		638		687		634		787		784		783		543	
Total prod'n (tons)		3833		2830		4267		5218		4298		3571		5136		5551		6250		4259		5845

Source: Ministry of Agriculture, Horticulture Division, Nairobi, Annual Reports 1995–2005

APPENDIX 5a.
Production statistics for fresh horticultural produce, 1989–2005

Crop: Peach

Year	Area (ha)	Production (tons)	Yield (tons/ha)
1989	91	605	6.648
1990	96	968	10.083
1991	180	1607	8.928
1992	105	1005	9.571
1993	55	481	8.745
1994	53	644	12.151
1995			
1996			
1997			
1998	62	450	7.258
1999	53	246	4.642
2000	74	633	8.554
2001	31	327	10.548
2002	72	364	5.056
2003	68	520	7.647
2004	73	401	5.493
2005	78	526	6.744
Average:			**8.005**

Source: Ministry of Agriculture and Rural Development, Nairobi, 1989–2005

APPENDIX 5b.
Provincial peach production statistics, 1998–2005

Province	1998		1999		2000		2001		2002		2003		2004		2005	
	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons	ha	tons
Central	44	348	34	135	52	520	6	144	52	260	52	416	52	380	52	364
Rift Valley	18	102	19	111	22	113	25	183	20	104	16	104	21	89	26	162
Total ha.	62		53		74		31		72		68		73		78	
Total prod'n (tons)		450		246		633		327		364		520		401		526

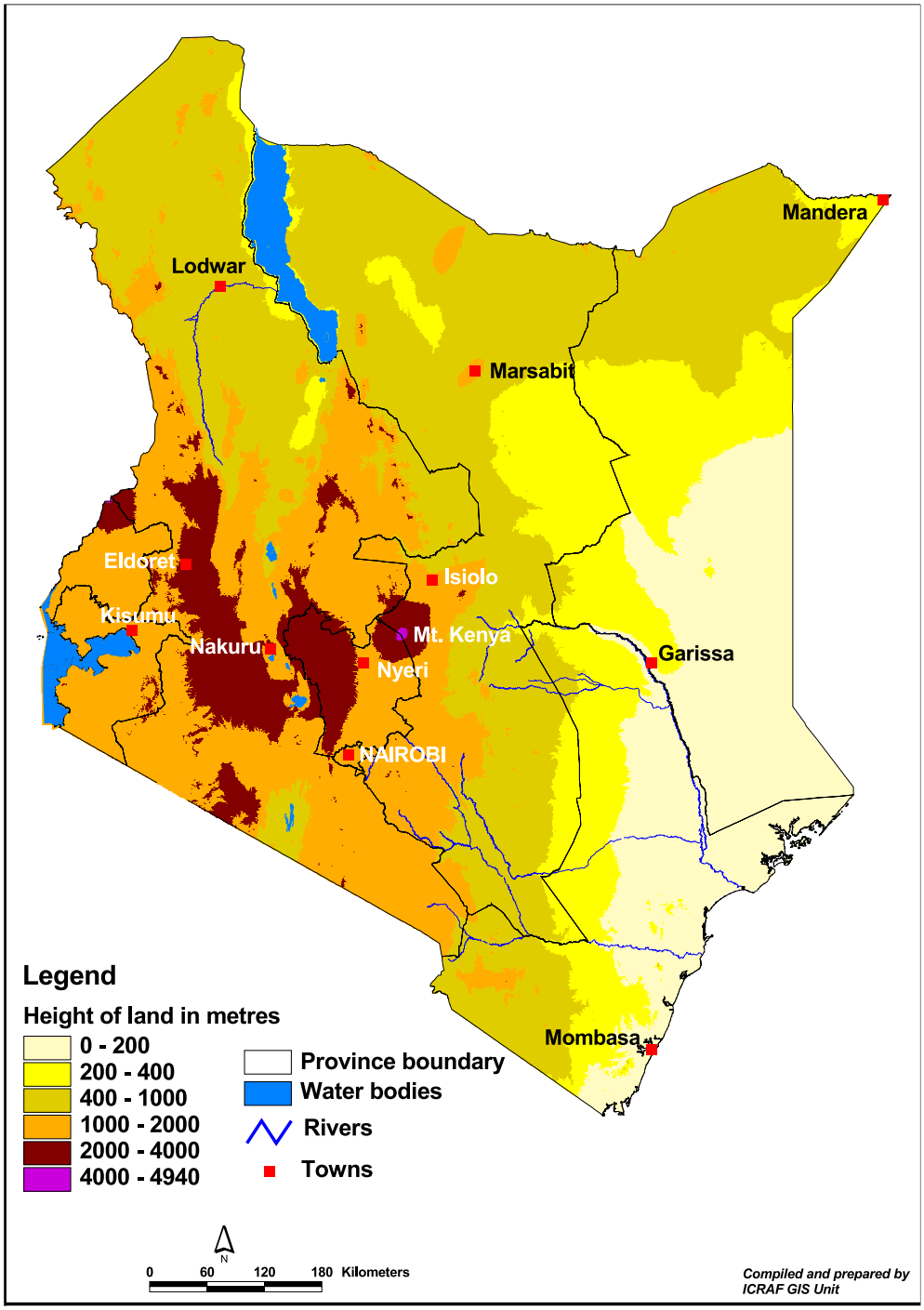
Source: Ministry of Agriculture, Horticulture Division, Nairobi, Annual Reports 1995–2005

