The Role of Training Systems in Maintaining Higher Density Mango Orchards

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ABSTRACT

Poor yields of mango orchards in the initial years can be attributed to wide tree spacing and the subsequent time lag in filling the allocated tree space. Higher density plantings and the associated tree manipulations for speedily attaining a complex tree with high orchard productivity is presently the order of the day. The purpose of this study is to test different training systems that can possibly be more beneficial when the more intensive orchards reach the overshadowing stage. Open vase, palmette, central leader, closed vase and a standard pruning system were compared with unpruned controls. In this paper the principles of the different systems are discussed. Results are presented to indicate how these systems affect tree volumes and influence tree spacing. The effect on the yield of six-year-old trees after the second year of training is presented.

UITTREKSEL

Lae opbrengste van mangobome in die aanvanklike jare na plant kan gedeeltelik toegeskryf word aan die wye spasierings en die gevolglike lang tydperk om die boomspasie te vul. Hoë digtheid aanplantings en die boommanipulasie wat daarmee geassosieer word om spoedig 'n komplekse boom te verkry, word tans algemeen toegepas. Die doel van hierdie studie is die bestudering van verskillende manipulasie tegnieke wat moontlik meer voordelig kan wees wanneer intensiewe boorde die stadium bereik waar bome mekaar oorskadu. Oop kelk, palmet, sentrale leier, geslote kelk en standaard snoei was met ongesnoeide bome vergelyk. In hierdie verslag word die beginsels van die verskillende sisteme bespreek. Resultate word aangebied om aan te toon hoe hierdie sisteme die boomvolume en boomspasiëring beïnvloed. Die invloed van die tweede jaar van manipulasie op ses jaar oue bome word ook aangetoon.

INTRODUCTION

The mango has been hailed for many centuries as the queen of all tropical exotic fruits. It is grown in nearly all tropical countries spreading through Africa, Asia and Latin America and is an important commercial crop in the Philippines, Indonesia, Thailand, West Indies, Mexico, Brazil and Venezuela (Schaffer & Andersen, 1994). The mango industry of South Africa is currently focused on the export market, where fruit size and quality are important factors.

The annual production is at present 43 thousand tonnes (Oosthuyse, 1993a). The mango has, however, a worldwide reputation as a poor yielding crop and very often, its low yield is intensified by irregular bearing (Wolstenholme & Robert, 1991). Yields worldwide range from 4 to 9 tonnes per hectare with annual yields in South Africa estimated at 4,2 tonnes per hectare (Oosthuyse, 1993a). Poor yields of the mango are partly due to the wide tree spacings with conventional orchards ranging from 10 to 12 m between trees in the row and between rows (Oosthuyse, 1993b). Canopies of these trees often take more than 10 years to fill their allocated space in the orchard row.

To resolve these problems, producers started with higher density plantings of 5 x 3 m, 6 x 4 m and 7 x 3 m. Yield data of high density plantings, that were recently made available, demonstrated the yield improvement obtained by increasing plant density (Oosthuyse, 1993b). Although the optimal spacing for each of the commercial cultivars still has to be established, there appears to be tremendous scope for increasing orchard productivity by increasing planting density.

The principles involved in the improvement of yield per unit area of land utilized by increasing plant density is based on the need to fill the allotted space in an orchard row as soon as possible and maintain the canopy size once the allotted space has been filled. According to Oosthuyse (1992) small trees in high density orchards are pruned by heading the flush growth prior to bearing. The number of new shoots produced are thus increased, and as a result tree sturdiness and number of flowering points are enhanced. Although a constant good yield might be expected in the first few years after planting, without pruning, individual tree yield will subsequently decrease due to shading of terminal branches caused by adjacent trees growing into one another. Once the allotted space in the orchard has been filled tree size control should be implemented. According to Oosthuyse (1992)tree size can be maintained by heading back branches shortly after harvest behind the site where lateral buds broke and developed after the previous harvest. Chadha (1985) has reported on the annual or biennial hedging of trees to control tree size and the introduction of mechanical pruning has encouraged hedgerow systems.

Other methods used for reducing canopy spread are dwarfing rootstocks, interstocks, or scions, and growth retardants. Many of these concepts however may prove to be inadequate because of the negative effect on tree development before the intra-row space is filled. Additional chemical and spraying costs to be incurred and the negative connotation attached to certain chemicals are two of the reasons favouring pruning as a method of tree size control.

In the present study, the aim was to ascertain how alternative training systems and methods of tree manipulation could be used to control tree size and improve orchard productivity. The results reflect work done during the 1994/1995 and 1995/1996 seasons and should not be regarded as recommendations.

