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Research Article

DEVELOPMENT OF A PACKAGE FOR INTENSIVE CULTIVATION OF MANGO USING ULTRA-HIGH DENSITY PLANTING (UHDP), DRIP AND FERTIGATION TECHNOLOGIES FOR HIGHER PRODUCTIVITY

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Abstract: Largest area under mango cultivation in the world is in India. However, the productivity is one of the lowest. The reasons are many, large number senile orchards, traditional methods of cultivation, mostly rain-fed or with occasional flow irrigation during fruit development, poor attention to the canopy, nutrition, pest and diseases, and lack of use of Good Agricultural Practices (GAP), lack of awareness among farmers of modern techniques like micro irrigation and fertigation, Integrated Pest Management (IPM), Integrated Nutrition Management (INM), and modern post-harvest management methods. The Research and Development team of Jain Irrigation carried out a number of field trials, with high and ultra-high density plantation techniques in mango and tried to determine, irrigation and fertilizer requirement using drip technology and based on the results of soil and leaf analysis for targeted yields, and crop regulation by optimum canopy management and use of Paclobutrazol (PBZ) for early uniform and regular flowering. They followed, IPM, Global-GAP and standardized, a package of practices for mango cultivars, under high density (4.5 m X 4.5 m) and ultra- high-density mango (3 m X 2 m). The composite mango production technology thus developed over a period of 14 years in the Research, Development and Demonstration Farms of JISL is now extended to many growers in the country. The mango yields increased two to three times, the gestation period for the first harvest was reduced to three to four years, the quality of fruits was good for export and fruiting was regular even in shy-bearing cultivars like Alphonso and Himampasand.

Keywords: *UHDP, Mango, High density, GAP, Drip, Fertigation*

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Introduction

Mango is traditionally planted at 10 m X 10 m spacing (100 plants/ha) extensively in medium to large holdings, mostly under rain-fed conditions, occasionally supported by irrigation during flowering to fruiting stage wherever water is available. Soil application of organic manures done during early monsoon and fertilizers applied during flowering and fruit-set. At this stage pesticides are sprayed once or twice. The average yield ranged between 8-9 t/ha, rendering mango cultivation economically unviable. Singh *et. al*. [1] studied the production and performance of mango cultivars in India over many years by growth and variability analyses and observed that production declined 0.96% per annum, while the compound growth rate in area under mango had been 3.78%. Availability of arable land for extending mango cultivation has been a limitation over the years. Considering the continual increase in human population and land use pressure in the country, there is limited scope to expand the area. Hence intensification of mango production system is the necessity in the country in the coming years. Increasing productivity of mango will only be possible by establishing high density orchards with intensive cultivation practices, hi–tech inputs like using drip irrigation and fertigation, training the young trees and pruning yearly to allow sufficient interception of light and develop the canopy within manageable height, permitting orchard operations like pruning, spraying, harvesting *etc.* made easy and efficient. High density orcharding is most appropriate to overcome low productivity and long gestation period for high returns. Intensive cultivation is most relevant to small holdings. This method of cultivation enables farmers to achieve faster economic progress. Such orchards usually include higher managerial inputs and often use sustainable methods. Horticultural intensive system aims to maximize yields, through use of hi-tech inputs, crop regulation, integrated pest and nutrition management *etc.*

Control of excessive vegetative growth is the most important aspect of high-density planting. Growth parameters have to be optimized, minimize unproductive components without sacrificing the overall health of the plants and the quality of the produce. Pruning operation aims to keep more fruiting shoots and minimum structural branches. Tamil Nadu, India accounted for 5.6% of the total production of mango in India [2]. The country's total production being 19.69 million ton from 2.263 million hectare and cultivar Totapuri accounts for half of the mango area in South India [3].

JISL experience with high density plantation technology

Jain irrigation systems Ltd (JISL), the world's largest processor of mango fruits, established experimental mango orchards in its captive farm in about 80 ha, at 4.5 m X 4.5 m spacing, using drip system for irrigation and fertigation during 1996 in Jalgaon, Maharashtra, India. Jalgaon is not a traditional mango growing area. The water requirement of mango based on evapotranspiration for different growth stages were determined. The fertilizer requirement of bearing mango, *cv*. Ratna was determined by carrying out two-year trial [4]. Sivakumar recorded that the highest yield 18.39 t/ha and 26.34 t/ha during 2006 and 2007, respectively in treatment having 100 % of recommended dose of fertilizers (RDF), *i.e*., 120g N, 75g P and 100g K/tree, through fertigation as against the control i.e. through direct soil application of fertilizers which produced only 13.49 t/ha and 17.98 t/ha in 2007 and 2008, respectively. The package of practices using drip irrigation and fertigation had been standardized for high density mango orchards (4.5m X 4.5m which accommodates 474 plants/ha). Encouraged by the promising results of the performance of mango cultivars under high density, orchards of cvs. Mallika, Totapuri, Alphonso, Ratna, Himampasand, Banganapalli have been established at 4.5m X4.5 m in 120 ha at Udumalpet, Tamil Nadu, India.

