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Tree shaping strategies for higher density mango orchards

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Abstract

This study examined different tree training systems for shaping trees to be more effective in higher density orchards when they have filled their allotted space. Open vase, closed vase, central leader, palmette and standard pruning systems were compared with unpruned controls. post harvest pruning and pruning after fruit set was also evaluated with each of the tree training systems as measures to maintain tree size. The study was conducted on the cultivars Sensation and Tommy Atkins. The effect of different tree training systems on tree size and yield, as well as the effect of fruit thinning by branch pruning on fruit size, was evaluated.

Introduction

Poor yields experienced by the South African mango industry are partly due to the wide tree spacings of conventional orchards with spacings ranging from 10 to 12 m between trees in the row and between rows (Oosthuyse, 1993a). Leaf canopies of these trees often take more than 10 years to fill the 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 from high density plantings illustrated the yield improvement achieved by increasing plant density (Oosthuyse, 1993b). Although the optimal spacing for each of the commercial cultivars still has to be determined, it would appear that there is tremendous scope for increasing orchard productivity by increasing planting density to 667 and more trees per hectare.

The principles involved in the improvement of yield, per unit area of land utilised, 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 training once the allotted space has been filled. The principles for achieving this have been outlined by Stassen and Davie (1996a) and Stassen and Davie (1996b).

When the allotted space in the orchard has been filled tree size can be maintained by heading back branches shortly after harvest, behind the site where lateral buds broke and grew after the previous harvest (Oosthuyse, 1992). Chadha (1985) has also reported on the beneficial affect of annual or biennial hedging of trees to control tree size by mechanical pruning. With the introduction of high density plantings, new systems, that use the allotted space more efficiently, were introduced to the mango industry by Fivaz and Stassen (1996). Tree shapes, such as the closed vase, central leader and palmette systems have, in common, the requirements of reduced tree size, simple framework, reduced planting distance and minimum pruning. These advanced training systems provide for better light interception and penetration into the canopy (Stassen & Davie, 1996b).

In this paper the authors report back on three seasons of pruning 'Sensation' and 'Tommy Atkins' trees. This paper also focuses on the effect of different times of tree pruning and fruit thinning on yield and fruit quality.

Materials and methods

The study was conducted on 'Sensation' mango trees grafted onto 'Sabre' rootstocks and grown at the Institute for Tropical and Subtropical Crops, Nelspruit. The trees were planted in 1990 at a 7 x 3 m spacing. A blocked factorial design with 6 tree training systems, pruned at 4 different time intervals, blocked in 8 randomised replicates was used.

The trees were pruned from their fourth year to different tree structures. Trees were trained to central leader, closed vase, open vase and palmette systems and the present standard pruning method. Trees that were not pruned or manipulated served as controls. During each season, commencing 1994, trees of each system were pruned at different times to the correct tree structures and to maintain canopy size.

Pruning in the post harvest period and during October/November involve cutting back some 30% of the shoots on the tree. These shoots were cut back to the desired length to accommodate the shape of the tree. The cuts were made just behind the ring of axillary buds but in situations where serious overshadowing occurred some shoots were completely removed. Because the October/November pruning was also a fruit thinning action shoots with small, malformed or no fruit were cut back.

Fruits were thinned out to one per flower panicle for both the post harvest pruned trees and those pruned in October/November. In both instances the old flower panicles on all the shoots that were not cut back, were removed after harvest.

Pruning the standard system involved cutting back all shoots to the second node above the flower panicle, in the post harvest period.

The 'Tommy Atkins' trees planted in 1991 at 8 x 2 m spacing were also shaped. Whole rows were pruned and then 24 trees were randomly selected to serve as single tree replicates They were pruned to a pyramidal system, while 24 randomly selected unpruned trees served as controls. In 1995 trees were pruned in April, and in 1996 and 1997 the trees were pruned immediately after harvest in January.

Yield and fruit size data were analysed using analysis of variance at P = 0.05. All statistical analyses were performed using the SAS computer programme.

In the case of post harvest pruning only about 30% of the shoots of the tree as a whole were cut back a node or more when pruned and the rest were cut to just behind the stalk on which the fruits were borne.

Results and discussion

'Sensation'

The slow growth of 'Sensation' trees compared to some other commercial mango cultivars makes high density orchards a necessity. At the same time the development of the tree and its bearer shoots need to be stimulated to develop a more complex structure. Thereafter, however, tree size needs to be maintained within its space. As to be expected, the intensity of the various tree training systems affected tree size as shown in Table 1. Control trees and trees pruned to open vase systems had after six years filled their allocated space while in the same time the central leader and closed vase systems had only partially filled their allotted space. This resulted in significant differences between tree volumes for the different tree training systems with both the central leader and closed vase systems having much smaller tree volumes. The results on tree size therefore indicate that a distance of 3 m between trees still takes too long to fill the space under the given conditions and the distance can be reduced to 2.5 or 2 m. Tree size at a 2 m in-row spacing can effectively be maintained by training trees to central leader, palmette or closed vase systems combined with correct pruning strategies.

