Orchard Systems–Conditions for Success

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ABSTRACT

A successful high density orchard should start cropping early and give annually a production of high amounts of high-quality fruit in an economically justified way. For such a system, some basic conditions with regard to light interception and distribution need to be fulfilled and sound decisions are needed on orchard design and management. Strategic decisions concern the choice of planting system, cultivar and rootstock. Tactic decisions comprise the type of plant material and tree establishment and operational decisions the methods of thinning and pruning in the first years.

For the full text of this paper, including relevant literature references, the reader is referred to the volume of *Acta Horticulturae* published on the occasion of the symposium of the International Society for Horticultural Science (ISHS) Working Group on Orchard and Plantation Systems held January 30 to February 4, 2000, in Nelson, New Zealand, just before the IDFTA meeting held in Napier, New Zealand.

INTRODUCTION

Worldwide new apple and pear orchards are planted more intensively than a few decades ago. Reasons for this trend toward high density planting (HDP) are universal: earlier return on capital, economizing on labor input and producing a high amount of quality fruit. Within limits, intensive orchards render more chance to achieve these goals than more extensive ones. Apples and pears are grown under a wide range of environmental and socio-economic conditions, with quite a number of scion and rootstock cultivars. This rules out a single recipe that meets all these numerous conditions. However, basic conditions need to be fulfilled everywhere to make a successful HDP. First, light interception by and light distribution within the canopy must be guaranteed by sound strategic decisions with regard to planting system, tree shape and cultivar-rootstock combination. Second, the right tactic decisions must be taken with regard to the plant material and measures and equipment needed for tree establishment. On the level of operational decisions, thinning and pruning practices are important, especially in the first years after planting.

LIGHT INTERCEPTION AND DISTRIBUTION

Apple production is linearly related to light interception up to 90%. However, to ensure regular production of sufficient fruit quality, it is sensible to aim at lower levels of light interception; 70% seems optimal for various locations. For pear, a maximum of 65% light interception seems better. With a same level of light interception, V-systems or Y-trellis may produce more quality fruit than standard single rows. This is due to the less uniform light distribution in rectangular arrangements in common single rows. Here relatively large differences in light occur between tree row and alley. In an ideal orchard, light should be evenly distributed under tree rows and alleys and be around 60-70%. In practice, however, this is not the case and even in successful orchards light-interception levels vary from 80% in the row centers to 40% in the alley centers.

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PLANTING SYSTEMS AND TREE SHAPE

Apple and pear orchards are planted over wide ranges of densities and systems. Higher densities usually intercept more light than lower ones although, in mature orchards, differences may be small due to adapted pruning. A higher growth/vigor level allows lower densities and vice versa. This is one reason why in colder regions at higher latitudes higher densities are needed to obtain similar levels of light interception compared to warmer areas at lower latitudes. In addition, small trees at high densities achieve the necessary better-illuminated canopies than large trees do at lower densities. For northern Europe, it seems that systems on M.9 with densities between 3,000 and 6,000 trees/ha (1200 and 2400 trees/acre) are optimal for quality production. These systems fill their space in about 3 years provided the plant material and growing conditions are good. Densities beyond 6,000 trees/ha are unattractive for economical reasons, certainly when they surpass the optimum light distribution.

Although pear lacks a really dwarfing rootstock, trees can be kept small quite well by cultural measures and thus densities may also be high. On Quince rootstocks, successful plantings occur with densities up to 4,000 trees/ha (1600 trees/acre) and with cordons even much higher densities can be good. The positive experiences with Y-systems at 3,000 trees/ha (1200 trees/acre) with four-leader trees or V-systems with 12,000 single-stem cordons illustrate this.

Sub-optimal light interception of single rows in apple orchards may be compensated by increased tree height. Light interception may increase with about 10% per m increase of tree height, provided that the leaf area per unit canopy volume is similar. In practice, effects on light interception are smaller because higher trees are often kept more open. Under such conditions, higher trees may produce better fruit quality than smaller, more compact trees.

CULTIVAR CHOICE

Indirectly, cultivar issues may affect future HDP choices, first, due to consumer attitude and, second, the flooded apple market. Consumers will be constantly in for something new and become more exacting with regard to restricted use of chemicals and to fruit quality aspects as appearance, fruit firmness and shelf life. Thus, cultivars requiring few chemicals, with attractive, firm fruit and good keeping qualities will get preference. This will lead to a more rapid turnover of cultivars.

