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Economic Analysis of High Density Orchards

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ABSTRACT

High density orcharding is one of the novel concept of increasing productivity without altering the quality of the fruits. The introduction of high density planting may well be one of the most important changes in fruit production practices. These orchards are capable of producing early and sustained yields of quality fruits. Crowding of plants is now considered an assured way of having a high production. No doubt, HDP orchards require significantly higher investments compared to the conventional orchards but they could provide earlier and better returns on invested funds. These early returns erode interest cost that can greatly impact the profitability and feasibility of the orchard investment. High density planting is highly precocious starting bearing from second year of planting and reaches full production in the 4th year which results in early pay back period as compared to conventional orchards. Apart from this, HDP has the highest ratio of A grade (>80%) fruits which are better both in terms of quality and price. Therefore, the way out for increasing the yield, productivity and quality of fruit is by shifting to high density orcharding.

Keywords. High density planting, high production, precocious, pay back period, quality

I.INTRODUCTION

India is the largest producer of fruits in the world after China. However, the average productivity of fruits in India is low (10 ton/ha) as compared to many developed countries (60-70 ton/ha) and its main reasons are old and senile orchards, low yielding varieties, poor orchard management and inadequate technological upgradation. Presently the continuing decline in the availability of cultivable land, rising energy and land costs together with mounting demand for horticultural produce has given thrust to the concept of high density planting (HDP).

High density planting (HDP) means to increase the plant production per unit area for increasing the production of fruit crops. It is also 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. It is the system in which a higher number of plants of same or different crop species are accommodated within a unit area in comparison to the conventional planting density so as to obtain maximum output by utilization of land, light and externally applied inputs viz, nutrients, water, pesticides, etc. The exact limits of the plant density to be termed as high density is not yet well defined. It varies with the region, species, varieties, rootstock, cost of planting material, labour and the likely return from the orchard and agro-techniques adopted for a particular crop.

Plant density needs to be designed to intercept solar radiations effectively keeping in view cultivar, soil fertility, climatic conditions, moisture level, planting system, planting material, management level and economic considerations. HDP aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without impairing the plant health. To overcome low productivity and long gestation period for early returns. The conventional systems of planting having a long juvenile period, are labour intensive and low yielding with poor-quality fruits, whereas high density orchard is more efficient orcharding system. It is precocious, easily manageable, has higher potential, with better quality fruits and higher returns /unit area. The purpose of this review to investigate the published literature as it relates to economics of high density planting and propose guidelines that make future research even more useful to commercial fruit growers.

II.HISTORY OF HIGH DENSITY ORCHARD

The conceptual background of High Density Planting (HDP) reveals that it was pioneered for temperate fruits in Europe. There has been a steady increase in tree planting density over the last 50 years from 70 trees/ ha to > 6000 trees/ha. High density orchards were first planted in Europe at the end of 1960 and since then there is a decline in traditional orchards with low densities. Heinicke (1975) developed Central Leader system in North America and this system was planted at a density of 300-700 trees/ha utilizing semi dwarfing rootstocks and was widely adopted. But in many cases as central leader trees aged, the upper limbs outgrew the bottom of the trees resulting in excessive shade in the bottom of the trees which reduced flowering and fruiting in the center of the tree. During the late 1970's and early 1980's a significant number of growers in the USA began planting more compact trees on M.9, Mazzard, Quince rootstocks at much higher tree densities (1000-1500 trees/ha) to achieve higher early yields. A significant trend in the late 1980's was to increase planting density in Slender Spindle orchards to improve light interception and thereby improve both early and mature yields (Oberhofer, 1987). Another more successful approach to improving yield in the late 1980's was to grow taller trees (3-4m high) by using Vertical Axis system (1000- 1500 trees/ha) developed by Jean Lespinase (1980). During the early 1990's much higher tree densities between 4000-6000 trees /ha were tested in single rows in either a vertical tree shape or V-shape. A more narrow tree form was developed which was named the Super Spindle system (Nuberlin, 1993) and this system had extremely high early yield and excellent fruit quality. Another significant trend during the late 1980's and 1990's was greater emphasis on the use of highly featured trees to obtain significant yield in the second year after planting. At the end of the century there was a great disparity of opinion among growers on which system was the most profitable with some growers using densities above 5000 trees/ha and some growers continuing to use densities below 500 trees/ha with the majority of growers planting densities in between.

