

Manipulation of citrus trees for new higher density orchards

F.J. Joubert, M.H. du Plessis, E.D. Steenkamp and P.J.C. Stassen

ARC- Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit, 1200, South Africa.

Fax : (27)-13-752-3854, E-mail: frikkie@itsc.agric.za

Abstract

The aim with new higher density citrus orchards is to reach the economic break-even point sooner and to maintain nett farming income per ha for as long as possible. The optimum leaf area per ha must be established in the shortest possible time and still be economically feasible. A specific planting system is adopted with trees that are smaller and more effective by means of specific tree management practices. Proper control of vegetative growth is essential for higher density plantings in order to maintain maximum fruit bearing surface, obtain high quality fruit and facilitate the cultural and harvesting operations. Good progress has been made with the development of pruning and training techniques for new higher density citrus plantings. Lemon and Valencia trees have been successfully trained to a central leader and an informal multiple leader system respectively. This results in easier management of higher density plantings and also facilitates further selective and/or mechanical pruning. The orchard, as well as each individual tree, obtains optimum light interception, penetration and utilization when trees are shaped to a pyramidal form. Central leaders are kept dominant over all the laterals. Laterals should be selected on different levels around the central leader and should be forced to branch further, in order to obtain a complex branch hierarchy. Newly established trees should be left to grow and develop during their first year, before any drastic pruning is initiated. However, smaller pruning cuts should be made where necessary to remove unwanted shoots. It must be emphasized that pruning is not a one-off operation, but rather a continuous series of less drastic actions.

Key words: *Citrus sinensis* (Valencia), *C. limon* (lemon), *C. paradisi* (grapefruit), *C. reticulata* (mandarins), planting systems, tree training, pruning, shaping

Introduction

The establishment of citrus involves high input costs, which are currently only recovered after five to ten years. With some other fruit tree crops, the unproductive period can be shortened and nett profit increased, by implementing higher density plantings with intensive management practices such as pruning and tree manipulation.

Crowding and encroachment of trees with subsequent inefficient light utilization, is an obvious problem with high-density plantings, if trees are not well managed. The internal bearing capacity of citrus trees also decreases with time, due to over-shadowing of internal bearing wood. This occurs, regardless of tree spacing. There is a need to examine manipulation techniques to control tree size and shape, since this aspect is not yet fully developed for citrus.

Presently, there is a worldwide resurgence of interest in pruning and shaping of citrus trees and the possible beneficial effects that it might have for the citrus industry. Stassen *et al.* (1995, 1997) working with avocados recommended that planting distances and tree shape should receive more attention. Square planting patterns (*e.g.* 5x5 m) should be avoided and pyramid shaped trees be developed.

The principles involved for improvement of yield per unit area of land by increasing planting density are, however, based on the need to fill the allotted space in the orchard row as soon as possible. Thereafter the canopy size must be maintained by correct pruning and tree shaping. The principles for achieving

this have been outlined by Stassen and Davie (1996a; 1996b).

The effectivity of an orchard is determined by the degree of light interception by the leaves and the amount of light penetrating the tree canopy in order to maintain and renew bearer shoots. Stadler and Stassen (1985) emphasized this aspect for deciduous fruits. The function of tree dimensions, shape, row orientation and planting distance has often been referred to in the past (Cain, 1972; Palmer, 1977; Jackson, 1978). The importance of a hedgerow system with a north/south orientation for sufficient light interception by the larger leaf surface area and penetration to all bearer shoots within the canopy has been discussed by Stassen and Davie (1996b). They also discussed various factors that determine the planting distances as well as the relationship between tree height and row width.

In this paper the authors report back on three seasons of tree shaping and pruning of newly established higher density plantings of lemons, Valencias, grapefruit and mandarins.

Materials and methods

The study was conducted on four citrus types, which included different cultivar/rootstock combinations, planting distances, training techniques and pruning methods as treatments at different localities (Table 1). Experimental layout for each trial is also described in Table 1.

The three initial pruning methods for framework development were only applied to the Valencia and lemon trial (Table 1). Two training systems were applied, a central leader system to

Table 1. Citrus manipulation and planting system trials which include different cultivar/rootstock combinations, planting distances, training techniques and pruning methods as different treatments