Table-1 *Planting details of experimental and demonstration area of mango cultivars under UHDP*

S	Particulars	Cultivars					
		Alphonso	Ratna	Himampasand	Totapuri	Mallika	Banganapalli
1	DOP (date of Planting)	June 2006 &November 2009	Jun-06	Nov-09	Nov-09	Nov-09	Nov-09
2	Area (ha)	17.27	2.02	7.85	18.39	0.91	0.6
3	Number of Plants	24056	2809	10936	24033	1266	856

Table-2 *Meteriological data of experimental location, Udumalpet, average of 2006-2018*

Month	Pan Evaporation mm	Rainfall in mm	Bright Sunshine hrs	Temperature °C		Relative humidity %		Wind Speed kmph
				Min	Max	8.00 AM	2.00 PM	
January	4.22	4.46	5.73	14.88	31.9	79.96	41.15	2.49
February	5.41	12.31	6.68	15.64	34.55	75.67	36.06	2.81
March	6.39	20.54	6.37	18.6	36.77	71.7	32.57	4.1
April	6.20	45.61	5.79	22.18	37.08	75.82	38.67	6.25
May	7.22	42.71	5.89	22.79	36.54	74.05	40.78	9.35
June	6.84	13.25	4.96	22.44	35.26	76.37	47.13	10.45
July	6.80	18.59	3.85	22.5	33.76	72.3	48.63	13.21
August	7.20	19.72	4.22	22.19	33.86	74.92	46.41	12.37
September	7.01	45.59	5.09	21.79	33.8	74.51	44.42	9.54
October	4.37	161.51	3.72	20.77	33.63	81.46	47.75	5.18
November	3.18	179.61	3.69	18.23	31.53	84.15	51.25	2.26
December	3.29	65.11	3.89	15.58	29.09	81.43	47.9	2.15
Average / Total	5.68	629.01	4.99	19.75	33.98	76.86	37.2	6.68

With an objective to further improve the productivity, experimental orchards of Ratna, and Alphonso were established in 4 ha during 2006 at 3mX2m and 3mX1m in Udumalpet, Tamil Nadu, which was called Ultra- High Density Plantation (UHDP). Based on initial success of this orchard of Himampasand, Mallika, Banganapalli and Totapuri were established in 2009 at 3m X 2m spacing in an additional 45 ha [Table-1]. These orchards were utilized to conduct various experiments to standardize the package of practices. JISL Research farm has become the innovative centre for UHDP in the country to test suitability of this method for other varieties and other tree fruit crops.