APPENDIX 6.
Recommended storage conditions and expected storage life of fresh fruit

Product	Temperature (°C)	Relative humidity (%)	Expected storage life
Apples	-1–4	85–95	3–8 months
Apricots	-1 – 0	85–5	1–4 weeks
Avocados	5 – 13	85–95	2–4 weeks
Bananas:			
green	11.5 –14.5	90–95	10–20 days
coloured	13 – 16	85–90	5–10 days
Blackcurrants	-1 – 0	90	1–2 weeks
Coconuts	0	80–85	1–2 months
Figs	-1– 0	90	7–14 days
Gooseberries	0	90	2–3 weeks
Grapes	-1– 0	85–90	3 weeks – 5 months
Grapefruit	4.5 –15.5	85–90	3 weeks – 3 months
Lemons:			
green	11 – 14.5	85–90	1–4 months
coloured	4 – 10	85–90	3–6 weeks
Limes	8 –10	85–90	3–8 weeks
Mandarins	4 – 7	85–90	3–12 weeks
Mangoes	7 –10	85–90	4–7 weeks
Melons:			
Honeydew	15 - 21	70–80	2–6 months
Watermelon	2 – 4	85–90	2–3 weeks
Nuts	7	70	1 year
Oranges	-1 – 7	85–90	1–6 months
Papaya	4 –10	85–90	2–5 weeks
Passion Fruit	5.5 – 7	80–85	4–5 weeks
Peaches	-1 – 1	85–90	1–8 weeks
Pears	-1.5 –1.5	85–90	1–7 months
Pineapple:			
Green	10	90	2–4 weeks
Ripe	4.5 – 10	85–90	2–6 weeks
Plums	-0.5 – 1	85–90	2–8 weeks
Pomegranates	1 – 2	90	2–4 months
Rasberries	0	85–90	3–5 days
Strawberries	0	85–90	1–5 days

Source: Recommended Conditions for cold Storage of Perishable Produce, 1967 Institut International du Froid, Paris

APPENDIX 7.
Altitude map of Kenya



APPENDIX 8.
The use of Cyanamide (Dormex™) as a chilling compensator in apple-growing in Kenya

Introduction

Deciduous fruit-trees grown in areas of Kenya with insufficient winter chilling, suffer from delayed foliation and bud-break. This results *inter alia* in reduced fruit-set and plant development because many buds remain dormant. In order to overcome this problem, a field trial was conducted at GK Prison Farm Kamiti (1460 m.a.s.l.) in the Central Province of Kenya. The purpose of this study was to assess the effectiveness of hydrogen cyanamide (Dormex™), which is known to control dormancy and stimulate bud-burst in different horticultural fruit species, including apples, pears, plums, apricots, grapes, kaki and kiwi.

Material and Methods

- The trial apple trees were planted in May 1984 and included the cultivars Rome Beauty, Ana, Winter Banana, Granny Smith and Starking.
- The following rootstock was used: MM 106, Bittenfelder and M II.
- A plant spacing of 2 x 3 m was chosen which is equivalent to a plant population of 1666 trees per ha.
- 9 lines (10 plants each) including two control lines were selected for the trial.
- The trial objectives included the determination of:
  - -Application time and concentration;
  - -Fruit-set and yield performance;
  - -Defoliation effect according to concentration of Dormex
- On 3 September 1990, five lines (50 plants), consisting of various apple cultivars, were hand-defoliated.
- The remaining four lines were left untouched (= no defoliation).
- Excluding the control lines, spraying applications were carried out on September 12, 1990. Concentration used was on defoliated trees was 1%, 1.5%, 2% Dormex + Agral (Spreader/Sticker). Concentration used on undefoliated trees was 2%, 3%, 3.5%, 4% Dormex + Agral.

Observations / Results

Observations were carried out on 20 and 29 Sept 1990, 12 October 1990, and 4 January 1991.

20 September 1990

Control: "Ana" and "Golden Dorsett" are leading in bud-break: the other cultivars are still dormant.

