ISSN: 2581-3749 (online) Advanced Agricultural Research & Technology Journal ▪ Vol. III ▪ Issue 1 ▪ JANUARY 2019
IMC-2018 Special

High Density Planting in Mango- Prospects and Problems

N. Kumar*

Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore (India) 641003

Abstract

High density planting (HDP) (5 x 5 m) or ultra-high density planting (UHDP) system (3 x 2 m) aims to make maximum use of land to achieve high yields in the early periods of orchard along with ease in its management. This system warrants adoption of certain important technologies like formative pruning in the initial years so as to have desirable plant architecture, proper canopy management annually to encourage vegetative growth immediate after harvest, stopping of the vegetative growth during September to favour fruit bud initiation and differentiation. Further, adoption of drip irrigation system so as to replenish the loss of moisture through evapo-transpiration and providing nutrients at required quantity at appropriate doses through fertigation technique are highly essential to get higher yield with quality fruits. Case studies wherein orchards planted under HDP or UHDP but without adopting the mandatory techniques, resulting in poor yield and more pest and disease incidences are discussed.

Keywords: Orchard, canopy management, planting density, double hedge.

The area under mango in India is about 2.3 million ha with a production of about 15.02 million t. registering an average productivity of 6.5 t ha^{-1} as against a higher productivity of 30 t ha^{-1} in Israel. The main reason for low productivity can be attributed to poor orchard management including water and nutrient management, wider tree spacing with dense canopies, experiencing poor sunlight interception, lack of proper ventilation encouraging more pest and disease incidences. Thus, adoption of High Density Planting (HDP) system with proper canopy management practices coupled with drip-fertigation system is highly essential to increase the productivity (Kumar 2013). High density planting makes maximum use of land to achieve high yields in the early periods of the orchard along with ease in its management. Although HDP in mango has been successfully demonstrated in the research institutes in India (Majumdar *et al*. 1982, Ram and Sirohi 1999, Ram *et al*. 2001), when this technology was implemented in the field by the farmers, many problems were encountered as the farmers did not follow all the aspects related to the HDP system. In this paper, the prospects and problems in adopting the HDP by certain farmers are discussed besides the related aspects to be followed in HDP.

Correspondence: kumarhort@yahoo.com
Received Date: 10/05/2018; Accepted Date: 20/12/2018

High Density Planting System

Recently, mango orchards are being established at closer than conventional spacing in many parts of India. After 10-11 years, ¾ of the canopy of trees in the high density orchard needs to be dehorned to present interlocking of branches. Under North Indian conditions, Dashehari was planted at a spacing of 3.0 x 2.5 m accommodating 1333 plants ha^{-1} where the yield was 10-14 times higher than normal spacing. In the case of cv. Amrapali, a close spacing of 2.5 x 2.5 m is recommended under North Indian condition. Field experiments conducted at TNAU to study the different systems of planting in mango cv. Kalepad revealed that the double hedge row system of planting with a spacing of 10 m between double hedges, 5 m within double hedge and 5 m between plants in double hedge (200 plants ha^{-1}) is the best planting system for obtaining maximum number of fruits and the highest yield per unit area. (Jasmine *et al.* 2009). However, State Department has started recommending HDP with 5 x 5 m spacing for all commercial varieties. In South India, under tropical condition, the following spacings have

Table 1. Spacings and planting densities followed in India over time

Sr. No.	Year	Spacing (m)	Plant population (plants ha^{-1})
1.	Before 1980s	12 x 12	69
2.	After 1980s	10 x 10	100
3.	2005 onwards	5 x 5	400
		10 x 5 x 5	200

Table 2. Mango varieties suitable for Ultra-High Density Planting

State	Varieties
Andhra Pradesh	Alphonso, Alampur Baneshan, Banganapalli, Totapuri (Bangalora), Mallika
Bihar	Bombai, Himsagar, Langra, Chausa
Goa	Fernandin, Mankurad
Gujarat	Alphonso, Kesar
Karnataka	Alphonso, Bangalora, Neelum, Mallika
Madhya Pradesh	Alphonso, Kesar, Ratna
Tamil Nadu	Alphonso, Banganapalli, Imampasand, Totapuri (Bangalora)
Uttar Pradesh	Bombay Green, Dashehari, Langra, Lucknow Safeda, Mallika, Chausa

been practiced (Table 1).

