Production technology and fruit tree nutrition

Gonda, I.

University of Debrecen, Centre of Agricultural Sciences, Department of Fruit Production
Böszörményi út 138, H-4032

Summary: Fruit yield quality and quantity are effectively enhanced if healthy vegetative conditions are ensured. These optimal conditions – i.e. the balance between shoot development and yield – can be achieved by the rationalization of the production technologies, such as:

- reduction of the size of the crown
- adaptation of the severity and method of pruning to the conditions of the actual year
- removal of the shoot tips
- timely fruit thinning

By establishing an improved level of plant nutrient uptake, this will ensure a healthy balance between shoot growth and yield.

Key words: apple, cherry, nutritional status, pruning, crown size, fruit position, shoot tip removal, fruit thinning

Introduction

The balance of nutrition is largely affected by the physiological conditions of the plant. The term "optimal physiological conditions" has long been a matter of interpretation among scientists. Among the available definitions, the explanation of *Zatykó* (1979) is the most commonly accepted. According to him "in their life processes (nutrition being one of those) trees have optimal conditions when vegetative growth and organic reserves are well balanced".

Zatykó differentiates between general conditions and conditions of the year postulating that

- **General conditions** should be interpreted as the result of the environmental (where he includes cultivation too) factors, whereas
- **Conditions of the particular year,** besides also being influenced by the environment (weather, foliage injury, cultivation etc.), are closely related to the actual mass of yield.

Regarding trees, general conditions are directly determined by the readily available supply of nutrients in the soil, water and air content of the soil, by the size and health of the foliage and by the environmental factors (temperature, air, orientation etc.) that are constantly influencing all aspects of healthy plant activities.

The biological bases, such as rootstock and variety choice, virus infection, crown size and shape, the ratio of productive and non-productive parts also directly influence nutrition.

Nutritional processes (food manufacturing, absorption, translocation) are both directly and indirectly related to the health care operations that are responsible for the maintenance of the balance between healthy plant growth and fruit production.

Proper cultivation enhances

- The photosynthesising area of the canopy,
- The activity of the photosynthesising area,
- The length of photosynthesising, which in turn, increases the volume and quality of nutrient deposition,
- The speed of the special and temporal translocation of assimilata, which in turn
- Increases the gross production of assimilative products, that
- Enhances root activity, root penetration in the soil, in final issue it enhances nutrient uptake.

In this paper we will discuss some effects of production technology on fruit tree nutrition.

Pruning severity and method

Winter and late-winter pruning of fruit trees activates the distribution and utilization of organic reserves at the generative and vegetative parts. The nutrient translocated to the generative and vegetative parts remaining after pruning, will have an effect on the primary phase of fertilization. Pruning is aimed to establish the right balance between the vegetative and generative parts. The proportion between these parts and the nutrient supply available will have a decisive importance in the early phase of fertilization. In the secondary phase, the natural fruit shed (June) is affected by the severity and method of winter pruning and the resultant shoot development. There is a linear relationship between vigorous shoot growth and fruit shed in June, being the latter the consequence of competition for nutrients between the shoots and the fruits.

Therefore pruning has to be done with the purpose of establishing optimal conditions for plant development, which results in the right ratio between long and short shoots (1:3) as well as the healthy growth dynamics of the shoots.

Together with severity, the method of pruning also has to be adjusted to the conditions in the given year in order to eliminate the adverse effects of extremes. This may involve moderate pruning or thinning without pruning of the twigs just as well as a highly sophisticated or just superficial pruning *(Gonda,* 1979, 1980).

Our experiences show that in case of poor flowering of certain apple varieties (Jonathan, Idared, Gala) is predicted, highly sophisticated, detailed winter pruning (moderate thinning of the twigs, cutting back of thin, underdeveloped twigs) will facilitate the fruit set in clusters. When such all-round pruning is applied, large amounts of the vegetative parts should be removed (selective thinning of the twigs), but those having the flower buds must be saved. When the year conditions are poor – the reason for this can be extremely high yields in the previous year, the lack of timely fruit thinning, poor photosynthesising canopy area resulting from mistakes in pest control, an upset foliage: fruit ratio – flowering and fruit set can be enhanced if a detailed, sophisticated pruning is done. In such years, no-pruning or partial pruning will reduce the fruit set (usually few in number) and will result in single fruit set per cluster formation. The more elaborate pruning is applied – paired with moderate cutting-backs of the twigs –, the higher number of clusters will be formed, which enhances multiple fruit set per cluster formation.

On *Figure 1* statistical data demonstrate supporting experimental evidences. In half of a 17-year-old Jonathan apple plantation on M4 rootstock the severity of the sophisticated, detailed pruning was altered in the four years of the experiment, whereas on the other half of plantation a simple canopy-thinning was practised in the experimental years. Equal cumulative amounts of yields gained from the two experimental sites in 4 years hide differences in annual yield alternations. In years 1976 and 1978 the flowering of apple orchards was reportedly weak or moderate, while in 1977 and 1979 flowering was rich in Hungary. Since moderate cutting-back enhances fruit set, application of the sophisticated, detailed pruning method resulted in higher yield in even years and helped to avoid extreme crop load in the consecutive odd years. However the harvests from the trees that received only canopy thinning tended towards extremities in both the even and the odd years.