Extensive studies have been carried out on canopy management of Alphonso cultivar under UHDP by Gopu *et al*. (6&9), Anbarasan [7]. They observed that the highest mean fruit weight was recorded in moderately pruned plants (30 % removal of past season growth), and stated that the removal of dried panicle stalks of previous season, light to moderate pruning, retaining 60-70 % of past season growth, during late June-early July, resulted in emergence of maximum number of panicles, highest percentage of fruit set and yield of fruits. Highest pooled yield of 12.71 kg/tree in control (no pruning) followed by 12.41 kg/tree under light pruning of Alphonso plants was recorded. They suggested moderate and heavy pruning treatment in alternate rows, so that, sustainable yield could be obtained over the years. Gopalan [8] observed in five year old Alphonso plants, that severe pruning treatments resulted in poor flowering and low yield, Gopu *et al*. (9) treated four year old Alphonso, in September after pruning with soil application of Paclobutrazol (PBZ) at 1 g a.i./m^2 canopy area and subsequently a 2% KNO_3 foliar spray and observed that the treated plants recorded the highest number of fruits/tree and was on par with Uniconazole at 1.5 g/l which also recorded high yield. In Himampasand the treatment with PBZ plus Ethephon @ 500 ppm foliar spray recorded maximum yield and highest number of fruits per tree. Prakash *et. al*. [10], observed that drip irrigation of 4 years old Alphonso trees at 24 l/day and fertigation at 125 % RDF, (150 N, 93.75g P, 125g K/plant) recorded highest yield of 14.79 t/ha. A TSS of 21.97 % of fruit pulp was recorded in trees under highest level of irrigation and 100% RDF fertigation. Later, Karthi [11] carried out investigations to study the response of Alphonso mango during 2011-2012, using three irrigation regimes 75,100, and 125 % Pan evaporation (PE) and four levels of recommended dose of fertilizers (RDF) 50, 75,100, and 125 % in a split plot design. The two treatment combinations, 100 % PE+125 % RDF and 100 % PE + 100 % RDF were effective in enhancing fruit yield to 12.90 kg/tree (21.49 t/ha) and 11.99 kg/tree (19.97 t/ha) in 2011 and 2012, respectively. These improvements were found to be resulting from increases in fruit volume, mean fruit weight and pulp weight. He found the quality attributes were also improved by these two treatment combinations. The recommended dose of fertilizers for the five years old UHDP mango is 120: 75: and 100 g NPK per tree. Chaudhari *et al*. [12] compared the water productivity of Totapuri mangoes under UHDP and conventional spacing (10 m X 10 m) and observed that the water productivity of UHDP mango orchard was more than twice (5.74 kg/m^3) that of conventional orchard (2.56 kg/m^3). Chaudhari [13] carried out extensive investigations on the management of mango pests under UHDP with drip irrigation and fertigation. He observed that BIPM (Bio Intensive pest management) module, integrating the various components protected the mango crop effectively from major pests like hoppers and leaf webber with yield 13.75 t/ha as compared to traditional farmers' practices which yielded 8-10 t/ha. The BIPM plot recorded higher cost: benefit ratio of 1:4.25.

The observations and the results of experiments carried out have shown that to get optimum benefits of UHDP mango Cv. Alphonso, the strict adherence to the following important aspects of practices are required.

- Application of drip irrigation based on pan evaporation.
- Fertigation with recommended dose of fertilizers.
- Canopy management by training in the first two years for structural development and judicious pruning of plants in subsequent years to permit maximum interception of sun light.
- Crop regulation by application of Paclobutrazol during September, and
- Integrated nutrients and pest management practices, and Good Agricultural Practices (GAP)

The standardized package of practices evolved with the results of these experiments conducted on Alphonso mango had been refined and adapted for other cultivars *viz*. Totapuri, Ratna, Himampasand, Banganapalli. The main objective was to develop an orchard planting system with high productivity that could be demonstrated to farmers. The proven package comprises of high density planting for these popular mango varieties of South India, high-tech inputs *viz*. drip irrigation, fertigation, crop regulation by pruning and growth regulators, INM, IPM, Global-GAP *etc*. It is observed that this system offered precocious production, better and uniform fruit quality through the better and efficient use of available sun light and the practices are easier to manage. Growers in overseas, especially in South Africa. Australia extol the virtues of these high density system as observed by the authors. The results of the experiments and the recommendation based on the results are discussed in the paper.

Materials and Methods

Investigations on intensive cultivation of mango cultivars under UHDP, using drip and fertigation technologies were carried out at the Research, Development and Demonstration Farms at Udumalpet, Tamil Nadu, India. The mango plantations Cvs. Alphonso, Ratna were established during June-July, 2006 and with Cvs. Banganapalli, Himampasand, Totapuri, Mallika at 3m X 2m accommodating 1666 plants per ha during 2009. Details of these orchards are given in [Table-1]. Experimental location is in the rain-shadow area having semi-arid climate and

relatively high wind speed during May to September. [Table-2] indicates that this area receives much less rain (629mm/year) than the annual evaporation and major rains are received during October and November (*i.e.*, North East Monson). Monthly average maximum temperature is 37.08°C and minimum is 14.77°C.
Irrigation was provided with drip system using 16 mm laterals with online drippers of 4 litre per hour discharge. First year only one drip emitter was installed and second year one more emitter was added at 60 cm providing two drippers per plant. Water requirement (WR lit/day/tree) of mango under UHDP was calculated using following formula.

$$WR = Epan \times B \times Kc \times Kp \times Ie$$

Epan = Pan evaporation previous day's in mm
B = Pan factor
Kc = Crop factor (vegetative stage 0.75: flowering and fruiting stage 1.0
Kp = Canopy factor, proportion of area covered by foliage to the area allotted ($6m^2$)
Ie = Efficiency of drip irrigation =90%

Canopy factor varied as per crop age and stage, similarly different crop factor was used for pre-flowering, flowering and post flowering stages.