Growers who wish to go along in time with new cultivars need short orchard cycles and, within limits, intensive orchards fulfill this requirement easier than extensive ones. Second, apples have to be sold in a congested market and thus only the best quality will stand a chance. Hence, there will be more need for systems that allow the highest production of top quality than for systems that excel in great total quantities. Consequently, light interception should never exceed 70%, of course combined with an excellent light distribution within the canopy. Price levels for apples will probably remain low in the near future. This affects the profitability of HDP in a negative way, and more so for ultra-high densities than for normal ones. Tree density must be chosen with care, not too low but certainly not too high either.

ROOTSTOCK CHOICE

Dwarfing and efficient rootstocks are needed for HDP. In apple, these conditions are met with rootstocks in the vigor range between M.26 and M.27. M.9 is the best known example with vigor midway in that range. With trees on M.9 and M.27 up to 70% of the total dry matter formed is invested in the fruit. The universal advance of M.9 illustrates the increasing wish for an efficient dwarfing rootstock.

Although M.27 is equally efficient, it can be used only on very vigorous soils. Within limits, at lower latitudes tree vigor needs to be somewhat greater than at higher latitudes. In the former, a layer of leaves around the fruiting zone of the trees is needed to protect the fruits from sunburn. This may lead to a slightly more vigorous rootstock than M.9. Alternatively, in these areas more invigorating pruning is needed.

For other reasons, too, M.9 and M.27 cannot be used everywhere. First, spur-type cultivars need a more vigorous rootstock than standard-type cultivars. Second, neither M.9 nor M.27 are considered winter hardy enough in some areas, although M.9 is perhaps not that sensitive. In cold areas, hardier but similarly vigorous and efficient rootstocks might be safer. Hardy alternatives for M.9 might be, amongst others, P.2, B.9, MAC.39 and V.3 and for M.27, P.22, P.81, B.146 and B.491, but experiences with these rootstocks are more limited than with both standards. Third, M.9 may not thrive at high soil temperatures. So, in hot areas alternative rootstocks may be needed as well. Fourth, M.9 is sensitive to woolly apple aphid and cannot be used in areas where this insect feeds on the roots. Combining more vigorous tolerant rootstocks, such as MM.106, with an M.9 interstem temporarily solves the problem. Resistant dwarfing rootstocks form an easier solution and some selections within the Japanese JM-series show promise. Fifth, M.9 is quite susceptible to fire blight, which precludes its use in some areas. In this regard, hope is set upon some new Geneva rootstocks.

Having stressed all limitations, it must be added that in some areas the value of dwarfing rootstocks like M.9 (and M.27) may have been underestimated due to improper management such as poor soil drainage, and inadequate weed control, water supply, tree support or thinning in the first years after planting. If this is all given more attention, it is likely that M.9 and even M.27 can be applied in a wider area than is current today. Good management is needed for all dwarfing rootstocks.

Within one rootstock, vigor may be adapted by cultural practices, allowing growers to stay with a trusted rootstock. High budding on a dwarfing rootstock reduces tree vigor and vice versa. Interstems on M.9 may also reduce vigor, an example being Summerred. Within M.9, a number of sub-clones exist. Most of these are quite similar in vigor and performance, but some induce less growth than others, such as M.9 Fl. 56. These measures can be utilized for bridging the too large vigor gap between M.9 and M.27. A simpler solution is use of a rootstock with a vigor in between, such as P.16.

For pear, no efficient dwarfing rootstocks are available. Quince rootstocks reduce vigor considerably more than *Pyrus communis* rootstocks and induce more precocity, but still are moderately vigorous, including MC, the least invigorating and most precocious quince. However, the tender Quince rootstocks cannot be used in areas with severe winters. More hardy Quinces are being sought and, although some hardy new selections are around, till now none have broken through. *Pyrus* rootstocks are hardy, but all (rather) vigorous, with the possible exception of the German Pyrodwarf and some new East Malling selections, but these have not yet been widely evaluated.

PLANT MATERIAL

For early return on capital, cropping should preferably start in the second leaf and continue to crop in the years thereafter. Precocity is most easily achieved when the trees possess a high number of more or less horizontal laterals and develop well in the first years after planting. So, nursery efforts should be directed to make a fair number of laterals. This requires a good growth level. Fresh and fertile land for every raising cycle is a must, as are ample planting distances and tree support. Regular attaching of the growing tips to the support is good practice. Repeated removal of the young leaves from the tips of the vertical stems and/or spraying the tips with benzyladenine compounds stimulate natural tendencies to form laterals.