Table 1. The relationship between training system and tree size for 'Sensation' mango trees

Treatment	Drip area (m^2)			Tree volume (m^3)		
	1995	1996	1997	1995	1996	1997
Control	5.57a*	7.30a	7.42a	7.16a	10.47a	12.75a
Open vase	3.88b	6.90ab	7.85a	2.91b	6.95bc	11.21b
Palmette	4.96a	6.34b	6.73b	6.46a	6.88bc	5.49c
Central leader	3.00c	4.70c	4.91b	1.77c	5.76c	4.46c
Closed vase	2.98c	4.63c	4.89b	1.58c	6.18c	4.50c
Standard	4.23b	7.32a	8.43a	3.31b	7.52b	12.37ab

*Averages within columns sharing a common letter are not significantly different (P<0.05)

Table 2. 'Sensation' mango yield data for three seasons with trees pruned and trained to different systems.

Treatment	Yield (kg/tree)			Accumulative yield (kg/tree)
	1995	1996	1997	1995-1997
Control	39.06a*	52.27a	33.11bc	124.44
Open vase	27.68bc	34.98b	35.42ab	98.08
Palmette	20.10d	27.36b	37.28a	84.74
Central leader	22.10c	31.01b	29.67c	82.78
Closed vase	18.09d	27.15b	36.49ab	81.73
Standard	28.47b	16.47c	24.28d	69.22

* Averages within columns sharing a common letter are not significantly different (P<0.05)

Although control trees had the highest yield in the initial years (Table 2), these trees have started to grow into each other and the yield was negatively affected in the 1996/97 season. All other systems except for the standard pruning, had constant yields for the three seasons and the yields for the palmette and closed vase systems increased significantly. The control trees, however, had the highest cumulative yield for the three seasons as these trees had larger tree volumes (Table 1). If the necessary calculations are made to express yield as a function of drip area or tree volume, the situation will change for both central leader and closed vase systems. Trees trained according to

these systems can easily be planted at 1000 trees per hectare (Table 3) due their size and this could increase early yields per hectare significantly.

In Table 3 the yields for two seasons are expressed as projected tonnes per hectare if the number of trees per hectare were increased according to tree size and with the spacing suggested for each specific tree training system. The implication of a smaller tree volume and drip area is that a larger number of trees can be maintained in the high density planting by correct tree training, and yields exceeding 30 tonnes per hectare could be expected. To facilitate the adoption of these suggested high density plantings, trees have to be pruned annually to maintain their size. Pruning directly after harvest will maximise the chances of the trees flowering the next season, but for a late cultivar such as Sensation, a complete pruning of all shoots after harvest can result in trees only having high yields every second season. This implies that if the trees are to be pruned after harvest only about 30% of the current bearing shoots should be pruned back.

Table 3. Yield, projected spacing and projected yield for 'Sensation' mango trees pruned according to different systems

Treatment	Yield (t/ha)		Projected spacing	Projected trees/ha	Projected yield (t/ha)	
	1996	1997			1996	1997
Control	24.88a*	15.76bc	6 x 3	556	29.06	18.41
Open vase	16.65b	16.86ab	6 x 3	556	19.44	19.69
Palmette	13.02b	17.75a	5 x 2.5	800	21.89	29.82
Central leader	14.76b	14.12c	5 x 2	1000	31.01	29.67
Closed vase	12.92b	17.37ab	5 x 2	1000	27.15	36.49
Standard	7.84c	11.56d	5 x 3	667	10.99	16.19

*Averages within columns sharing a common letter are not significantly different (P<0.05)

Table 4. Yield data for 'Sensation' mango trees pruned for three seasons at different times during the season

Treatment	Yield (kg/tree)			Accumulative yield (kg/tree)
	1995	1996	1997	1995-1997
Control	31.81a	29.62b	31.12b	92.55
Postharvest	21.74b	27.11b	37.86a	86.71
October	18.44b	40.67a	33.59b	92.70
November	21.56b	28.38b	31.56b	81.50

* Averages within columns sharing a common letter are not significantly different (P<0.05)

Pruning trees early after fruit set (October) stimulated early vegetative growth that enabled the trees to bear a normal crop the following season (Table 4). Due to the small fruit size problem of the cultivar Sensation, October and November pruning treatments combined with fruit thinning significantly increased fruit size (Table 5). The combination of pruning after fruit set and thinning fruit can therefore solve the problems of alternate bearing and small fruit but again no more than 30% of the shoots should be pruned.