MATERIALS AND METHODS

Tree manipulation

The study was conducted with bearing 'Sensation' mango trees grafted on 'Sabre' rootstocks, grown at the Institute for Tropical and Subtropical Crops, Nelspruit. The trees were planted in January 1990 at 7 x 3 m. From their fourth year the trees have been trained into different tree structures. Trees used in the study were manipulated according to the central leader, open vase, closed vase and palmette systems, as well as the present standard pruning method described by Oosthuyse (1992). Trees that were not pruned or manipulated in any manner served as controls. Thirty-two trees were pruned according to each system.

Yield data were analyzed by using analysis of variance at P = 0,05. All statistical analyses were performed using the SAS computer programme.

RESULTS AND DISCUSSION

Tree manipulation

Pruning of mango trees is done to create a sturdy tree that will fill its allotted space in the orchard in the shortest time possible, to maintain the tree canopy, to correct a situation of low light penetration into the tree and renew as well as shorten the bearer shoots. The slow development of 'Sensation' mango trees in the initial years makes high density orchards a necessity. At the same time the development of bearer shoots needs to be stimulated to enhance tree complexity and thus its bearing potential (Oosthuyse, 1993b).

Depending on the plant distance the semi-dense planting should fill the allocated space within three to six years. The question posed is how this orchard can subsequently be maintained without the reduction in optimal production as a result of overshadowing. 'Sensation' mango trees were spaced at 7 x 3 m

Fig. 1 *Six year-old 'Sensation' trees pruned and trained to different tree training systems.* ***(a)*** *Control trees that have filled the allotted space in the orchard row,*

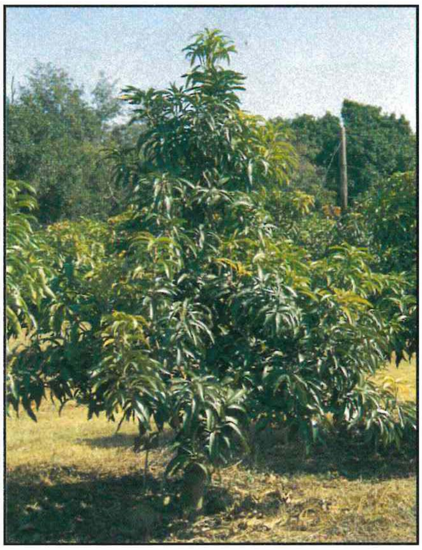

Fig. 1(b) *central leader tree,*

Fig. 1(c) *closed vase,*

and manipulated during the first three years, with the exception of the controls (Fig. 1a) which were left untouched. During November to May of the fourth year trees were trained to different structures (Fig. 1b-f). As to be expected the intensity of the various treatments affected the tree size as shown in Table 1. Control trees had after six years filled 100% of their allocated space of 7 m^2 (Fig. 1a) while the treated trees only filled between 63% for the closed

Fig. 1(d)*open vase,*

Fig. 1(e) *palmette system and*

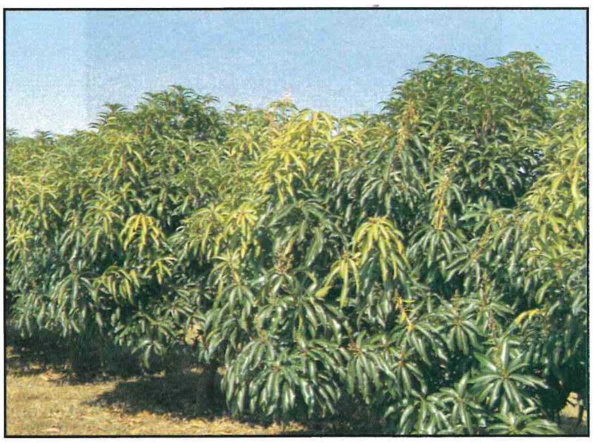

Fig. 1(f) *standard pruning.*

vase and 95% for the open vase system respectively according to the drip area measurements (Tables 1 & 2). The results show that a planting distance of 3 m between trees still takes too long to fill the space. This distance can therefore be reduced to 2,5 m or less depending on the training system being applied.

Although progress has been made with the introduction of new systems to manipulate and prune mango trees it appears, however, that pruning has a detrimental effect on the yield of the tree (Table 3). This is understandable in light of the results shown in Table 1. The control trees (no pruning) had the highest yield per tree for both seasons compared to

Table 1 *The relationship between training system and tree size in 'Sensation' mango*

Treatment	Drip area (m^2)		Tree volume (m^3)	
	1995	1996	1995	1996
Control	5.57*a*	7.30*a*	7.16*a*	10.47*a*
Open vase	3.88*b*	6.90*ab*	2.91*b*	6.95*bc*
Palmette	4.96*a*	6.34*b*	6.46*a*	6.88*bc*
Central leader	3.00*c*	4.70*c*	1.77*c*	5.76*c*
Closed vase	2.68*c*	4.63*c*	1.58*c*	6.18*c*
Standard	4.23*b*	7.32*a*	3.31*b*	7.52*b*