III. CATEGORIES OF HIGH DENSITY ORCHARD

There are following categories of high density orchards:

1.1 **Low Density Planting (LDP):** It accommodates 100 plants/ha and there is no use of dwarfing rootstocks, minimum training and pruning, trees come into commercial production potential after 10-15 years and yield during early years was very low.

1.2 **Medium Density Planting (MDP**): It accommodates 250-500 plants/ ha. It requires proper pruning, gives more yield and quality fruits and have long productive life.

1.3 **High Density Planting (HDP):** It accommodates more than 1000 plants/ha. It requires rigorous training and pruning, dwarfing rootstocks and chemicals to maintain optimum growth. Here both yield and expenses are higher and establishment and maintenance of HDPs requires technical backup.

1.4 **Ultra High Density Planting (UHDP):** It accommodates more than 2000-5000 plants /ha. It requires severe pruning and training, proper canopy management, chemical assistance and nutrient management and also requires technical backup.

1.5 **Super High Density Planting (SHDP):** It accommodates more than 10,000-40,000 plants/ha. Here severe top pruning is practiced similar to mowing of grass land, heavy use of growth regulators as well as judicial canopy management and tree yields after 1 or 2 years after planting. In apple, 10000 plants/ha can be accommodated at a spacing of 1 x 1m.

IV.PRINCIPLES OF HIGH DENSITY ORCHARD

1.1 Obtaining maximum productivity through planting more number of fruit trees per unit area.

1.2 To make the best use of vertical and horizontal space per unit time.

1.3 Optimizing the exploitation of natural resources like land, air, solar energy and water.

1.4 Getting higher yield of quality fruits.

V.CHARACTERISTICS OF HIGH DENSITY ORCHARD

1.1 The trees of HDP should have maximum number of fruiting branches and minimum number of structural branches.

1.2 The trees are generally trained with the central leader surrounded by nearly horizontal fruiting branches (feathers).

1.3 These branches should be so arranged and pruned in such a way that each branch casts a minimum amount of shade on other branches

VI.COMPONENTS OF HIGH DENSITY ORCHARD

HDP 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/size is an important pre-requisite for success of HDP in any fruit crop. High density of fruit orchards is generally achieved by controlling

the size of the tree or through improved planting systems. The following methods are applied to control the size of plants in high density planting:

1.1 Use of genetically dwarf scion cultivars:

The genetically dwarf cultivars offer a great scope for close planting. Such varieties are limited in number and available only in few crops e.g. spur bearing varieties in apple (Silver Spur, Gold Spur, Super Chief, Red Spur etc) and cherry (Compact Lambert and North Star).

1.2 Use of dwarfing rootstock: Unlike the temperate fruits wherein this technology was first adopted with the use of rootstocks, spur bearing varieties and training and pruning, the choice of rootstock and dwarf varieties is limited in tropical and sub-tropical crops. The dwarfing rootstock of some of the fruits are given e.g. apple (M9, M26, M27, B9, B146, P-22 etc), cherry (Gisela 3, G5, G12, Colt etc), pear (Quince A, Quince C, Knee Eline etc) and plum (Pixy).

1.3 Pruning and training: It is well known that a pruning in any form has a dwarfing effect on the trees. Slow growing trees respond more favorably to pruning and training and can be maintained at a given size and shape without sacrificing yield. Tree size control through pruning is limited to grape, apple and some other temperate crops. Of the various training systems being followed in apple eg. Spindle Bush, Dwarf Pyramid, Espaliers and Cordon raised on M8, M7 and M4 rootstocks found to be promising training systems for HDP.

1.4 Use of growth retardants: Various growth retardants have been used to restrict the vegetative growth of the plant eg. AMO 1618, CCC, Ancymidal, Paclobutrazol, Phosphon D and Chloramquat.