Ultra High Density Planting System

Recently, experiment conducted by TNAU in collaboration with Jain Irrigation Systems Ltd (JISL), Udumalpet revealed that we can go for still closer spacing of 3 x 2 m called Ultra High Density Planting System (UHDP). The varieties that can be grown successfully under UHDP in different states are shown in Table 2. As the Cultivation Practices are very intensive, high value varieties are recommended.

Under UHDP, Mango is planted at 3 m x 2 m which accommodates 674 plants acre^{-1} (Fig. 1). Pits should be marked at 3 m x 2 m before pit digging and pits of l x l x l m are to be dug at marked places.

Alternatively one meter deep and one meter wide trench can be prepared at every three meter, but it is bit costly, however, it is more convenient, good for establishment and growth. The pits should be allowed to wither for some weeks before filling with mixture of planting media. The media consists of 40-50 kg native soil, 0.5-1.0 kg Single Super Phosphate (SSP), 0.25 kg Neem cake, 20 kg compost or 10 kg vermi-compost and 10-15 g of Thimet or 20 g Furadon. Plantations are to be raised by using grafted saplings. Plants must be procured well before planting. While planting, soil around each graft should be pressed well. The ball of earth around the base

Fig. 1. Ultra-high density plantations

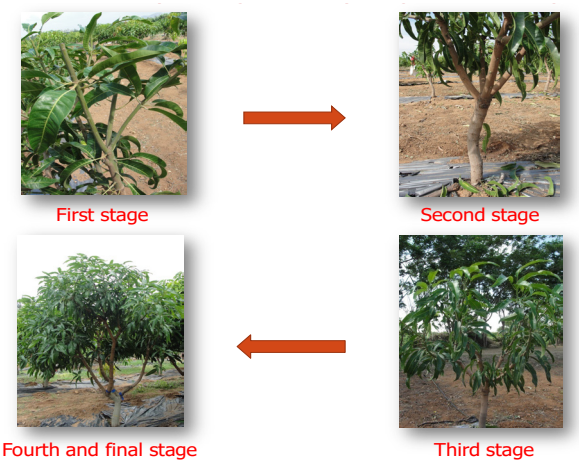

Fig. 2. Canopy management in young mango trees

of the graft should be retained intact and the graft joint should remain just above the ground level.

The success of high density planting depends upon certain factors which are dealt here.

Canopy Management

Canopy management is essential in high density planting system to control size of the tree and also to strike a balance between vigour and productivity. It starts from early months from planting

Training

When the plant height reaches 45-60 cm, the terminal bud should be pinched at 5-6 cm below the apex to encourage growth of auxiliary buds. After the growth

from auxiliary buds 2-3 vigorous shoots are to be retained in different directions at 15-20cm interval which will develop as primary branches (Fig. 2).

After 4-6 months growth of primary branches, they should be headed back at 45-60 cm length to allow further growth of 4-5 secondary shoots on each branch, which in turn will form tertiary shoots in due course. Ultimately the tree row will form a dome shaped hedge. In many orchards, improper training especially the formative pruning resulted in overcrowding of branches resulting in more incidences of hopper, powdery mildew and anthracnose disease etc.

Pruning

Pruning is very essential and critical operation of HDP or UHDP to maintain fruiting shoots and contain the canopy. Pruning must be completed as soon as possible after harvest preferably before 15th June in Central and Southern India. Tertiary branches have to be headed back in such a way that the plant height can be maintained at 1.5 m and having 10-15 tertiary shoots. Excess tertiary shoots have to be thinned out to avoid overcrowding. Cut ends to be pasted with Bordeaux paste or 2% Copper Oxychloride (COC) suspension. About one month after pruning, thinning of newly emerged shoots is essential to avoid excess shoots and overcrowding. On each tertiary shoots 3-4 new shoots are to be maintained. Dried panicle along with 2-3 leaves and dried shoots / branches must be removed at the time of pruning. The following points are to be borne in mind for new orchard while carrying out canopy management.