Factors	Valencia	Mandarin	Lemon	Grapefruit
Cultivar/Rootstock	Delta/Swingle Midknight/Swingle Delta/Carrizo Midknight/Carrizo Delta/X639 Midknight/X639	Nova/Swingle Nules/Swingle	Eureka/X639 Eureka/MXT Eureka/Rough lemon	StarRuby/ Swingle StarRuby/ Carrizo
Planting distance	4m x 1.5m 5m x 3m	4m x 1.25m	i) 3m x 1m ii) 4m x 1.25m iii) 5m x 2m	i) 4m x 1.5m ii) 5m x 2.5m
Initial pruning method	1,2,3	3	1,2,3	3
Tree training system	Central and Multiple leader	Central leader	Central and Multiple leader	Central and Multiple leader
Experimental layout	Field trial, Randomised block, 3 replications, 4 trees/plot.	Field trial, randomised block, 3 replications 10 trees/plot	Field trial, randomised block, 3 replication, 6 trees/plot	Field trial, randomised block, 4 replications, 8 trees/plot
Locality	Nelspruit	Lydenburg	Nelspruit	Malelane
Planting date	April, 1996	October, 1997	November, 1996	November, 1997
Area	1 ha	1 ha	0.5 ha	0.5 ha

the higher density and a multiple leader system to the lower density plantings. Pruning and tree shaping were mainly done during the summer months, to correct tree structures and to maintain canopy size.

Pruning methods:

- (1) Trees cut back to 50cm height after planting and trained with new growth
- (2) Trees shaped after planting without cutting back
- (3) Trees shaped after one years growth.

Planting densities:

3x1m	=	2222 trees/ha
4x1.25m	=	2000 trees/ha
4x1.5m	=	1667 trees/ha
5x2m	=	1000 trees/ha
5x3m	=	667 trees/ha

Results presented are based on actual observations regarding vegetative growth reaction of trees to pruning and shaping.

Results and discussion

Pruning, manipulation and framework development: Citrus growth exhibits poor apical dominance as shown in Fig. 1. The citrus branch will, however, be forced over into a more horizontal position by the weight of leaves and fruit. When this eventually occurs, the tip will no longer be the most elevated point of the branch. Terminal dominance ceases and the lateral buds now at the most elevated part of the branch begin to grow vigorously. These new lateral branches then become the upright fruiting branches, until they eventually bend over, and the cycle repeats.

Therefore, the citrus tree tends to grow into a bush-like form which results in poor light penetration and utilization. In order to shape and develop a citrus tree into a pyramidal form, certain selective pruning cuts and manipulations are necessary. The type of pruning cut used, the severity of pruning as well as the time of pruning will all influence the reaction of the tree.

The leader/leaders of the framework must always be kept dominant over the lateral branches, by cutting back laterals that exceed one third of the thickness of the leader branch (Figs 1 and 2). In this way, branch hierarchy can be maintained. Any laterals that develop from the central leader should preferably have a wide angle. These laterals are well connected and do not easily tear-off.

To establish side branches at the desired levels within the framework, lateral shoot growth may be stimulated during the growth period, especially during framework development of the tree. Growing points of leader and lateral shoots may be tipped, by removing the very tip of the branch. Response to tipping is shown in Fig. 3. Branching can also be achieved by heading back (topping) of a leader (Fig. 4) and of a lateral branch (Fig. 5), through cutting away a certain part of the shoot. This cut stimulates excessive growth that must be well managed. If a side shoot is needed at a specific site where no shoots exist, then notching can be practiced above a dormant bud to stimulate growth of that bud (Fig. 6).

Development of complex lateral bearers (Fig. 7), evenly spaced around the leader at certain intervals or where needed, is most important for framework development. This can be achieved by selecting horizontally placed side shoots after the response to tipping or heading back of laterals (Fig. 5).