1.5 Induction of viral infection: Though not commercially adopted, tree size can be reduced by inducing viral infection eg. Citrus, apple. In apple virus free rootstock series East Malling Long Ashton (EMLA) are vigrous than their infected counterparts**.**

1.6 Use of incompatible rootstocks: The use of graft incompatible scions and stocks also induces dwarfness in the composite plants eg. Ber

VII.INITIAL PLANNING OF HIGH DENSITY PLANTING

There are many interlinked decisions that need to be made during initial planning for an intensive system that are critical to ensuring success. These decisions will be influenced by a range of site, economic and management factors. The factors vary from orchard to orchard. Making the right choices about intensive system establishment and management depends on growers having a good understanding of the financial commitment and risks associated with intensive production. Management commitments need to ensure maximum potential for high annual yields beginning as early as possible in a new orchard's life. Growers must understand the importance of integrating technical aspects (variety x rootstock x planting system x management regime) for best orchard outcomes. These include

1.1 Financial commitment

The higher cost of establishing HDP are due to higher tree numbers and higher cost of trees, installation of trellis/ support system, more intensive management during establishment years and possible cost of interest on borrowed money to establish support systems

1.2 Management commitments

It includes paying attention to the quality of planting material, ensuring optimal site preparation and tree planting, tree nutrition, irrigation and pruning and training.

1.3 Choosing the right combination

It includes choosing the right combination of rootstocks, varieties, planting system, management options, soil fertility and climate

1.4 Risks

The biggest financial risk with HDP system is crop failure, particularly in the early years of establishment. There may be range of reasons for crop failure including extreme weather or poor management decisions. Failure to produce early yields will not only have an immediate financial impact but may also affect yield production in subsequent years. It is crucial that orchards have risk management options in place from the beginning. This is particularly important for risks that growers have less control over e.g. extreme weather events associated with ongoing climate change. So planning for HDP should include provisions for managing the risk of crop loss, such as hail netting, frost fans and overhead irrigation for evaporative cooling.

VIII.INFLUENCE OF HIGH DENSITY PLANTING ON, YIELD, PAYBACK PERIOD AND QUALITY

1.1 Apple

Badiu *et al.* (2015) studied evaluation of economic efficiency of apple orchard investments and found that the most efficient technological system is the super-intensive one. This is explained by the fact that the system begins producing from the second year, that it is the most productive, and that it has the highest ratio of Extra Class apples (more than 80%), which are better appreciated on the market (both in terms of quantity consumed and in terms of premium price).

Clements (2011) analyzed mini' apple orchard systems trial: a comparison of central-leader, vertical-axis, and tall-spindle apple orchard systems on three different rootstocks and found that the tall-spindle (TS) system planted on B.9 rootstock had the highest cumulative yield (1202 bu/acre) of Honeycrisp fruits during the 3rd, 4th and 5th seasons. In fact, cumulative yield was almost twice that of the vertical-axis system.

Robinson *et al.* (2007) observed an economic comparison of five high density apple planting systems and found that the greatest profitability was with the Slender Axis system ($23,900), followed by the Tall Spindle ($23,400), Super Spindle ($19,200), Vertical Axis ($17,100), and least for the low density Slender Pyramid system ($9,000).

Cahn and Goedegebure (1992) studied the economic aspects of apple production in relation to tree density and results showed that long term profitability of apples increased with increased tree density upto 5000 trees/ha. In addition, payback period (4th year) analysis decreased with increased tree density.

1.2 Mango

Kerutagi et al. (2017) analyzed the comparative economics of traditional viz high density mango cultivation in Karnataka and observed that in high density orchard, the average yield obtained was more (7.86 t/acre) than in traditional orchard (3.50 t/acre).

Gaikwad *et al.* (2017) studied the effect of spacing on growth, yield and quality of mango and observed that highest fruit yield (21.4 MT) was produced in closer spacing of 5 x 5m in cultivar Kesar.

Rajbhar *et al.* (2016) observed the performance of high density planting of mango (*Mangifera indica L.,)* under mid-western plain zone of Uttar Pradesh and found that after 11 years, the yields of the plots planted at 1111 trees per ha were more than ten times the yields of plots planted at 100 trees per ha (59 t/ha versus 5.9 t/ha).