Defoliation + 1%, 1.5%, 2% Dormex: All treatments show the same response as above.

No defoliation + 2%, 3%, 3.5%, 4% Dormex: All cultivars are still dormant. According to concentration, leaf scorching has started, but up to now there is no leaf drop.

29 September 1990

Control: Ana and Golden Dorsett still advanced (overall trial) and have reached 59% flowering stage. Bud-burst of other cultivars has started.

Defoliation + 1%, 1.5%, 2% Dormex: All treatments regarding the cultivars Ana/Golden Dorsett show no difference = 30% flowering stage. Bud-burst of other cultivars has started, but is much more numerous than the control trees.

No defoliation + 2%, 3%, 3.5%, 4% Dormex: According to concentration, scorching

continues and lead-abscission started. Up to now, very weak bud-break and no indication of flowering.

12 October 1990

Control: For Ana and Golden Dorsett the flowering time is over: Winter Banana and Rome Beauty are in full bloom. All cultivars show a lot of 'blind buds'.

Defoliation + 1%, 1.5%, 2% Dormex: All cultivars have reached an 80-90% flowering stage. The 2%-treatment shows the best burst of vegetative buds.

No Defoliation + 2%, 3%, 3.5%, 4% Dormex: Leaf-scorching and leaf-shedding continues. At the moment, and as a defoliator, the 3.5% treatment performs best. All concentrations delayed bud-break very much; only Ana reached about 40% flowering stage.

4 January 1991

- The final fruit-set count was carried out in January 1991.
- At the time of the year, all trees not defoliated but treated had shed their leaves, and their development had caught up with the group of defoliated trees.
- Compared with control trees, all treated plants have shown improved vegetative growth which will most probably increase future yields.

Conclusion

- All Dormex treatments promoted an increased and uniform bud break percentage
- It has yet to be confirmed whether low-chilling cultivars like Ana and Golden Dorsett have to be sprayed at all.
- Due to scorching, Dormex induces the essential defoliation effect which makes the time-consuming hand-defoliation unnecessary.
- In this case it seems that a 2.5 – 3% concentration is sufficient, but it is important that trees receive a full cover spray.
- For defoliated trees, best results were achieved when using a concentration in the range of 1.5 – 2%.
- For undefoliated treated trees a delayed bud-break and flowering stage has been observed, but these did not delay the picking season significantly.
- Due to increased vegetative growth and leaf formation, improved fruit quality output has been noted.
- Compared with the control trees, most of the treatments enforced a better fruit-set and respective returns. Since this is a preliminary experiment, the poor response of some cases has to be followed up in order to meet the objectives.

J. Griesbach
Nairobi, 23 January 1991

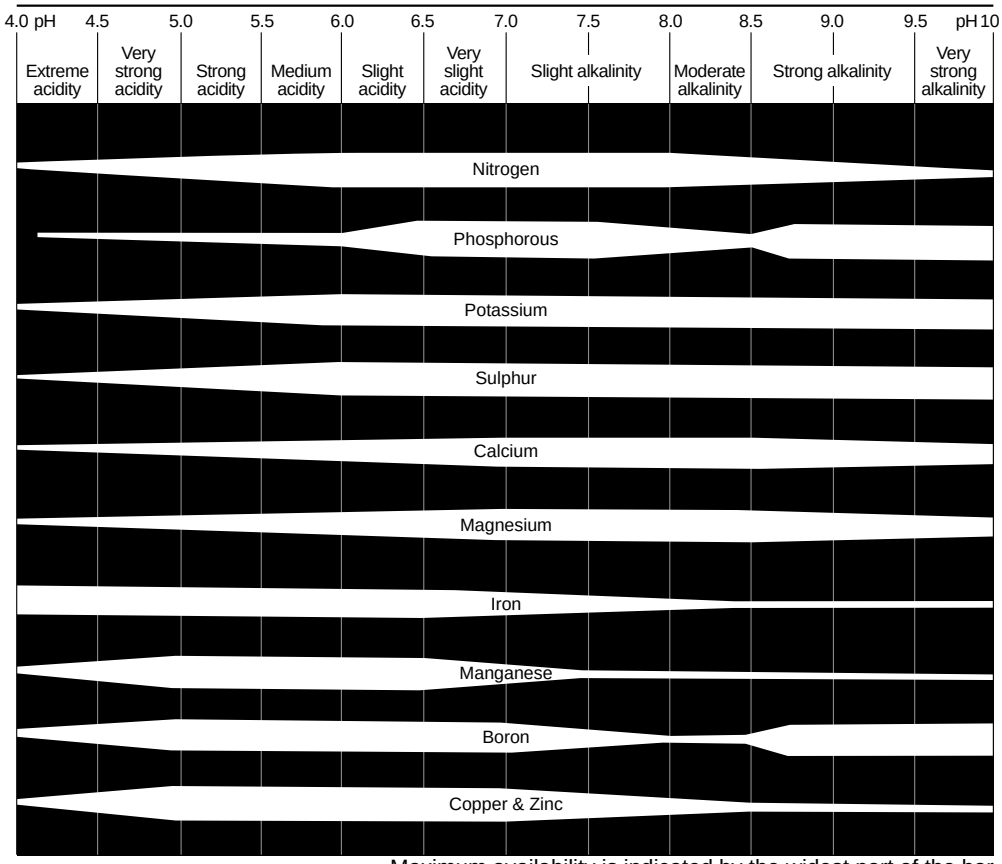
APPENDIX 9.
Space requirement for plants per hectare: Fruit orchards