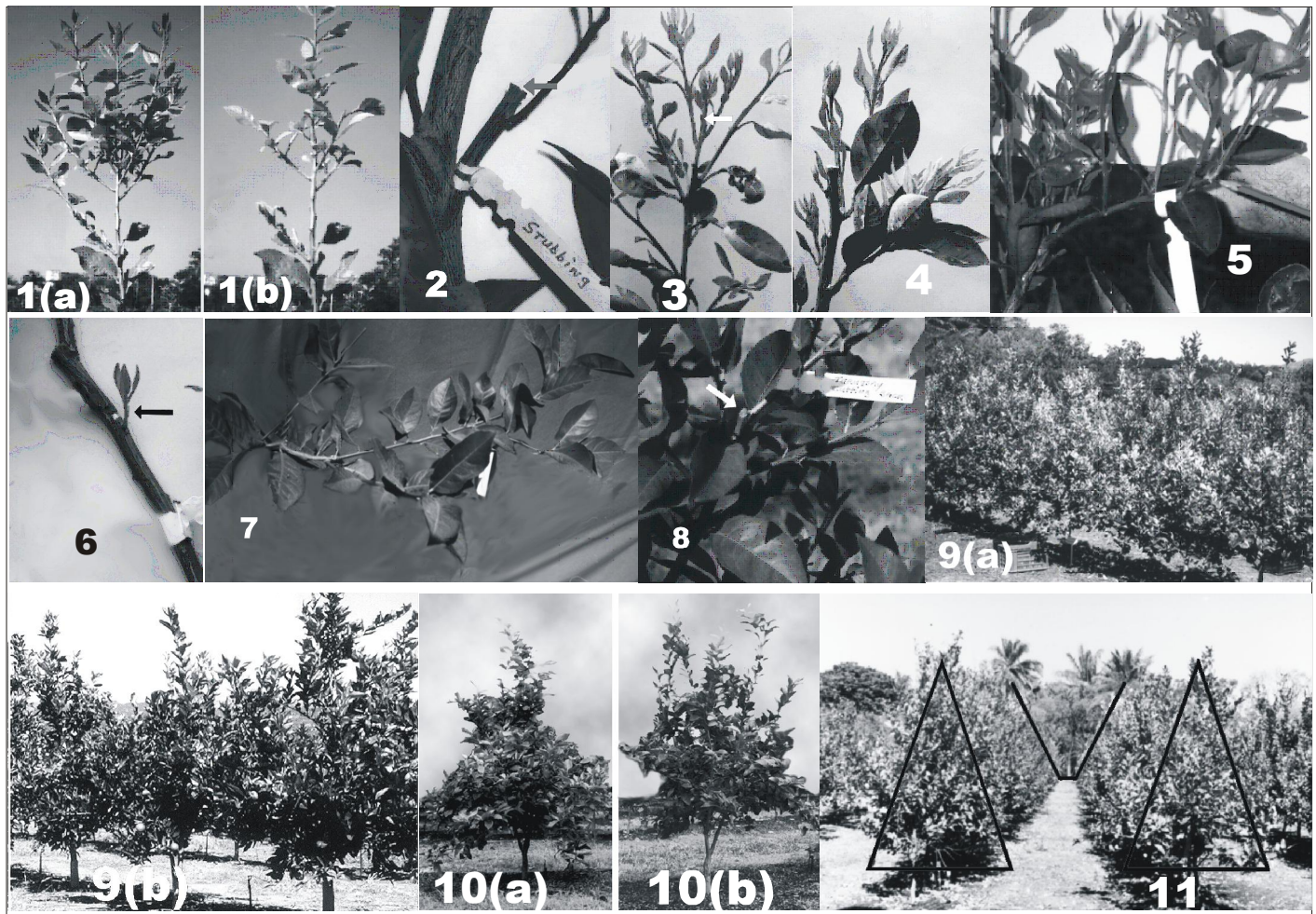


Fig. 1. (a) Poor apical dominance exhibited by citrus growth. (b) Citrus tree pruned to a central leader system. Side branches have been pruned back in order to reassert apical dominance and tree hierarchy. Pruned-back laterals should be further developed to form complex bearer branches at different levels.

Fig. 2. Lateral branches exceeding one third of the thickness of the central leader should be cut out or stubbed, in order to maintain branch hierarchy. Stubbing provides an alternative to cutting out of branches to such an extent that subsequent growth is less vigorous and may be used for further framework development in sites where needed.

Fig. 3. Tipping as a manipulation tool may be used to stimulate lateral shoot growth for framework development of the citrus tree. Arrow shows site where tipping was done. Of the first 6-8 buds developing the strongest shoot will be selected as the new leader.

Fig. 4. Lateral shoot growth can also be achieved by heading back (topping) of a leader for further framework development. The growth response on this type of cut should be monitored closely, since vigorous and excessive growth can be expected. The strongest, most upright shoot may be selected as the new leader with others to be developed as lateral bearer branches.

Fig. 5. The growth response after heading back (topping) of a lateral shoot. Pencil shows site of pruning cut. This lateral shoot was, however, initially cut back to a less vigorous and more horizontally placed shoot to open up the framework (also refer to Fig. 8). These newly developed shoots are approximately one month old and will be hardened-off after 6-8 weeks, at which time further manipulation and framework development can proceed. The desired end result is shown in Fig. 7.

Fig. 6. Notching as a manipulation tool to induce growth at desired sites/levels where further framework development is needed.

Fig. 7. Top view of a lateral bearer branch of a Eureka lemon tree to show complex branch hierarchy. Note the flat Afan-like appearance with several side shoots. No vertical shoots are present to interfere with light penetration and utilization.

Fig. 8. Cutting back to laterals as shown just below the tag. This cut is used to shape trees and to reduce spread or height. The direction or vigour of original growth can be altered.

Fig. 9. Two training systems are being applied, (a)-central leader system (CLS) and, (b) an informal multiple leader system (MLS). Note the pyramid shaped form of these lemon trees to allow for maximum light interception, penetration and utilization.

Fig. 10. The effect of different planting systems on the filling rate of the space allotted to each tree. (a)- lemon trees of the highest density (3 x 1 m) and trained to a *central leader system* (CLS), have already filled their allotted space within the rows after three years. (b)- Valencia trees of the lower density (4 x 1.5 m) and trained to an informal *multiple leader system* (MLS), have not yet filled their allotted space.