To circumvent quality variations often encountered with 1-year-old trees, 2-year cut (snip) or interstem trees may be produced. In the nursery the single stem that arises from the scion bud is headed back (snip) in the next spring at heights between 50 to 80 cm (20 to 30 inches). Only the highest bud is allowed to grow out and usually grows out so vigorously that a strong vertical shoot arises, often well provided with laterals. On an interstem, similarly, a well-feathered tree may be obtained. Manual or chemical improvement of feather formation is possible with these tree types, too. Snip and interstem trees perform so much better than 1-year-old feathered trees of similar quality that they should have preference. Although formerly growers were satisfied with feathers arising at 50 to 60 cm (20 to 24 inches) above soil level, today slender spindle trees should have the lowest temporary laterals at 80 cm (32 inches) above the soil. Permanent fruiting branches should be inserted at 1 to 1.20 m (39 to 47 inches). A long trunk allows the fruiting branches to bend down without the disturbance of unwanted shortening.

With pear, well-branched 2-year-old trees satisfy as plant material for most HDP, either for slender spindles or Y-hedges with four-leader trees. For high-density cordon systems, 1-year-old nonbranched trees seem better.

Given the importance of early cropping and because plant-material costs are of minor importance for orchard economics, growers should not economize on this expenditure and should buy only good trees to start the orchard.

TREE ESTABLISHMENT

In apple HDP, the allotted space should be filled rapidly to ensure that the ceiling production level is quickly reached. In apple, replant problems may lead to inadequate growth. This harms profitability, particularly in case of high densities. Replant problems will become more frequent when orchard cycles become shorter. Biotic causes can be solved by soil sterilization, but the chemicals needed are not permitted everywhere. A solution for replant problems on light soils caused by nematodes is the use of nematode-suppressive cover crops, such as *Tagetes patula*. However, this takes a year. Filling planting holes with fresh, organic soil mixtures and providing the trees with adequate water by localized irrigation are remedies against the specific replant problems on heavier land. Enriching the irrigation water with nutrients adds improved flower bud formation, indispensable for a crop in the second leaf. As fertigation may have more consistent effects on growth than soil sterilization, it might become an environment-friendly alternative to overcome replant problems in apple. Planting new tree rows in the former grass alleys can further alleviate replant problems. So far, no gain in precocity has been achieved with fertigation in pear.

The quantity of water required for a good start will depend on tree size, soil and climatic conditions. More insight in the water requirements of newly planted trees is needed to get a good balance between growth and early cropping on the one hand and to avoid waste of costly water on the other. Granular Matrix Sensors, sold as ‘Watermarks,’ that easily measure soil water potential are being evaluated to establish how much water a tree needs for a proper start. Where drought stress may occur and irrigation is not possible, less developed trees may rightly be preferred at planting.

THINNING AND PRUNING

For a successful HDP, cropping should not be too high in the first years. This is to avoid biennial cropping, insufficient growth and not having the allotted space filled in a timely manner. Fruits inhibit flower bud formation and root development. To guarantee balanced tree development in this early period, ample fruit thinning is needed from the second year onward. We advocate that chemical thinning programs start in the second growing season, provided that well-feathered trees were planted. According to our experiences such an early start does not harm precocity.

Pruning depends on tree shape and cultivar but should be minimal in the early years as is customary in slender spindles and Solaxes. On the other hand, bending may be worthwhile.

CONCLUSION

With some exceptions worldwide, apple and pear orchards are planted more or less intensively. It is good to note that the extreme densities of more than 6,000 apple trees/ha (2400 trees/acre), advocated in Europe in the eighties, did not carry through, not even in their German cradle. Such intensive systems were neither economically nor technically good. This calls for prudence if in future other “fashions” turn up. It seems sensible not to go along without sound experimental data. For pear, the perspectives seem slightly different.

Experimental data show that densities up to 12,000 trees/ha (4850 trees/acre) can be an attractive option provided that high, regular yields are obtained. However, even here it seems sensible to use 3,000 triplet (3-branched trees) or ‘Mikados’ (4-branched trees) trees in Y-hedges. This leads to the same numbers of fruiting “elements” per ha that give rather similar results compared with the fourfold number of individual cordons, but with fewer risks.