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Density Concept of Orcharding

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Abstract

Density planting, a new concept in orchard planting throughout the world, refers to the maximum utilization of available space by accommodating maximum number of fruit plants per unit area to achieve maximum production of quality fruits within short period with low growing cost. Fruit plants come into fruiting very early, often in second or third year after planting, as compared to standard trees which come into bearing 5-6 years after planting. Maximum utilization of land and solar energy can be done by accommodating more number of plants per unit area through different systems of density planting. Closer planting and maintaining reachable canopy. On the basis of degree of dwarfness or tallness of plants and agronomical factors, planting densities may be of following types: low density planting, medium density planting, high density planting, and ultra density planting. For high density plantation some technique and tips we followed such as pruning, thinning, modern harvesting operations etc.

Keywords: *Density, Orchard, Fruits, Yield*

Introduction

High density in fruit crops has been pioneered for temperate fruits in Europe. First planted in Europe at the end of 1960. HDP is defined as planting at a density in excess of that which gives maximum crop yield at maturity if the individual tree grows to its full natural size. In other words, it is the planting of more number of plants than optimum through manipulation of tree size. HDP is one of the improved production technologies to achieve the objective of enhanced productivity of fruit crops. Yield and quality of the produce are two essential components of the productivity. HDP aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without impairing the plant health.

Principle of HDP

- To make the best use of vertical and horizontal space per unit time and
- To harness maximum possible returns per unit of inputs and resources.
- Increased capture sunlight per unit area.
- Land use efficiency.
- Appropriate vegetative reproductive balance of the plants

Key aspects of HDP in fruits:-

The HDP can be with one species (mono species) or with different species (multi species, multi storied) of crops. The mono species HDP basically comprise the planting of small tree densely, restricting their vegetative growth by using dwarfing rootstock, bioregulators or other horticultural technique such as pruning thereby, diverting much of the plant energy to the economical part. In the multi species HDP, the interception of incident solar radiation at different tiers by canopies of various species based on their light transmission characteristics and shade tolerance are exploited. Fi Important components of HDP are-

- Planting system
- Canopy management
- Use of dwarfing rootstock/interstock
- Training and pruning
- Shoot pruning
- Root pruning
- Use of growth regulators

These components are harnessed in HDP which help in attaining the goals. At present majority of temperate fruit orchards in Europe, America, Australia, New Zealand, Israel and Japan are under intensive systems of fruit production. There are several fruit crops where success on their HDP has been achieved, e.g. apple, peach, plum, sweet cherry, pear among temperate fruits and banana, pineapple, papaya among tropical fruits. In India HDP technology has been successfully tried in banana, pineapple, papaya and recently in mango, guava and citrus especially Kinnow.

High Density and Meadow Orchard planting in fruit crops

High density planting technique is a modern method of fruit cultivation involving of fruit trees densely, allowing small or dwarf tree with modified canopy for better light interception and distribution and ease of mechanized field operation.HDP and meadow orcharding gives higher yield as well as return/ unit area. It is possible by regular pruning and use of bio regulators for maintaining the size and shape of the tree. It is well known that the diversity in soil and climate conditions in India permits growing of a large variety of Tropical, Subtropical and Temperate fruits in different regions, due to which India is regard as a horticultural paradise. In recent years, the concept of fruit production is undergoing a change where

emphasis is being given to higher production per unit area.

High density planting or meadow orchard system is the fastest way of reducing the gestation period and increasing the productivity of the orchards. The choice of the system of planting in the orchard depends on topography, crop variety, plant density, production technology to be followed.

Table1. Comparison between Traditional system and HDP/Meadow system of fruit growing

S..No.	Attributes	Traditional system	HDP/Meadow system
1.	Tree numbers	Few large trees/ha (150-200 trees/ha)	Many small trees/ha (500-1,00,000 trees/ha)
2.	Bearing	After two years	From first year
3.	Production	Lower yield	Higher yield
4.	Management	Difficult to manage due to large tree size	Easy to manage due to small tree size
5.	Labour requirement	Requires more labour	Requires less labour
6.	Production cost	Higher cost of production	Lower cost of production
7.	Harvesting	Difficult	Easy
8.	Quality	Large canopy, poor sunlight penetration and Poor quality fruits.	Small canopy, better air and Sunlight penetration, mini. disease incidence and high quality fruits with good colour development

Factors Affecting HDP

Factors responsible to effect the choice of plant density in various fruit crops includes Cultivar ,System of Planting, Planting material, Nutrition and moisture, Economics of production etc.