Spacing (m)	Space Requirement (m^2)	No. of plants required per ha
2 x 3	6	1667
2.5 x 3.5	8.75	1143
3 x 3	9	1111
2.5 x 4	10	1000
3 x 4	12	833
4 x 4	16	625
4 x 5	20	500
5 x 5	25	400
5 x 6	30	333
5 x 7	35	285
6 x 6	36	278
6 x 7	42	238
6 x 8	48	208
7 x 7	49	204
7 x 8	56	178
7 x 9	63	158
8 x 8	64	156
8 x 9	72	139
8 x 10	80	125
9 x 9	81	123
9 x 10	90	111
9 x 11	99	101
10 x 11	110	91
10 x 10	100	100
10 x 12	120	81
11 x 11	121	83
11 x 12	132	76
11 x 13	143	70
12 x 12	144	69

APPENDIX 10.

Influence by Soil Reaction on the Availability of Plant Nutrients

According to E. Troug, USA: cited by Vladimir Ignatieff, EFFICIENT USE OF FERTILISERS.



Maximum availability is indicated by the widest part of the bar

APPENDIX 11.

Some common and fully or provisionally (*) registered insecticides[1]

(Those under temporary registration are not included)

Trade name	Active ingredient	Range of effectiveness
Actellic 25 EC	Perimiphos-methyl	Fast acting; for the control of storage pests, but it also controls a wide range of insect pests in horticultural crops
Agropyrifos 48 EC*	Chlorpyrifos	Controls caterpillars and sucking insects in horticultural crops
Agrozinon 60 EC*	Diazinon	Broad spectrum contact poison, effective against many sucking and biting insects
Applaud 40 % SC	Buprofezin	Controls white flies in citrus and mealy bugs in passion fruit
Basudin 600 EW	Diazinon	Contact poison; kills biting and sucking insects
Brigade 25 EC	Bifenthrin	Broad spectrum insecticide/ miticide
Buminal*	Protein	Bait for fruit fly
Chenothion 50 EC	Fenitrothion	Contact and stomach poison; kills biting and sucking insects
Danadim	Dimethoate	Contact/systemic insecticide/miticide against a broad range of insects
Decis 2.5 EC	Deltamethrin	Broad spectrum contact poison
Diazol 60 EC	Diazinon	Poison for the control of a wide range of pests in fruit/vegetable crops
Dipterex 95 SP	Trichlorfon	Mainly a stomach poison, particularly effective against flies and caterpillars
Ethion 4 EC	Ethion	Controls i.e. root mealy bug, scales, leaf miner etc.
Evisect-S	Thiocyclam	Insecticide for the control of leafminers, aphids, thrips on horticultural crops
Furadan 5 G	Carbofuran	Systemic granular insecticide/nematicide mainly for the control of soil pests
Gusathion - M* 200 EC	Azinphosmethyl	Contact and stomach poison. Very effective against a broad spectrum of sucking/biting insects
Hostathion 40 EC	Triazophos	Insecticide/acaricide for the control of insect pests and mites
Karate 17,5 EC	Lambdacyhalothrin	Synthetic pyrethroid with broad spectrum rapid knock-down action
Kelthane 18,5 EC	Kelthane	Non-systemic acaricide
Lebaycid 500 EC	Fenthion	Contact and stomach poison against sucking/biting insects

[1]The listing of specific trade names does not constitute endorsement of these products in preference to others containing the same active chemical ingredients.