- Heading back of plants when they attain the age of one year.
- Heading back should be done with sharp secateurs to give a sharp and smooth cut during October-December.
- Height of heading back should be 60-70 cm from the ground.
- Heading back results in emergence of new shoots during March-April (spring season).
- For development of ideal open canopy, thinning of excessive shoots is needed during May. Thinning should be done in such a manner as to retain four well distributed shoots in all directions. These shoots develop as primary branches.
- If crotch angle of retained shoots is smaller, then bending should be done at this stage to increase the crotch angle of newly developed shoots. It should be done with a jute rope (use of nylon or poly threads should be avoided).
- Second cutting is required when these shoots attain maturity. Shoot maturity in mango is determined by colour change of shoots from green to brown. Generally, this stage comes after 7-8 months of growth in north India.
- Thus, second cutting of primary branches is done in October-November. This cutting also induces new growth during ensuing spring season.
- Again, thinning of excessive shoots should be done to ensure 2-3 shoots per primary branch. These shoots develop as secondary branches.

This initial training results in open and spreading canopy of trees.

Canopy management in Bearing Mango Orchards

TNAU experiments proved that canopy management through pruning immediately after harvesting and checking its vegetative growth by September through soil application of paclobutrazol @ 1 g a.i. per sq m tree canopy is beneficial. Further, off-season cropping can be induced in mango through appropriate canopy management practices. The limitation to these techniques is that it can be practiced only under irrigated and well maintained plantations. As manual method of heading back of the shoots is a laborious one under large scale, mechanical means to prune the mango tree is to be developed (Kumar *et al*. 2012)

In the case of bearing trees under UHDP, annual pruning of shoots after harvest is recommended. Light pruning in one year followed by medium pruning in the next year should be followed in alternate years to maintain the tree size under control as indicated in Fig. 3.

Similarly, the problem of large tree size in mango can be tackled by using topping and hedging because large and crowded trees pose many disadvantages. Appropriate height, topping and hedging, cutting angles, as well as time and frequency of hedging determined for mango, which are common practices in Israel, USA, Australia and South Africa, can be used for increased efficiency and production in India. Shaping the mango tree immediately after planting has its own importance for keeping desirable plant height at first branching, so that proper clearance for equipment is possible. The following points are to be borne in mind while carrying out canopy management in bearing orchard.

- In bearing mango trees, for management of canopy

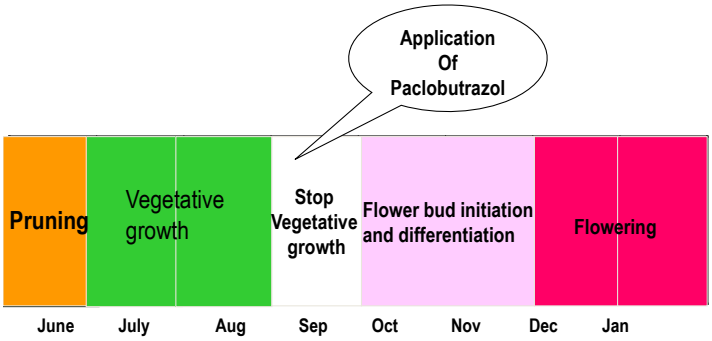

Fig. 3. Concept of new crop management practice in mango

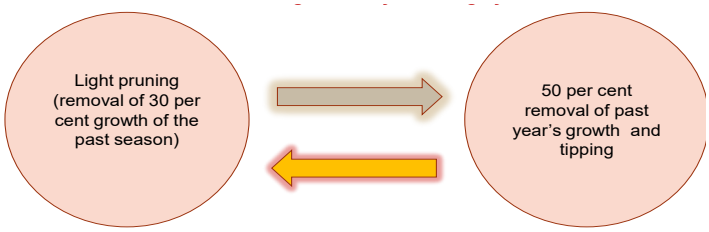

Fig. 4. Ultra-high density planting systems results in higher productivity and maintenance of mango trees