1.3 Pear

Robinson (2010) studied high density pear production: an opportunity for NY growers and noticed that the extremely high planting density of the Super Spindle achieved a yield of 1,000 bu/acre in the 4th year and has continued to be productive indicating good long profitability followed by Tall Spindle having the moderate planting densities which also had high yields but with lower initial investment cost also have greater economic profitability.

Elkins *et al.* (2008) observed the economic evaluation of high density versus standard orchard configurations; case study using performance data for Golden Russet Bosc pear and noticed that a high-density planting came into production sooner, showing a profit after six years compared nine years for the traditional planting and the cost of establishing the orchards were recovered after ten years in the high density planting compared with twenty one years for the traditional planting.

1.4 Cherry

Whiting *et al.* (2005) determined rootstock and training system affect sweet cherry growth, yield and fruit quality because 'Gisela 6' rooted trees were the most productive, yielding between 13% and 31% more than 'Gisela 5'rooted trees and 657% to 212% more than Mazzard-rooted trees, depending on the year. Both 'Gisela 6' and 'Gisela 5' were significantly more precocious than Mazzard and induced fruiting two years after planting. They also found that cumulative yields of 'Gisela 6', 'Gisela 5' and Mazzard rootstocks were 136, 108 and 42 Kg respectively.

Manolova & Kolev (2007) examined economic results from growing of cherry in different levels of intensification and the trial showed that experimental fields on rootstock P. Mahaleb started yielding on the fifth year (4200 Kg/ha) and reached full fruit-bearing on the eighth year (21000 Kg/ha) while as rootstock 'Gisela 5' began to yield on the third year (7500 Kg/ha) and reach full yielding on the fifth year (37500 Kg/ha) respectively.

Seavart and Long (2009) noticed financial and economic comparison between establishing standard and high density cherry orchard and found that the full production yield is 13,450 kg per ha in a standard-density orchard

and 15,243 kg per ha in a high-density orchard. The break-even year in which gross income covers all previous years' economic costs is year 8 for the high-density orchard and year 15 for the standard-density orchard.

1.5 Plum

Milosevic *et al.* (2008) noticed a comparison of low-density and high-density plum plantings for differences in establishment and management costs, and in returns over the first three growing seasons – a mini-review and found that in the low-density planting, initial fruit bearing was attained by the end of the third growing season and a modest yield of 1.2 kg plum fruit per tree (399.6 kg ha–1) was obtained, producing a low gross income of € 79.92, representing just a 2.0% return on investment, when considering the average market price of € 0.2 kg–1 plum fruit in the years of study whereas in the high-density planting resulted in yields of 6.6 kg plum fruit per tree (8,250 kg ha–1) in total over the first three growing seasons, producing an income of € 1,650.This represented a 21.3% return on investments associated with the establishment and maintenance of the high-density plum planting over the first three growing seasons.

Meland (2005) studied high density planting systems of European plums-the effect of growth and productivity of three cultivars after nine years and proved that the Y-trellis system is an efficient way to increase both early and cumulative yield.

1.6 Almond

Kumar *et al.* (2012) analyzed studies on high density planting in almond in Kashmir valley and found that maximum nut yield was recorded in higher plant density (4.01 t/ha) followed by medium density (3.06 t/ha) and minimum in lower plant density(2.54t/ha).

1.7 Peach and nectarines

Zec *et al.* (2015) studied influence of planting density on yield of peach and nectarine and found that in a dense planting all cultivars achieved significantly higher yield per unit area (22,120 t/ha) and reach full bearing earlier compared with semi-dense planting(20,500 t/ha) and standard-density planting(14,312 t/ha).

IX.CONCLUSION

Horticulture sector provides excellent opportunities in raising the income of the farmers and also provides higher unit productivity. With this background in the mind, an attempt was made to assess the economics of fruit cultivation. This review implies that fruit cultivation was more attractive in high density compared to traditional method because of reduced cost of labour resulting in low cost of production, facilitates better utilization of solar radiations and increase in bearing surface per unit land area. Finally, it was concluded that high density planting resulted in increased yield, induces precocity and improves fruit quality.

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