Trade name	Active ingredient	Range of effectiveness
Malathion 50 EC*	Malathion	Contact and stomach poison against many sucking/ biting insects
Marshal 250 EC	Carbosulfan	Broad spectrum contact insecticide/miticide
Mesurol 500 SC	Methiocarb	Broad spectrum insecticide for the control of sucking and biting insect pests
Metasystox*	Oxydemeton-methyl	Systemic insecticide/acaricide with rapid action
Metigan 18,5 EC	Dicofol	A specific miticide for the use on a wide range of crops
Methomex 90*	Methomyl	Insecticide to control mainly sucking pests on horticultural crops
Nemacur 050*	Fenamiphos	Granular insecticide/nematicide
Perimor 50 DG	Pirimicarb	Specific poison for the control of aphids on a wide variety of crops
Sevin 85 S	Carbaryl	Broad-spectrum insecticide for use on horticultural crops
Tafgor 40 EC*	Dimethoate	Systemic insecticide/acaricide mainly effective against sucking insects
Thiodan 35 EC	Endosulfan	Contact and stomach poison. Wide range insecticide effective against chewing/ biting insects
Thuricide H.P.	*Bacillus thuringiensis*	Biological insecticide for the control of Lepidopterian larvae on coffee and other crops

Source: "List of Pests Control Products" registered by the Pest Control Products Board, Nairobi, March 2003

APPENDIX 12.
Some common and fully or provisionally (*) registered fungicides[1]

(Those under temporary registration are not included)

Trade name	Active ingredient	Range of effectiveness
Afugan 30 EC	Pyrazophos	Systemic; controls powdery mildew on a wide range of crops
Aliette 80 WP	Fosetyl-aluminium	Systemic; primarily effective against phytophtora and downy mildew
Antracol 70 WP	Propineb	Contact; a broad spectrum protectant for the control of diseases on vegetables, fruit crops and flowers
Bayfidan 250 EC	Triadimenol	Systemic; controls i.a. powdery mildew on fruit crops
Benlate	Benomyl 50 %	Systemic; control of many diseases of cereals, vegetables and fruits
Cercobin*	Thiophanate	Contact; fungicide for use in fruits, vegetables and cereals
Clortocaffaro 75 WP *	Chlorothalonil	Contact; controls coffee berry disease (CBD) and is also used in horticultural crops
Cobox	Copper oxychloride 50%	Contact; controls CBD and leaf rust on coffee but also several vegetable diseases
Copper Nordox	Cuprous oxide 50%	Contact; controls coffee diseases and also useful on horticulture crops
Daconil 2787	Chlorothalonil 75%	Contact; a broad spectrum protectant of many diseases on fruit and vegetables
Dithane M-45	Mancozeb 80%	Contact; protectant for the use on a broad spectrum of horticultural crops
Isacop	Copper oxychloride 85%	Contact; protectant for the control of a wide range of diseases on horticultural crops and coffee
Kocide DF	Copper hydroxide	Contact, broad spectrum protectant for the control of a wide range of diseases on horticultural crops, flowers
Merpan 83 WP	Captan	Contact; a broad spectrum protectant of many horticultural diseases
Nimrod 25 EC	Bupirimate	Systemic; control of powdery mildew on a wide range of horticultural crops
Nustar*	Flusilazole	Contact; for use in grapes and citrus
Polygram DF*	Metiram complex	Contact; broad spectrum: controls many diseases of fruits, vegetables and ornamentals

[1]The listing of specific trade names does not constitute endorsement of these products in preference to others containing the same active chemical ingredients.

Trade name	Active ingredient	Range of effectiveness
Previcur-N	Propamocarb	Contact; controls soilborne diseases
Rova 75*	Chlorotalonil	Contact; fungicide against CBD and various other diseases in vegetabes and flowers
Rovral 50 WP	Iprodione	Contacy; controls botrytis in fruits and vegetables
Saprol 20 EC	Triforine	Contact; control of fungal diseases in horticultural crops
Thiovit-Jet	Sulphur	Contact; controls powdery mildew and mites on a wide range of fruit crops.

Source: Fungicides registered by the Pest/Disease Control Products Board, Nairobi, March 2003

APPENDIX 13.
Some common horticultural insecticides/fungicides[1] and their recommended pre-harvest intervals