Fig. 11. Effective tree training of a well planned lemon orchard. Note the pyramidal shape and well developed framework of the trees. This hedgerow orchard clearly illustrates the typical V-shape that is required between the rows for effective light penetration and utilization.

Water-shoots, suckers and other unwanted upright growth must be removed at an early stage before too much energy is utilized or light penetration is prevented. Some of the upright growth can be cut back (stubbed) (Fig. 2), to harden-off the excessive growth and to manipulate the subsequent growth into a bearer branch where needed.

Cutting back to laterals (Fig. 8) is used throughout the year but especially in the growth season. It is used more specifically to shape trees and to reduce height and spread. It involves cutting back of the shoot or branch to a lateral or weaker shoot in order to change the direction or vigour of the original growth.

Shoots can either be bent or twisted in different directions and at different angles, rather than removing them. Specially formed wire struts may be used to bend shoots in order to widen crotch-angles. These young upright shoots of pencil thickness and approximately 20 to 30cm length, can be twisted by simultaneously pulling and twisting the shoot to its new position. By bending or twisting upright shoots horizontally, fruitfulness and side growth can be induced.

It may be necessary to remove branches and shoots periodically with a smooth cut at the point of origin (branch thinning). This is used to remove excess foliage and also to improve light penetration and its utilization by more leaves.

Pruning back a newly established tree to 50cm height after planting, had negative influence on tree volume and development compared to other pruning treatments. Therefore the space allotted to each tree for this treatment could not be filled rapidly. Trees should rather be left to establish first, before any drastic pruning is commenced. However, smaller pruning cuts must be made where necessary to remove unwanted shoots.

Tree training and planting systems: Both the central leader system (CLS) and informal multiple leader system (MLS) were applied to the lemon and Valencia trees (Fig. 9 and 10).

However, lemon trees were trained more successfully to a CLS (Fig. 9). A higher level of manipulation and pruning is needed with the MLS, since leaders of the same strength and development phase are difficult to find.

Due to the different growth habit of the Valencia compared to the lemon, trees were more easily trained to a MLS. It is best not to prune the Valencia tree drastically in order to develop it into a central leader. Trees must rather be left to develop during the first year and only unwanted shoots should be removed or pruned back. After one year of development trees should be formed into a MLS by using two to three leaders in the framework.

Complex branch hierarchy was achieved (Fig. 7 and 8). Trees at the highest density, lemons (3 x 1m) and Valencias (4 x 1.5m) (Fig. 10), have filled their allotted space compared to the lower density plantings. The first reduction of tree size has already been done by means of mechanical pruning at the higher density plantings (Fig. 11).

Citrus trees can be initially trained to a central leader or multiple leader system by applying a tree training and shaping program. This can be applied with success during the first 2-3 growth seasons. Planting distances must be logically determined to accommodate the growth habit of different cultivars. Effective training in the early stages facilitates easy maintenance in the following years. Maintenance can be done by a combination of selective pruning cuts and by using light mechanical equipment.

Pruning must be carried out at different times of the year. The frequency will be determined by cultivar and growth vigour. Special attention must be given to the regular removal of watershoots. The purpose is not to stimulate vigorous watershoots, but to develop fruitful bearer shoots throughout the tree canopy.

Tree manipulation must be seen as an integral part of the many different management inputs, such as irrigation, fertilization and other aspects for achieving success. If pruning is done regularly and correctly, large areas can be handled with relatively low labour inputs.

References

- Cain, J.C. 1972. Hedgerow orchard design for most efficient interception of solar radiation. *Search Agriculture*, 2(7):1-15.
- Jackson, J.E. 1978. Utilization of light resources by high-density plantings. *Acta Hortic.*, 65: 61-70.
- Palmer, J.W. 1977. Diurnal light interception and a computer model of light interception by hedgerow apple orchards. *J. Appl. Ecol.*, 14: 601-614.
- Stadler, J.D. and P.J.C. Stassen, 1985. Pruning and training deciduous fruit trees. Lighting, plant densities and pruning procedures. *FFTRI Information Bulletin*, 531.
- Stassen, P.J.C., S.J. Davie and B. Snijder, 1995. Principles involved in tree management of higher density avocado orchards. *S.A. Avocado Growers' Assoc. Yearbook*, 18:47-50.
- Stassen, P.J.C. and S.J. Davie, 1996a. Tree manipulation ? its application in the citrus and subtropical fruit industries. *ITSC Information Bulletin*, 285:2-10.
- Stassen, P.J.C. and S.J. Davie, 1996b. Planting and training systems for citrus and subtropical fruit trees. *ITSC Information Bulletin*, 285:10-19.
- Stassen, P.J.C., S.J. Davie and B. Snijder, 1997. Guidelines for *Neltropika*, 298:39-50.