Table 2 *Tree size of different training systems compared to unpruned 'Sensation' mango trees and projected spacing based on tree size.*

Treatment	% Tree size compared to control tree size		Projected spacing	Trees/ha
	1995	1996		
Control	100	100	5 x 3	667
Open vase	69.9	94.5	5 x 3	667
Palmette	89.0	86.8	5 x 2.5	800
Central leader	41.3	64.4	5 x 2	1000
Closed vase	48.1	63.4	5 x 2	1000
Standard	75.9	100	5 x 3	667

the different tree structure systems (Table 3). They had the best yields as they had a higher number of bearing terminal shoots, compared to the central leader (Fig 1b), closed vase (Fig. 1c) and palmette systems (Fig. 1e). According to Oosthuyse (1993b) the cropping ability of 'Sensation' is directly related to the number of terminal shoots. Since the central leader and closed vase trees have fewer terminal shoots, the yields are subsequently also lower. If the necessary adaptations are made to express yield as a function of tree volume, the situation changes as indicated in Table 3. The tree volume was calculated for each system (Table 1) and showed the same tendency as that for the tree drip area. These calculations were used to determine yield on a kg/m^3 basis (Table 3).

In Table 4 the yield is expressed as projected tonnes per hectare if the number of trees per hectare were increased according to the spacing suggested for the specific tree training system. The effect of this is that a larger number of smaller trees can be maintained in the high density planting by training these trees to central leader trees.

On the other hand it is also to be expected that unpruned trees will initially fare best until they have filled the space allotted to them. After this the yield

Table 3 *Yield data for two seasons of 'Sensation' mango trees pruned according to different training systems expressed as kg/ tree, tonnes/ ha and kg/ m³.*

Treatment	Yield (kg/tree)		Yield (t/ha)		Yield (kg/m³)	
	1995	1996	1995	1996	1995	1996
Control	39.06*a*	52.27*a*	18.59*a*	24.88*a*	5.88*dc*	5.47*a*
Open vase	27.68*bc*	34.98*b*	13.18*bc*	16.65*b*	9.98*bc*	5.20*a*
Palmette	20.10*d*	27.36*b*	9.57*d*	13.02*b*	3.50*d*	4.50*a*
Central leader	22.10*c*	31.01*b*	10.52*c*	14.76*b*	16.44*a*	5.61*a*
Closed vase	18.09*d*	27.15*b*	8.61*d*	12.92*b*	13.01*ab*	4.83*a*
Standard	28.47*b*	16.47*c*	13.55*b*	7.84*c*	9.13*bc*	2.54*b*

of the control trees will most probably start to decline due to the overshadowing by the tree tops of the tree base and also on the inside of the canopy.

Although the pruning of the 'Sensation' mango trees show reduced yields at this stage of the trial, the results will change over the next season or two when the untreated trees start growing into each other while the pruned trees achieve their optimum yield when they fill their allotted space. The increasingly dense outer foliage layer of the untreated control trees causes shading with loss of growth activity inside the tree and in the lower limbs as well as in the overlapping tree canopies. The importance of light interception into the orchard makes it necessary for producers to consider alternative tree forms and methods of pruning for high density orchards. Efficient light interception in orchard canopies is critical to maximize yield. Trees should be pruned to allow tree canopies to be exposed to sufficient light on all sides. However, the phenology of the mango, a product of the interaction of genotype and environment, is one of the keys to pruning strategies which maintain tree size, maximize light interception and enhance fruit yield and quality.

CONCLUSION

It is evident from the results obtained that mango trees can be pruned to retain the correct tree size and to utilize orchard space more effectively. Results showed that higher density plantings can be made to ensure substantial yields in the initial years. Before the trees reach an overshadowing stage, a training system can be applied to maintain orchard productivity.

Future research will be aimed at the development of the number of bearer shoots annually required for producing the estimated yield of marketable fruit. Each bearer shoot will preferably only bear one fruit. In this way the bearer shoots will alternately but continuously be renewed and the tree form maintained.

A specific training system for 'Sensation' mango trees must, with the help of the data obtained, be developed. Optimal yield per hectare must be assured as soon as possible after planting and thereafter the yield of marketable fruit must be annually maintained.

Table 4 *Yield, projected spacing and projected yield for 'Sensation' mango trees pruned according to different training systems.*

Treatment	Yield (t/ha)	Projected spacing	Projected trees/ha	Projected yield (t/ha)
	1996			1996
Control	24.88*a*	5 x 3	667	34.87
Open vase	16.65*bc*	5 x 3	667	23.33
Palmette	13.02*d*	5 x 2.5	800	21.89
Central leader	14.76*c*	5 x 2	1000	31.01
Closed vase	12.92*d*	5 x 2	1000	27.15
Standard	7.84*b*	5 x 3	667	10.99

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