Plant Architecture in HDP

Plants for high density should have more number of Fruiting branches and minimum number of structural branches. These branches should be so Arranged and sized that each branch cast minimum shade on other branches. Plant architecture is influenced by the method of propagation, rootstock and spacing.

Desirable Architecture of Temperate Fruit Plants can be developed as follows-

- Prevent upright growth and develop horizontal laterals.
- Space small laterals along the central leader.
- Develop and maintain fruiting spurs along entire branch as it develops.
- .Develop rigid, strong,self supporting laterals.
- Maintain fruiting branches in one position.
- Develop fruiting spurs along the sides rather than top or bottom of lateral branches.

Concept of high density planting and meadow orcharding in fruit crops-

Accommodation of the maximum possible number of the plant per unit area to get the maximum possible profit per unit of the tree volume without impairing the soil fertility status is called the high density planting. Meadow orchard system is a new concept of planting which has been developed in guava for the first time in India at CISH Lucknow. The meadow orchard is a modern method of fruit cultivation using small or dwarf tree with modified canopy. Better light distribution within tree canopy increase the number of well illuminated leaves. Fertilizer dose, spacing, growth regulation by the training and pruning, use of the mechanical devices etc may also be tried either singly or coupled with other crop management practices concept. It also promotes rate of photosynthesis that leads to high yield per unit area. Basically, the availability of a dwarf plant is the first and foremost prerequisite for establishing any high density or meadow orchard.

Table2. Successful stories in high density orcharding in India

Successful stories in high density orcharding in India				
Crop	**Spacing**	**Planting density/ Plant per hectare**	**Yield t/hectare**	**% increase over traditional methods**
Mango cv. Amarpali	2.5m x 2.5m	1600	19.2	250
Citrus(Kinnow)	1.8m x1.8m		20	200
Banana	1.4m x1.4m	3000	145.44	250
Pineapple	25cm x35cm x90cm	4444	90.0	200
Guava	1m x 2m	6400	50	250
		5000		

Methods of HDP

High density can be achieved by close planting which in turn is made possible through Control of tree size or planting in a system which accommodate more number of plants. Manipulation of tree vigour is an important prerequisite for success of high density planting in any fruit crop. High density of fruit orchards is generally achieved by controlling the size of tree or through improved planting system.

Tree size can be controlled by applying different methods such as - Use of genetically dwarf scion cultivars, Use of dwarfing rootstocks and inter stock Training and Pruning, Use of growth retardants, Induction of viral infection, Use of incompatible rootstock, and Use of genetically dwarf scion cultivars etc

Use of Dwarfing Rootstock-

While Standard plantation on standard apple rootstocks (MM106) at 5x5 m accommodate 400 plants/ha, The Non spur type cultivar on dwarf rootstock M9 spaced at 2 x 2 contain 2500 plants /ha. The density of Spur apple cultivar on standard rootstock MM111 at 4 x 4 m and semi dwarf MM106 and M7 at 3x3m accommodate 1111 plants/ha.

Training and Pruning

Training and Pruning are effective tools in HDP and meadow orcharding by virtue of their impact on shape and size control of the tree. Slow growing trees respond more favourably to pruning and training and can be maintained at a given size and shape without sacrificing yield. Mango, guava, litchi and most of the other fruit crops in India are evergreen and are seldom pruned. The training begins when the tree is first planted and continues throughout its productive life. Proper tree forms, branch angle and limb spacing in it aids in growth control. First training is done after one growing season. Each plant is allowed to maintain single stem with upward growth up to 60-80cm and then four scaffold branches are allowed in four directions to make the tree frame. Thereafter, two shoot arising from each primary branch at a distance of 60-75cm from main stem is allowed to form secondary and likewise the tertiary branches. After start of bearing in plants, shoot arising from secondary and tertiary branches are given 15-20cm deep pruning soon after fruit harvest. Spray of 01% urea combined with 0.2% Blitox-50 or any other copper fungicide should be done soon after pruning. Pruning is applied to regulate crop in guava, ber and fig, and rejuvenation of old orchards in mango. Tree size control through pruning is limited to grape, apple and some other temperate fruits. Spindle bush raised on M9, M7 and M4 rootstocks is a promising training system for HDP.