Table-3 *Daily water requirement for mango plantation under UHDP (3x2m) system (JISI, Udumalpet)*

Month	Evaporation, mm	Liter/Day/Plant			
		1st yr	2nd Yr	3rd yr	4th yr onwards
Jan	4.60	0.63	2.53	5.69	10.12
Feb	5.90	0.8	3.21	7.21	12.82
March	7.29	1	4	8.99	15.98
April	6.69	0.89	3.55	7.99	14.21
May	7.54	0.94	3.76	8.45	15.03
June	7.45	1.01	4.05	9.12	16.21
July	7.47	1.03	4.11	9.24	16.43
Aug	7.84	1.09	4.35	9.78	17.39
Sept	7.78	0.96	3.84	8.64	15.35
Oct	4.74	0.55	2.21	4.97	8.83
Nov	3.84	0.59	2.35	5.28	9.39
Dec	3.90	0.58	2.33	5.25	9.33
Avg.	6.02	0.93	3.73	8.39	14.92

Nutrients were applied through drip system (fertigation) one dose per week. The fertilizers are dissolved in water and injected through a venturi. The recommended fertilizer dose for UHDP Mango in soils having medium nutrients content is given below. Estimation of fertilizer requirement based on soil analysis and targeted yield, accurately done.

Table-4 *Fertilizer doses for UHDP mango*

Age	g/tree			FYM kg/tree
	N	P_2O_5	K_2O	
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 *Nutrient application scheduling for bearing orchard*

Nutrient	Stages of application				Total
	Immediately After pruning	Pre flowering	Flowering to fruit set	Fruit development	
N	25%	40%	20%	15%	100%
P_2O_5	40%	30%	20%	10%	100%
K_20	25%	20%	20%	35%	100%

The plants were trained in the first two years to ensure a dome shaped canopy architecture and subsequently pruned once a year. All the orchard practices were performed under supervision of specialists and all the experiments were designed in consultation with all authors in this research article.

Results and Discussion

Training: Keeping in view of the crop geometry adopted (3 m x 2m) and space provided to a tree ($6 m^2$), spacing of various branches and height and pruning methods were assessed by the authors [14].

Table-6 *Fertigation schedule for UHDP Mango (Application once every week)*

Age	Fertigation schedule and quantity (kg/dose /ha)					
	Months	Number of Doses	Urea	H_3PO_4	MOP	$MgSO_4$
1st yr	July- Sept.	12	3.5	1.3	2	0
	Jan- May	20	4.2	1.5	2.3	0
2nd yr	July- Sept.	12	6.8	3	5.8	0.695
	Jan – May	20	4	1.8	3.5	0.418
3rd yr	15 June- Aug	12	11.3	5.8	8.8	1.4
	September	4	3.5	3	7.8	0
	Jan-May	20	8	3	3.8	0.832
4th yr onwards	15 June- Aug	12	18	8.8	11.5	2.08
	September	4	5.5	4.3	10.5	0
	Jan- March	12	12.8	4.3	8	2.08

Removing terminal growth 2-3 months after planting by cutting off the terminal bud 4-5 leaves below the bud at 45-60 cm height from the ground was found suitable to produce shoots laterally in all directions to have vigorous 3-4 primary branches. To induce secondary branches, pruning of primary branches after 20-30 cm growth 3-4 leaf below the terminal bud or whorl was most effective to get 3-4 secondary branches on each primary. Finally, about 3-4 tertiary branches in each of the secondary branch were developed by pruning of secondary branches to form a dome shaped canopy. All three steps of training can be completed in 10-16 month depending on crop growth and orchard development. This kind of regimented training system enabled better light interception to all part of canopy as compared to plants not trained.

Irrigation

The plants are irrigated through drip daily, based on pan evaporation [Table-2] and fertigated with water soluble fertilizers venturi injector according to the schedule given in [Table-3]. The fertigation schedule has been prepared based on targeted yield, soil nutrients status and the results of foliar analysis for its nutrient elements content. For the bearing trees (3rd year onwards) irrigation to be given at survival level during September 3rd week to October and no irrigation till flowering. The rainfall events are erratic and therefore not adjusted on a daily basis. The general recommendation is that if rain fall exceeds 10 minutes in any day, then suspend drip irrigation for the next 2 to 3 days.
The online drip system is found to be suitable for Mango. The drip laterals are spaced at the relevant row spacing. Each tree is provided with one dripper of 4lph during first two years and two more drippers of 4lph from 3rd year. When two drippers are installed, they should be placed 45cm away from the trunk.