Table 3. Water requirement in different months

Month	Evaporation mm	Water Requirement* L plant^{-1} day^{-1}			
		1st year	2nd year	3rd year	4th year onwards
Jan	2.87 - 40.60	0.5 - 0.75	2.0 - 2.6	4.0 - 5.8	7.0 - 10.3
Feb	3.38 - 5.90	0.75 - 1.0	2.5 - 4.1	6.0 - 9.3	10.0 - 16.5
Mar	3.79 - 7.29	0.75 - 1.3	3.0 - 5.3	6.5 - 12.0	11.5 - 16.4
Apr	6.69 - 8.38	1.3 - 1.5	5.0 - 6.5	11.3 - 14.0	20.0 - 25.0
May	7.54 - 9.32	1.5 - 2.0	5.8 - 7.0	13.0 - 16.0	23.1 - 28.0
June	5.97 - 7.45	1.0 - 1.2	3.5 - 4.5	7.5 - 10.0	13.0 - 23.1
July	4.24 - 7.47	0.5 - 1.2	2.0 - 4.8	4.5 - 10.7	8.0 - 19.0
Aug	3.22 - 7.84	0.5 - 1.2	1.5 - 4.8	3.5 - 10.8	6.0 - 19.2
Sept	3.57 - 7.78	0.5 - 0.6	1.0 - 2.2	2.5 - 4.9	4.0 - 8.7
Oct	4.42 - 7.47	0.4 - 0.5	1.5 - 2.0	2.2 - 3.0	3.9 - 5.0
Nov	3.48 - 3.84	0.4 - 0.5	1.6 - 2.0	3.5 - 4.0	6.2 - 6.5
Dec	3.15 - 3.90	0.4 - 0.5	1.5 - 1.6	3.5 - 3.6	6.0 - 6.5
Avg	4.65 - 6.02	0.8 - 1.0	2.8 - 3.3	6.3 - 7.5	10.8 - 13.3

**Based on the location the water requirement will vary.*

and enhancing their productivity, identify uprightly growing branches in each tree and thin them out for increasing the productivity.

- Remove only one or two uprightly growing branches from centre of tree to reduce tree height significantly and increase availability of light inside the canopy for better photosynthesis.
- Cutting of uprightly growing branches should be done during October-December from the base of their origin.
- During removal of branches, first cut should be given on lower side of branch to give a smooth cut and avoid bark splitting.
- Protect branches with wide crotch angle as they are more productive.
- In bearing mango trees, not more than 25 % biomass should be removed at a time for better canopy management; otherwise it results in excessive vegetative growth.
- Under high density planting system, remove 10-15 % biomass annually during October-December to increase light penetration inside the canopy. Removal of 10-15 % biomass should include criss cross branches, dead wood and diseased shoots.

Nutrient and water management

The success of mango production under HDP or UHDP also depends upon proper Nutrient and water management**.**

Irrigation management

The critical component of UHDP technology is the management of inputs: irrigation water and fertilizer. These two are provided through drip irrigation system. In several states in India, mango is not considered as an irrigated crop. In the event that UHDP gets acceptance from Indian mango growers in order to enhance productivity and income it is imperative that they should adopt drip irrigation, wholly and not in parts. The quantity of water per tree also varies with age and season (Table 3).

For the bearing trees (3rd year onwards) irrigation to be given at survival level during

September 3rd week to October to induce flowering. The rainfall events are very erratic and therefore not adjusted on a daily basis. The general recommendation is that if rainfall exceeds 10 mm in any one day, suspend drip irrigation for the next 2 to 3 days. The online drip system is found to be more suitable for Mango. The drip laterals are spaced at the relevant row spacing. Each tree is provided with one dripper of 4 L h^{-1} during initial two years and 2 drippers of 4 L h^{-1} from 3rd year. When 2 drippers are installed they should be placed 45 cm away from the trunk (Anon 2015).

Application of fertilizer

The recommended fertilizer dose for UHDP Mango in soils having medium nutrient content is given below. Estimation of fertilizer requirement based on soil analysis and targeted yield will be more accurate. The NPK fertilzers are also to be given as per the following schedule in tune with the different stage of the crop based on uptake pattern (Table 4, 5 and 6)

However, the timing and number of schedule may vary with place to place depending upon the flowering and fruiting season including the variety under cultivation.

Based on this, Jain Irrigation Systems Limited recommends the following fertigation schedule for UHDP mangoes (Soman 2009).

- If phosphorus has to be given as solid fertilizer like SSP it can be given in two equal split doses along with organic manure.
- If chloride injury is found or if the water contains high chloride then MOP should be replaced by Potassium nitrate or sulphate.

Benefits of UHDP and associated technologies

- Increases productivity upto 2-3 times, 10 year old UHDP yielded upto 18-20 MT ha^{-1}.
- Reduces orchard gestation period to three years as compared to conventional orchards.
- Makes orchard crops as profitable as other cash crops.
- Reduces water used for irrigation upto 50 %.
- Increased fertilizer uptake by plants when fertigation is practiced.