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Table 3. Dwarf scion varieties

Crop	Dwarf cultivars with Desirable features
Apple	Spur varieties like Red Chief, Oregon Spur Bear on short stem, spurs; grow to 60-70 % of standard cultivars in vigour and bear more spurs and yield more
Mango	Amarpalli Precocious & tend to bear regularly
Banana	Dwarf Cavendish (AAA) High yielding with dwarf stature
Cherry	Compact Lambert, Meteor and North Star High yielding, self fruitful Dwarf
Papaya	Pusa Nanha Dwarf & tend to bear at lower height
Peach	Red heaven Dwarfing & high yielding
Sapota	PKM1 PKM3 Columnar tree shape Dwarf tree stature

Table 4.Dwarf Rootstock Varieties

Crop	Dwarfing Rootstock
Apple	M9, M26, M27(Ultra dwarfing), Bud.9, P22 & Ottawa3
Ber	Zizyphus rotundifolia
Citrus	Citrangequat, Feronia and Severinia buxifolia, Trifoliate orange, Sour orange, Citranges
Guava	Psidium friedrichsthalianum,P. pumilum,,Aneuploid-82
Mango	Vellaikolumban(Alphonso),Olour(Himsagar, Langra)
Pear	Quince C
Peach	Siberian C, St Julien X, Prunus besseyi and Rubira
Plum	Pixy Cherry Colt and Charger

Planting Density:-

Enough though a small canopy with a high number of well illuminated leaves is efficient in photosynthesis but it is very poor in light interception, which leads to low potential yield per hectare. Light interception could be improved by increasing tree density. An optimum tree density is the level of density which is required to facilitate optimum light distribution and interception leading to high photosynthesis. As a result, yield per hectare is maximized. An optimum light interception is a factor of plant form, planting density, tree arrangement, and leaf response to light for photosynthesis. Optimum light interception can be defined as a level of light intercepted by an orchard system above or below which,the economic yield will be reduced

Planting Geometry:-

Planting system is a combination of tree arrangement and plant form. Tree arrangement in HDP system must have sufficient alleyways for movement of farm machinery. The way tree are arranged also determines the light distribution pattern and light interception level. Single hedge row and double hedge row system and square system having enough alley space is being practiced in developed countries for HDP.

Mechanization:-

Another component in high density fruit planting is the system automation which contributes to high production. One of the important farm operations that can be automated is irrigation and fertigation vis- a-vis indiscriminate mechanical. In fact, irrigation and fertigation have been identified as one of the key factors for the success of high density orchards. Plant should not be kept under stress after pruning therefore, assured irrigation coupled with fertigation is essential after pruning and during fruit development in high density orchards.

Use of Growth Retardant

Use of Bio-regulators can Prolong dormancy**,** Reduce vegetative growth**,** delay Flowering**,** Reduce fruit drop etc.Commercially adopted Growth retardants are CCC, Ancymidal, Paclobutrazol , B-9 (Phosphon D) and chloramquat. Paclobutrazol have gained commercial application in crop regulation in mango. Tree size can be reduced by inducing viral infection e.g. Citrus, apple, but not adopted commercially. In apple, virus free rootstock series East MaIling Long Ashton (EMLA) are vigorous than their infected counterparts.

Use of Incompatible Rootstocks

Use of graft incompatible scion and stock also induces dwarfness in the composite plant. It is not commercially exploited for this end. In ber, cultivars

on Zizyphus rotundifolia, Z. nummularia induces dwarfness due to graft incompatibility.

Planting Systems

Planting Systems Aimed to achieve high assimilated production for its conversion into economic yield. Various planting systems adopted in fruit crops areSquare, triangular, quincunx, rectangular, hexagonal, hedgerow (single & double), paired planting and cluster planting. Square and triangular systems are followed for HDP in mango, Kinnow, banana, papaya and Hedge row system in apple and pineapple in India. Planting systems accommodating various number of plants in cultivar starcrimson on MM109 rootstock are square(1116), paired(1480), hedgerow(1860),cluster planting(1948) and double hedge row(2480).

Impact of HDP:-

In mango, Amrapali at 2.5x 2.5m in triangular system accommodation of 1600 plants and Dashehari at 3.0 X 2.5 m in square system 1333 plants per hectare, Increase in yield per hectare was 2.5 times in Amrapali than that of the low density orchards of vigorous cultivar. In Dashehari mango, the average yield in high density is reportedly 9.6 tonnes compared to 0.2 tonnes in low density planting. This yield can further be improved in alternate bearing cultivars like Dashehari, Chausa and Bombay Green through the application of growth retardant like Paclobutrazol. In Citrus, Kinnow on Troyer Citrange and Karna khatta rootstocks could be planted at 1.8 x1.8.m and 3x3 m to accommodate 3000 and 1088 plants per hectare, respectively. In pineapple, population density of 63758 per hectare coupled with improved package of agro techniques result in increase in yield from 15-20 to 70-80 tonnes/ha.