Insecticides			Fungicides		
Trade Name	**Active Ingredient**	**Pre-Harvest Interval/ days**	**Trade Name**	**Active Ingredient**	**Pre-Harvest Interval/ days**
Actellic 25 EC	Perimiphos-methyl	7	Benlate	Benomyl	14
Agropyrifos 48 EC	Chlorpyrifos	14–40	Morocide	Binapacryl	14
Agrozinon 60 EC	Diazinon	14	Nimrod	Bupirimate	7
Basudin 600 EW	Diazinon	14	Moduna	Captafol	7
Brigade 25 EC	Penvalerate	14	Orthocide	Captan	7
Chenothion 50 EC	Fenitrothion	10	Morestan	Chinomethionate	10
Danadim 40 EC	Dimethoate	7	Cupravit	Copper	7
Decis 2,5 EC	Deltamethrin	14	Copper 50	C. hydroxide	7
Dipterex 95 SP	Trichlorfon	14	Cobox	C. oxychloride	7
Folimat 500 SL	Omethoate	21	Green Copper 50	C. sulphate	7
Furadan 5 G	Carbofuran	21	Karathane	Dinocap	10
Gusathion-M 200 EC	Azinphos-methyl	14	Dithane	Mancozeb	7
Karate 17,5 EC	Lambdacyhalothrin	14	Rovral	Iprodione	7
Kelthane 18,5 EC	Dicofol	7	Ridomil	Metalaxyl	7
Malathion 50 EC	Malathion	7	Polyram Combi	Metiram	7
Mesurol 500 SC	Methiocarb	7	Antracol	Propineb	7
Metasystox 50 EC	Oxydemeton-methyl	14–21	Afugan	Pyrazophos	7
Methomex 90	Methomyl	21	Thiovit	Sulphur	7
Nemacur 50	Phenamiphos	28	Bayleton	Triadimefon	7
Sevin 85 S	Carbaryl	7	Calinix	Tridemorph	7
Thiodan 35 EC	Endosulfan	28–40	Saprol	Triforine	2
			Lonacol	Zineb	7

Source: " Agricultural Insect Pests of the Tropics and their Control", Dennis S. Hill, Cambridge University Press, 1983

Source: National Agricultural Laboratories, Kabete, Kenya, 1988

[1]The listing of specific trade names does not constitute endorsement of these products in preference to others containing the same active chemical ingredients.

APPENDIX 14.
Production and export statistics summary 2003–2005

(a) Production statistics summary 2003–2005

Sector	Area (ha)			Production (MT)			Value (KShs)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
Fruits	148,925	152,837	155,498	1,936,957	1,986,714	1,892,392	11,339,596,160	14,783,875,197	20,011,851,170
Macadamia	2419	2583	2591	13,144	10,910	12,958	249,892,000	351,878,000	761,582,554
Sub-total	**151,345**	**155,420**	**158,089**	**1,950,101**	**1,997,624**	**1,905,350**	**11,589,483,160**	**15,135,754,197**	**20,773,433,724**
Vegetables	107,794	99,497	111,117	1,331,151	4,142,756	2,951,772	5,658,040,138	17,667,869,295	16,301,764,430
Irish Potatoes	112,300	128,484	120,842	1,060,003	1,084,412	980,163	4,580,072,678	5,156,495,528	5,331,427,287
Sub-total	**220,094**	**227,981**	**231,959**	**2,391,154**	**5,227,168**	**3,931,935**	**10,238,112,816**	**22,824,414,823**	**21,633,191,717**
Herbs and Spices	1944	1957	2513	11,235	10,184	12,915	267,293,015	314,713,937	552,176,860
Flowers	1798	2177	2098	855	1444	3290	3,796,359,000	5,173,259,000	7,809,071,823
Total	**375,181**	**387,535**	**394,659**	**4,353,345**	**7,236,420**	**5,853,490**	**25,891,247,991**	**43,448,141,957**	**50,767,874,124**

Continued next page

Appendix 14 cont'd

(b) Export Statistics Summary 2003–2005

Sector	Volume (MT)			Value (KShs)		
	2003	2004	2005	2003	2004	2005
Fruits	23,576	20,090	18,522	1,895,562,148	1,803,004,400	2,049,920,712
Vegetables	48,271	52,805	61,220	10,390,853,088	11,820,522,755	13,574,590,528
Herbs and spices	406	26	398	79,381,587	4,762,955	135,846,111
Flowers	60,983	66,805	82,056	16,495,531,184	18,092,175,024	22,238,013,340
Processed fruits and nuts	–	103,843	123,787	–	7,820,000,000	5,724,530,448
Total	**133,233**	**243,569**	**287,988**	**28,839,583,186**	**39,540,415,134**	**44,893,926,025**

(c) Contribution of horticultural sector to the Kenyan economy in 2003–2005

Item	2003	2004	2005
Total production in value (KShs)	25,891,247,991	43,448,141,957	44,276,551,566
Total export value (KShs)	28,839,583,186	39,540,445,134	44,893,926,025
Grand Total Value (KShs)	**54,730,031,177**	**82,988,587,091**	**89,170,479,596**
Source: Annual Horticultural Reports 2003-2005, Ministry of Agriculture, Nairobi, Kenya			

APPENDIX 15.
Export market statistics for deciduous fruits from Kenya in kilogrammes

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005*
Apple	14,556	5,951	6,444	36,261	38,816	14,117	8,391	99,028	17,318	1,929	136,714
Plum	4,640	8,751	4,701	238	12,875	424	619	1,489		9	2,360
Pear						887	729	554	31	48	1,793
Peach							52	137			3

Sources: HCDA-Statistics, 1995–2004
** Kenya Revenue Authority, 2005*

APPENDIX 16.
Rootstock performance trial of selected apple cultivars

Introduction

In order to evaluate the behaviour of different rootstocks/cultivar combinations, a respective trial was conducted at GK Prison Kamiti (1460 m.a.s.l.) in the Central Province of Kenya. The goal of the trial was to obtain local information in order to be able to adjust this future propagation programme.