Nutrition and Fertigation

Recommended dose of fertilizers is given in [Table-4]. RDF is 120 g N, 75 g P, 100 g K/tree/per year from fourth year onwards. Sources for nitrogen was Urea (46 % N), for P_2O_5, Phosphoric Acid and Muriate of Potash for K_2O. Sulphate of Potash (SOP) instead of MOP can also be applied. Pruning of bearing orchard: Pruning of the bearing plants was done immediately after harvest in June by removing more than 90% of last season's growth and also cutting the panicle stalks, any unwanted criss-cross growth, dried branches *etc.* followed by copious irrigation.

Disease and pest control

The cultural operations like pruning, mulching, pesticide and nutrient sprays *etc* were carried out according to the standard practice. During February second fortnight, Imidacloprid 17.8 % SL 0.007%, against hoppers, was effective. Quinalphos 25% EC 0.05 % was effective against leaf webber. Acephate 75% SP 0.075 %, Dimethoate 30% EC 0.05% and Pongam oil 1% against thrips; Wettable sulphur 80% at 2g/l, Contaf 5EC 1 ml/l, effective against Powdery Mildew.

Crop regulation

Paclobutrazol (PBZ) 1g a.i./m canopy diameter (Cultar23% Sc w/w of Syngenta Crop Sci. Ltd) was applied using collar drench method in the first week of September by mixing required quantity of chemical in 10 litre of water. Recommended irrigation was given before and after application of PBZ.

Table-7 *Performance of mango cultivars under UHDP (2009-2019)*

Variety	Year of planting	Spacing (m)	Yield t/ha										
			2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Ratna	2006	3X2	6.5	18.5	20.5	22.5	22.5	22.5	22	22	26	24	22.25
Alphonso	2006	3X2	3.3	1.18	4.28	4.38	5	5.55	5.7	5.5	13	12	9.75
Banganapalle	2009	3X2	YP	YP	YP	YP	8.55	12.97	18.23	18.87	17.95	18.3	16.9
Imampasad	2009	3X2	YP	YP	YP	YP	3.56	6.54	7.43	7.81	8.79	8.1	7.3
Totapuri	2009	3X2	YP	YP	YP	YP	12.2	15.32	22.56	25.5	25.5	26	24.9
Kesar	2009	3X2	YP	YP	YP	YP	6.67	9.5	12.56	11.4	12.1	11.8	12.1
YP: Young plants (age =less than 4 years)													

Table-8 *Fruit quality (average of three years 2015, 16 and 17) of different cultivars under UHDP*

SN	Particulars	Cultivars					
		Alphonso	Ratna	Imampasand	Totapuri	Mallika	Banganapalli
1	TSS*	18.6	20.9	18.39	15.69	21.8	20.36
2	Reducing Sugar*	4.07	4.94	3.88	4.07	3.5	6.3
3	Total Sugar*	10.28	13.47	12.4	11.07	-	16.45
4	Acidity*	0.28	0.23	0.26	0.26	0.48	0.23