Table 5. Spacing at different planting system in fruit crops-

Sr.No.	Crop	Normal spacing(m)	HDP spacing(m)	Meadow spacing(m)
1	Mango	7.5 X 7.5 - 12.5 X 12.5	3 X 2.5 – 5 X 5	2.5 X 2.5 - 3 X 1
2	Banana	2 X 2 - 2 X 3	1.5 X 1.5 - 1.8 X 1.8	1.2 X1.2 - 3 X 0.5
3	Citrus	6 X 6 – 8 X 8	3 -6 X 3 -4.5	-
4	Papaya	2 X 2 – 3 X 3	1.8 X 1.8	1.2X1.2 - 1X1
5	Guava	6 X 6 – 8 X 8	3 X 3 – 3 X 1.5	2X2 - 2X1
6	Sapota	10 X 10	5 X 5	-
7	Aonla	10 X 10	5 X 5	-
8	Apple	10 X 10	3 X 0.75	3 X 0.37 - 0.60

Different Types of Planting:-

Low density planting:-

Non intensive system, age old planting system, trees planted at wide spacing, accommodating about 100-250 plants/ha. Dwarfing rootstock not used. Tree acquire commercial production potential after 10-15 years of planting. Output from orchard during early 10-15 years is less. Less input and care intensive, hold popularity among growers.

Medium density planting:-

Highly minimized distance covering 250-500 plants/ha.Proper pruning undertaken to manage tree in desirable shape. More care, intensive labour requirement is more, obtained yield is more, lead in output reliable growers to produce amenable fruit crops like pomegranate, citrus, guava, papaya, banana etc.

High density planting:-

Very condensing planting with 500-10,000 plants/ha depending on fruit crop, relies heavily on rigorous training and pruning. Maintenance of pruning is very heavy. Dwarfing rootstock and chemicals also used in this system. Yield as well as expenses per unit area is high

Medium high density:-500-1500 plants/ha

Optimum High density: - 1,500-10,000 plants/ha

Ultra high density:- 10,000-1,00,000 plants/ha

Meadow Orcharding:-

Meadow grassland, also known as Ultra high density planting i.e, growing 10,000-1,00,000 plants/ha. In order to maintain tree form, severe top pruning is practiced similar to mowing of grassland. Plants intended to produce yield after two years.

Merits of HDP/Meadow:-

- Best utilization of land and resources.
- Higher yield per unit area with quality fruits.
- Facilitate better utilization of solar radiation and increase the photosynthetic efficiency of the plant.
- It is amenable to modern inputs application techniques such as drip irrigation, fertigation, mechanization etc.
- Early economic returns.
- Induces precocity, increases yield and improves fruit quality.
- Reduces labour cost resulting in low cost of production.
- Facilitates more efficient use of fertilizers, water, solar radiation, fungicides, weedicides and pesticides.

Demerits of HDP/Meadow:-

- High initial establishment cost than conventional system.
- Economic life span of the orchard becomes lower.
- Chance of reduction in fruit size and weight.
- Intercultural operation becomes difficult.
- Maintenance of plant architecture becomes a tedious job.
- Lack of standardization of production technology and extension of technical knowhow to the farmers.
- Lack of promising dwarfing rootstock in mango, guava, sapota, peach, sweet cherry etc.
- In apple, commercial utilization of dwarf rootstocks for tree size control in HDP is restricted due to their poor anchorage, occurrence of sloppy, shallow and rain fed lands and low fertility.
- High incidence of some diseases in HDP e.g. Sigatoka leaf spot & finger tip in banana causes hindering effect in HDP.

Conclusion:-

HDP and meadow orcharding gives higher yield as well as returns per unit area due to increasing the number of tree/unit area. It is possible by regular pruning and use of bio regulators for maintaining the size and shape of the tree. Mango planted at spacing of 5m x5m (Kesar and Alphonso) and 3m x 1m (Keit) gives higher yield under high density and meadow, respectively. Guava planted at spacing 2.5m x2.5m and 3m x6m under HDP and 2m x 1m under meadow gives higher production as well as more income in Allahabad Safeda and L-49. Citrus gives higher production when planted at 6m x 3m spacing under HDP. For HDP in banana is planted at 1.0m x 1.2m spacing gives better yield in cv.Rajapuri.

Future thrust:-

There is need to more research on time and intensity of pruning on each fruit crop. Screen the varieties having less canopy area and erect growth.Research on plant growth regulators for increasing yield and improving quality under high density planting as well as meadow orchard system. Need more research on development of meadow orchard in each fruit crop .

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