Materials and Methods

- The trial was planted in May 1984 and included cultivars like Rome Beauty, Ana, Starking, Golden Dorsett, Winter Banana, Granny Smith, Cowin, Law, Winesap, Grand and Lyda.
- The following rootstock was used: Bittenfelder seedling, as well as the clonal stock MM 106, M II and M XI. Deliberately, the above include only vigorous and semi-dwarfing rootstocks
- A plant spacing of 2 x 3 metres was chosen which means a plant population of 1666 trees per ha.
- Almost every rootstock/cultivar combination was represented in 14 repetitions using single tree plots.
- Trees had to survive under rainfed conditions but were permanently under a heavy mulch cover.
- Regular maintenance activities included clean weeding, fertilizing, pest and disease control, defoliation and summer/winter pruning.
- The first crop was harvested two years after planting, and since then yields have been recorded annually.
- All yield figures listed in the chart are summarized recordings of two cropping seasons —a large one and a small one—per year.

Results

- Six years after field establishment there were no indications of any scions/rootstock incompatibility.
- Due to their performance, the cultivars Winesap, Grand and Lyda are not recommended for the Kamiti location.
- All the other cultivar combinations are still in a good phase of balanced development and some more years of satisfactory productivity can be expected.
- Even when using the strongest rootstock, Bittenfelder (B.F.) seedling, a plant spacing of 2 x 3 m is sufficient
- According to their yield performance it is obvious that after 5 cropping years the rootstocks M II and MM 106 grafted with cultivars Rome Beauty, Ana and Winter Banana are the leading combinations.
- For the remaining cultivars, additional rootstock combinations are needed in order to obtain final results.

Conclusions

When including figures (5 years overall yield / tree) from a previously conducted trial, one will realize that rootstocks like M II and MM 106 have priority for future propagation:

Rome Beauty			**Ana**		
M II	=	29.103 kg	A2	=	37.632 kg
A2	=	23.581 kg	MM 106	=	19.274 kg
M VII	=	23.515 kg	M II	=	17.019 kg
M XI	=	18.760 kg	B.F.	=	15.232
B.F.	=	14.968 kg			

Winter Banana			**Golden Dorsett**		
MM 106	=	36.448 kg	A2	=	24.555 kg
M II	=	32.716 kg	M XI	=	10.287 kg

- A 2 is impressive as a good "starter" but due to over-bearing it will quickly lose the characteristics of a strong grower. Additional maintenance care is needed to overcome decline and yield reduction after about 9 to 10 years in the field.
- Bittenfelder, the only seedling stock, is a slow starter but develops a deep, drought-resistant root system, a vigorous tree, good fruit-quality and dominates in longevity.

Finally, a recent spraying trial using the plant growth regulator Dormex™, which is known to control dormancy and stimulate the bud burst, has been incorporated. Already there are indications that the performance of difficult cultivars like Granny Smith, Starking, Glockenapfel, Rome Beauty , Winter Banana, Acpye, Gloster, etc. can be improved.