Table 5. Average fruit size and fruit counts for 'Sensation' mango trees, over three seasons, pruned at different times during the season

Treatment	Fruit size (g/fruit)			Average fruit size-g/fruit (count in 4kg carton)
	1995	1996	1997	1995-1997
Control	282.34c*	274.44b	388.39b	315.05 (13)
Postharvest	328.32b	295.67ab	389.75b	337.91 (12)
October	392.94a	323.19a	397.00b	371.04 (11)
November	341.52b	316.71ab	415.38a	357.87 (11)

* Averages within columns sharing a common letter are not significantly different (P<0.05)

'Tommy Atkins'

Since 'Tommy Atkins' is an early cultivar, pruning was performed after harvest with the expectation that the vegetative flush stimulated by pruning will harden off sufficiently before the onset of flowering the next season. Trees pruned after harvest in 1995, had a significantly lower yield than the control trees (Table 6), but there was no significant difference in yield the following season. A possible reason for the lower yield in 1995/1996 was the fact that the trees were pruned late or more probably because this was the first pruning and severe pruning was necessary to shape the tree. During 1996 and 1997 the trees were pruned immediately after harvest and only moderate pruning was needed. Although there was also no significant difference in fruit size during the 1995/1996 season (Table 7), fruits from the control trees were significantly smaller in the following seasons.

Table 6. 'Tommy Atkins' yield data for three seasons with trees pruned to an informal pyramidal system

Treatment	Yield (kg/tree)		
	1995/96	1996/97	1997/98
Pruned	17.45b*	18.56a	18.29a
Control	22.99a	20.59a	19.11a

* Averages within columns sharing a common letter are not significantly different (P<0.05)

Table 7. 'Tommy Atkins' average fruit size for three seasons when pruned to an informal pyramidal system

Treatment	Fruit size (g)		
	1995/96	1996/97	1997/98
Pruned	464.15a*	437.48a	420.10a
Control	451.06a	378.50b	390.90b

* Averages within columns sharing a common letter are not significantly different (P<0.05)

Table 8. The effect of pruning of 'Tommy Atkins' mangoes on external fruit colour.

Treatment	External fruit colour (>30% blush)		
	1995/96	1996/97	1997/98
Pruned	78.40a*	77.92a	84.90a
Control	60.56b	60.45b	55.60b

* Averages within columns sharing a common letter are not significantly different (P<0.05)

The fruit of 'Tommy Atkins' can develop a brilliant shade of pink or red skin colour when exposed to enough light during the fruit development period. According to Schaffer *et al.* (1994) who referred to Winston and Whiley (1993) differences in skin colouration of 'Kensington' fruit are attributed to varying levels of light reaching different areas of the tree canopy during the fruit development period. From the results in Table 8, it is clear that pruning 'Tommy Atkins' trees to an informal pyramidal system enhanced colour development significantly. Bearing in mind that the blush development enhances the attractiveness and marketability of the 'Tommy Atkins' fruits, pruning trees to allow for better light interception is recommended if the trees are pruned immediately after harvest.

From the results obtained, the authors developed a pruning combination strategy for 'Sensation'. It involves certain post harvest cuts being made mechanically and selectively and then followed up with selective pruning in the bearing stage. These results will be discussed in a subsequent article.

Conclusions

Seven-year-old 'Sensation' and six-year-old 'Tommy Atkins' mango trees that have been trained and pruned consecutively for three years were used in the trial. Results clearly show that the 7 x 3 m planting distance is too wide for 'Sensation' under prevailing conditions. Planting of trees at 5 x 2 m is therefore justified if a tree training and manipulation programme is in place for maintaining such an orchard from its third year. The informal pyramidal form (something between a central leader and a closed vase) appears to be ideal for achieving good light management with a possible yield exceeding 30t/ha after seven years. In windy areas the palmette system has certain benefits as the bearers are supported by wires but this is more expensive because of the trellis system.

In the case of a late cultivar, such as Sensation, a system must be adopted where annually a percentage of the bearers can be hardened off in time for bearing fruits in the current season and the rest will be new bearers for the fruit of the following season. Where a small-fruit problem occurs, as happens with 'Sensation', the rejuvenation pruning can be carried out on the bearing tree (October/November). Bearers with weak, malformed and small fruits are cut back behind the axillary ring at the desired length to keep the branch hierarchy in place. On the remaining bearers the fruit are thinned to numbers the tree can cope with, giving marketable fruits while maintaining yield. In this way, improvement in fruit size can be achieved. An early cultivar such as 'Tommy Atkins' should be pruned immediately after harvest to an informal pyramidal shape. This will allow enough light into the canopy for good colour development on the fruit.

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