Table 7 indicates that HDP/UHDP is generally good to get higher yield and quality fruits.

Management of pests and diseases under HDP or UHDP

As proper pruning is taken up in these orchards, generally the pests especially hopper or diseases like anthracnose and powdery mildew would be minimum as spraying operations are easy and efficient. Studies conducted at TNAU revealed that anthracnose disease incidence was found to be high in mango trees planted in the 'Double hedge row system of planting', however, they were better managed by periodical pruning of trees and spraying recommended dose of fungicides or biocontrol agents at regular intervals. (Balasubramanyan *et al*. 2009). However, they observed no significant variation in hopper numbers among the various planting systems over the years.

Problems faced in certain HDP mango orchards

Once HDP is adopted, all the recommended practices are to be followed scrupulously, otherwise, it would result in failure only. The experience of HDP/UHDP in three different mango orchards is described below.

Orchard Number One

The orchards is 12-13 years old with spacing 7 m x 6 m. Soil depth is good with poor water retention capacity. Annual rainfall is 1250-1500 mm. The orchard is under rainfed condition with no drip system. No addition of NPK fertlizers etc.

Problems confronted included vigorous, more crowdy, upright growth, no sunlight penetration, very poor yield, (1.5-2.0 MT ha^{-1}) harvesting problem because of higher growth, severe incidence of powdery mildew, white scale and anthracnose. The leaf nutrient content

Table 4. Fertilizer recommendation for UHDP Mango planted in normal soil

Age	Fertilizer g $tree^{-1}$			FYM
	N	P	K	kg $tree^{-1}$
1st year	35	15	25	5
2nd year	45	25	50	5
3rd year	75	50	75	10
4th year onwards	120	75	100	15

Table 5. Fertigation Schedule for Mango. Minimum number of Fertigation dose for all stages are six.

Nutrient	After Harvest (June- Aug)	Pre-flowering (Sept-Oct)	Flowering to Fruitset (Dec-Jan)	Fruit	Total
N	25%	40%	20%	15%	100%
P	40%	30%	20%	10%	100%
K	25%	20%	25%	30%	100%

Table 6. Fertigation schedule for UHDP Mango (to be applied at weekly interval)

Fertigation Schedule and Quantity (kg^{-1} $dose^{-1}$ $acre^{-1}$)						
Age	Month	No. of Doses	Urea	H_3PO_4	MOP	$MgSO_4$
1 yr	July-Sept	12	1.4	0.5	0.8	0.000
	Jan-May	20	1.7	0.6	0.9	0.000
2 yr	July-Sept	12	2.7	1.2	2.3	0.278
	Jan-May	20	1.6	0.7	1.4	0.167
	15 June-Aug	12	4.5	2.3	3.5	0.555
3 yr	Sept	4	1.4	1.2	3.1	0.000
	Jan-May	20	3.2	1.2	1.5	0.333
	15 June-Aug	12	7.2	3.5	4.6	0.833
4 yr	Sept	4	2.2	1.7	4.2	0.000
	Jan-March	12	5.1	1.7	3.2	0.833

Table 7. A comparison of different planting systems (Soman 2012).

Particular	Planting Type		
	Traditional	Medium Density (HDP)	Ultra High Density
Gestation Period (years)	9	5	4
Duration to reach full potential (Years)	15	8	5
Yield potential	Medium	High	Very High
Orchard management activities :			
Pruning	Very difficult	Manageable	Easy
Spray operation	Difficult	Manageable	Easy
Spray efficiency	Very poor	Fairly Good	Good
Harvest	Very difficult	Possible	Very easy
Control on fruit quality	Impossible	Possible	Easy
Expected yield at maturity (t ha^{-1})			
1. High volume varieties	12	18-20	20-25
2. Low volume varieties	6	10-Aug	10-12
Commercial orchard life (years)	Up to 50	30-35	20-25

analysed in this orchard are shown in Table 8.

Low level of K found in the leaves would have encouraged the heavy incidence of powdery mildew and anthracnose disease prevailing in the mango orchard. The low amount of micronutrients like Boron and Zinc are also causing a concern as their critical level helps to provide resistance against diseases and insect pests. In order to improve the yield potential of the orchard, following recommendations were made:

- Soil moisture conservation practices which include mulching, use of coir brickets
- Use of VAM application
- Decomposting the fallen leaves and the cut savannah grasses
- Developing the infrastructure for irrigating the mango orchard
- Further, canopy management in mango orchards such as rejuvenation pruning
- Centre opening and Formative pruning in young

Table 8. Leaf (tissue) nutrient content in HDP orchard number one.