J. Griesbach
Nairobi, 14 August 1990

Appendix 16 cont'd

Apple cultivars/rootstock trial at GK Prison Kamiti Farm

Cultivar	Rootstock Planting Distance Year	1986 kg/tree Ton/acre Ton/ha	1987 kg/tree Ton/acre Ton/ha	1988 kg/tree Ton/acre Ton/ha	1989 kg/tree Ton/acre Ton/ha	1990 kg/tree Ton/acre Ton/ha	5-year Overall Total kg/tree Ton/ha
Rome Beauty	MM 106 2 x 3m May 1984	1.042 0.694 1.737	2.676 1.782 4.458	4.212 2.805 7.017	5.790 3.856 9.646	8.617 5.739 14.356	22.337 37.214
Rome Beauty	M II 2 x 3m May 1984	0.905 0.603 1.508	4.088 2.723 6.811	7.674 5.111 12.785	7.711 5.135 12.847	16.073 10.705 26.778	36.451 60.729
Ana	M II 2 x 3m May 1984	0.869 0.579 1.448	1.990 1.325 3.315	2.387 1.590 3.977	7.184 4.785 11.969	4.589 3.056 7.645	17.019 28.354
Ana	Bittenfelder 2 x 3m May 1984	0.957 0.637 1.594	1.614 1.075 2.689	3.333 2.220 5.553	5.291 3.524 8.815	4.037 2.689 6.726	15.232 25.377
Starking	M II 2 x 3 m May 1984	1.232 0.821 2.053	2.050 1.365 3.415	3.212 2.139 5.351	5.325 3.547 8.872	6.564 4.372 10.936	18.383 30.627
Golden Dorsett	M XI 2 x 3m May 1984	0.621 0.414 1.035	1.121 0.747 1.868	2.380 1.585 3.965	5.025 3.347 8.372	1.140 0.759 1.899	10.287 16.104
Winter Banana	MM 106 2 x 3m May 1984	2.626 1.749 4.375	4.663 3.106 5.798	7.902 5.236 13.165	10.497 6.991 17.488	10.760 7.166 17.926	36.448 38.752
Winter Banana	M II 2 x 3m May 1984	2.022 1.347 3.369	3.226 2.148 5.375	6.080 4.049 10.129	10,428 6.945 17.373	10.960 7.297 18.259	32.716 54.505
Granny Smith	MM 106 2 x 3m May 1984	1.234 0.822 2.056	1.102 0.734 1.836	2.825 1.882 4.707	3.136 2.089 5.225	3.360 2.242 5.598	11.657 19.422
Cowin	Bittenfelder 2 x 3m May 1984	2.746 1.829 4.829	1.584 1.055 2.639	7.075 4.712 11.787	9.768 6.505 16.758	9.610 6.400 16.010	30.785 51.769
Law	Bittenfelder 2 x 3m May 1984	1.8.45 1.229 3.074	1.799 1.198 2.997	5.085 3.387 8.472	4.905 3.267 8.172	11.385 7.582 18.967	25.019 41.682

Source: Author's own records and calculations (1984–1990)

Appendix 16 cont'd

Recorded average fruit-set (January 1981) for Apple trial, Kamiti

Cultivar/Root stock	Control	Defol. +1%	Defol. +1.5%	Defol. +2%	Defol. +2.5%	Defol. +3%	Defol. +3.5%	No defol. +4%
Granny Smith (106)	13.5	20	3	21.1	14	5	–	12
Winter Banana (11)	46	118	154	95.5	–	151	147	141
Rome Beauty (11)	25.5	45	91	122	12	98	42	–
Winter banana (106)	33.5	118	95	82.2	77	–	88	138
Ana (BF)	25.7	28	11.5	44	34.5	52	27	33
Starking (11)	–	47	10	–	7	–	–	–
Ana (11)	–	–	36	42	67	86	–	26
Rome Beauty (106	–	16	49	74.3	4	0	133	162

– Data not available.

Source: Horticulture Annual Report 2004, Ministry of Agriculture, Nairobi - KenyaYield Performance

Yield performance

Yield Score	Treatment							
	Control	D + 1%	D + 1.5%	D + 2%	ND + 2.5%	ND + 3%	ND + 3.5%	ND + 4%
1			1	2		2		2
2		3		1	1	2	1	
3		1	3	2	2		1	
4	1	3	2		1		1	2
5							1	2
6	1				2	1	1	
7	3		1		1	1		
8			1					

Remark: 1 = highest yield; 8 = lowest yield

Note: How to read this table:
e.g. D + 1.5 %: scored 1 once, 3 thrice, 4 twice, 7 once and 8 once.

Appendix 16 cont'd

Fruit-set performance of various cultivars according to different treatments and rootstock combinations

Treatment	1	2	3	4	5	6	7	8
Control				Gr.Sm 106		R.B. 11	ANA BF W.B. 106 W.B. II	
D + 1%		Gr.Sm 106 W.B. 106 Stark II		R.B. II	R.B. 106 ANA BF W.B. II			
D + 1.5%	W.B. II		R.B. II W.B. 106 Stark II	ANA II			Gr.Sm 106	ANA BF
D + 2%	Gr.Sm 106 R.B. II	ANA BF	ANA II R.B. 106		W.B. 106 W.B. II			
D + 2.5%		ANA II	ANA BF Gr.Sm. 106	Stark. II		R.B. 106 W.B. 106	R.B. II	
D + 3%	ANA BF ANA II	W.B. II R.B. II				Gr.Sm 106	R.B. 106	
D + 3.5%		R.B. 106	W.B. II	W.B. 106	R.B. II	ANA BF		
D + 4%	W.B. 106 W.B. 106			W.B. II ANA BF	Gr.Sm 106 ANA II			

Scale of performance: 1 = highest; 8 = lowest

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