Yield and fruit quality

The yield data for the five cultivars from the third year of planting Cvs. Alphonso and Ratna (Planted in June 2006) and Cvs. Banganapalli, Himamasand, Totapuri, (Planted in June-July ,2009) are given in [Table-7&8]. The values of yield and quality components are the mean of preceding three-year values (2016, 2017, 2018). A critical examination of the yield and quality components shows that all the cultivars have responded well under UHDP. The cultivars differed in their yield response. Alphonso a shy- bearer with its excellent yellow color, red blush, TSS >19%, unique aroma, incredibly rich smoothness of its after-taste exhibited a yield steadily increasing from 1.17 t/ha in the first crop to 5.7 t/ha in the 7th year harvest. However, in the last two years *i.e.* in the 8th and 9th year harvest, Alphonso recorded 13 and 12 t/ha (2017,2018) respectively. Himampasand, also a shy-bearer, large size up to 800g/ fruit, with characteristic flavor, recorded in the first harvest (2013, fourth year of planting) 3.56 t/ha, yield steadily increased to a peak of 8.79 t/ha in 2017 and seems to have stabilized at 8.1 t/ha during 2018. These two cultivars, believed to be prone to alternate bearing, showed tendency to regular bearing under UHDP, with pruning and PBZ treatments. Cv. Ratna, a hybrid between Neelam X Alphonso with TSS 22 %, had recorded consistently higher yields from the third year of planting, reached peak yield of 26 t/ha in the 11th year. The yield has been hovering around 20t/ha since its second harvest and proved promising in Tamil Nadu where it has been introduced for the first time for commercial planting by JISL. Cultivar Totapuri, a processing variety with TSS > 14%, piquant flavor, and native of South India also performed equally well. After the second-year harvest, its performance doubled (22.5 to 26 t/ha), establishing the fact that the variety can be relied for its unfailing response to proper nutrition and management, employed in the present study. Banganapalli is one of the finest varieties, popular throughout India for is flavor, taste, shape size, colour and long shelf-life and transportability, has responded well to UHDP, also to pruning and PBZ treatments, recorded an average yield of 18 t/ha from the sixth year of planting.

Global GAP Standardized procedures are strictly followed in respect to application time, irrigation and fertigation schedules, pruning time and intensity, PBZ concentration and time of treatment, appropriate pests and disease management.

All the five cultivars started giving economic yield from 3rd to 4th year of planting as they developed canopy fast and covered the allotted space within 2-3 years, and entered reproductive phase precocious. Training in the first two years and subsequent yearly pruning, restricted the excessive vegetative growth and the canopy is maintained within manageable height. Light interception was unrestricted, facilitating maximum photosynthetic efficiency. Pruning triggered vigorous vegetative growth from the axillary buds, just below the cut ends, providing more vigorous fruiting shoots. The overall performance of these five cultivars show that even the shy, alternate bearing Alphonso and Himampasand, bear regular crops under UHDP, responding to pruning and PBZ treatments. Regular bearing cultivars, Banganapalli, Totapuri, and Ratna have recorded high yields of 20-25 t/ha indicating further scope of improvement in performance in the coming years, as these plants are only 9-12 years old.

High density planting system offered early production, from 3-4 year of planting and economically viable produce under intensive cultivation and efficient management with proper selection of cultivars and precision in resource inputs. The orchard operations like pruning, spraying and harvesting are easy and more efficient. During 2006, when this planting system was initiated, farmers and academics alike were skeptical about the technology. How can mango trees with huge canopy under traditional geometry be grown at such narrow spacing of 3m X 2m? The plants responded to drip, fertigation, pruning and crop regulation and the yielded more than 2 to 3 times that of the harvest under traditional system in the juvenile years itself. The results of these studies have clearly demonstrated that irrigation through drip, based on pan evaporation and fertigation based on the estimated nutrient requirement of plants for targeted yield and crop regulation by judicious pruning followed by PBZ treatment, and appropriate integrated pest management could result in very high and sustained productivity year after year. Bio-intensive pest management module integrating the various effective components protected the mango crop effectively from the major pests, and adhering to Global- GAP ensured higher yield of fruits of acceptable quality. Additional improvements in the UHDP system in mango can be controlling tree size using dwarf root stocks like Vellaikolumban, salt tolerant root stock like 13-1, kurukkan for salt –affected soils, mechanization of orchard operation like pruning on a commercial scale are yet to be considered. JISL team, has begun these studies too. JISL's management and Research, Development and Demonstration Farms team have been quick, invaluable in addressing mango growers' issues and raising farmers' awareness and confidence in raising high density orchards. The only way to increase productivity is to intensify mango cultivation and adopt high density planting system with improved irrigation and fertigation management. With this in view, JISL initiated a demonstration project in 2011-2012, established >200 demonstration UHDP orchards in Chittoor district of Andhra Pradesh where the highest concentration of Totapuri orchards are observed and later extended the project in all the four southern states and central state of Maharashtra in India. JISL is the only organization in the country which has invested quite a large funds and supported its research and extension team in educating farmers in improved agro-techniques and expose them to latest technologies. The observations and result of the extension project and farmers' response to the project will be the next topic for publication.

Application of research: UHDP technology developed and reported in the paper is of direct use to several farmers in India and other Mango growing countries.

Research Category: Applied Horticulture Science

Abbreviations: UHDP - Ultra High Density Plantation, PBZ – Paclobutrazol

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