Nutrients	Kent	Alphonso	Kiett	Tommy Atkins	Ideal Values
Nitrogen (%)	1.4	1.6	1.21	1.34	2.5-3.0
Phosphorus (%)	0.23	0.41	0.23	0.40	0.15-0.20
Potash (%)	1.3	0.62	0.72	0.84	2.0-2.5
Calcium (%)	2.8	3.1	2.3	2.2	1.5-2.0
Magnesium (%)	0.26	0.42	0.40	0.52	0.2-0.25
Sulphur (%)	0.18	0.12	0.17	0.18	0.2-0.26
Zinc (ppm)	28.2	23.2	21.2	18.2	25-30
Boron ppm	12	14	16	18.2	30-35
Manganese (ppm)	26.2	22	34	23	45-55

plants were suggested.

Orchard Number Two

The orchards is 17 years old with spacing adopted 5 x 5 m. Irrigation through drip system and technologies like formative pruning, annual canopy management not followed. Problems include over crowding of branches, with more incidence of pest and diseases. They removed alternate trees over a period of 2-3 years and the spacing now is 10 m x 10 m.

Orchard Number Three

The orchard is only three years old with spacing adopted 3 m x 2 m and 4 m x 2 m. Technologies followed include drip irrigation but watering at 10-15 days interval, no proper formative pruning, no fertigation. This resulted in poor growth of the plants.

Conclusion

Thus, it is imperative that once HDP or UHDP is adopted, the related technologies like formative pruning to develop proper plant architecture and annual canopy management are to be followed regularly. Besides, providing optimum irrigation through drip to replenish moisture loss through evapo-transpiration and proper fertigation practices to provide balanced vegetative growth and fruiting, are highly essential so as to get higher yield. If these practices are followed, the management of pests and diseases would be very effective.

References

Anonymous 2015. Mango-Ultra High Density Planting System (in Tamil) published by Jain Irrigation Systems Ltd., Udumalpet, Coimbatore district.

Balasubramanyan S., Saraswathy S., Parthiban S., Sankaranarayanan R., Revathy N. and Rajamanickam C. 2009. Effect of planting densities on mango (*Mangifera indica* L.). In National Seminar on "Production, Post-harvest Technology and Marketing of Mango" held on 23-25 September 2009 at Horticultural College and Research Institute, Periyakulam (TNAU): 79-81.

Jasmine J., Nainar A. P. and Balasubramanyan S. 2009. High density planting system for mango (*Mangifera indica* L.) variety Kalepad. In National Seminar on "Production, Post-harvest Technology and Marketing of Mango" held on 23-25 September 2009 at Horticultural College and Research Institute, Periyakulam (TNAU): 74-75.

Kumar N. 2013. Drip-fertigation to increase the productivity of mango cv. Alphonso raised under Ultra-High Density Planting (UHDP) system. Paper presented at the XXII International Plant Nutrition Colloquium meeting (IPNC) held at Istanbul, Turkey from 19th to 22nd August 2013.

Kumar N., Ramesh Kumar A. and Jayavalli R. 2009. Canopy management in mango – TNAU's experience. In National Seminar on "Production, Post-harvest Technology and Marketing of Mango" held on 23-25 September 2009 at Horticultural College and Research Institute, Periyakulam (TNAU): 95-99.

Majumnder P. K., Sharma P. K. and Singh R. N. 1982. A sutdy on high density orcharding in Mango (*Mangifera Indica* L.) var. Amrapali Panjab Hort. J. 22: 123-127.

Ram S. and Sirohi S. C. 1999. Feasibility of high density orcharding with Dashehari mango. Acta Hort., 191: 207-212.

Ram S., Singh C. P and Shukla P. 2001. Effect of different planting densities on growth and yield of mango. Indian J. Hort. 58:191-195.

Soman P. 2009. Ultra high density plantation in mango - A Rewarding Experiment. In National Seminar on "Production, Post-harvest Technology and Marketing of Mango" held on 23-25 September 2009 at Horticultural College and Research Institute, Periyakulam (TNAU) : 89-94.