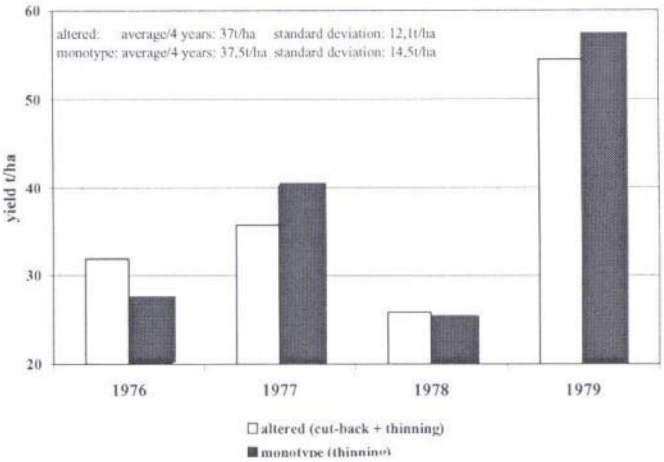

Figure I The effect of annually altered and monotype pruning methods on the amounts of yield, Újfehértó, 1976–1979

Cutting-back applied in years with poor flowering reduces yield fluctuation not only by enhancing fruit formation in that year, but also because

- In the consequence of detailed pruning, the development of the generative parts is reduced and
- Increased shoot growth happens at the expenses of the development of the generative parts, which incorporates the initiation of the flowers too.

Besides the effects they have on the activity of growth substances, the different methods of pruning applied in different years also influence the level of nutrient supply required for healthy fruit set. Vegetative growth on trees of little or no pruning starts earlier than flower bud break. This time gap may decrease nutrient availability for generative organs as generation of sink power of flowers is retarded. If the threats by the competitors are reduced (by elaborate pruning and by the removal of the tips of the early growth of shoots), the initial nutrient supply of the flower parts will improve, which will result in better fruit set potentials.

In years when high yield (rich flowering) is expected, less sophisticated pruning – restricted only to the thinning of the older branches and twigs – is recommended. In such years ample number of flowers and a wealth of vegetative parts are competing, the rival reduces the actual amount of nutrients available to each flower. This condition lead to single flower setting, which – by reducing the tree's potential for clustering on the whole – reduces the chances of extreme high yield formation.

By adjusting both the intensity and the method of pruning to the actual conditions of the year, the right balance of vegetative growth and yield will be established and the highest level of nutrient utilization will be achieved.

Crown size

Woody plants have parts with highly developed storing capacities for nutrient reserves, which can be interpreted as a kind of buffering capacity too. The larger the size of the tree, the higher is the ratio between the total volume of the tree and its storage parts. As the size of tree increases, the proportion of the sunlit productive parts is being reduced, the proportion of productive and unproductive parts (those with a storing function) increases. As the size of tree decreases, this happens inversely, the buffering capacity will also be reduced. The decrease in buffer capacity may cause occasionally negative effects in nutrient supply, though they are usually eliminated or moderated by the increased level of photosynthesis and the improved activity of the root system. Damages in nutrient supply, caused by temporary inadequacies in root system functioning, due to scarcity of nutrient content of the soil, or originated from soil water or air deficiency are usually reduced by improved performance of the aerial parts.

Another consequence of the crown size reduction – beside improved sunlight penetration and reduced buffering capacity – is that the circulation of the nutrients between the subsoil and the aerial parts is improved (both in time and space).

Plant nutrition, nutrient uptake and photosynthesis, the intensity of nutrient absorption are all directly or indirectly affected by the size (diameter) of the tree, by its shape and by the proportion that is established between its active and passive (productive and unproductive) parts. By means of the increasing of intensity, reducing the size and increasing tree density/hectare, the processes of plant nutrition will improve in efficiency.

The size of the tree and the position of the fruit

In the process of nutrient absorption and manufacturing, different parts of the tree receive different amounts of nutrient. The actual differences are closely related to the size of the tree. Well illuminated, active zones manufacture nutrients that are passed to the poorly lit parts or to passive, non-productive parts that lack green leaf areas for photosynthesis. The productive parts are bearing the high quality portion of the fruit load and are the main sites for the growth and the regenerative processes too. The fruits growing in the shaded or semi-shaded inner parts of the canopy receive much less nutrient. This can be well illustrated by the analysis of fruit ingredients carried out in an 8-year-old "Érdi bőtermő" sour cherry plantation *(Figures 2, 3)*. Here, the more than 20% difference measured between the ingredients of the fruits in the outer and in the inner parts involves really significant differences of quality.

In a large tree, fruits in the outer, well-lit canopy area (unlike the fruits growing in the sun-lit, productive outer area of a small tree) are exposed to a certain degree of peripherical dilution. This means that although the fruits are developing in a sunny canopy site and are supplied with nutrients from well-lit leaf zones, the transportation of nutrients from the outer to the inner parts of the tree canopy in order to supply the shaded, low activity parts requires significant efforts that will only grow as the size of the tree increases. Fruit quality safety is also strongly related to the tree size. Smaller sized trees are more suited to provide healthy nutrient supplies.

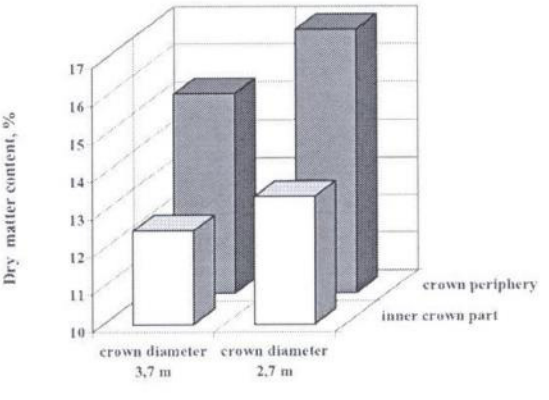

Figure 2 The relationship between fruit position and the dry matter content of sour cherry fruits grown on trees with differing crown sizes, Debrecen–Pallag, 2001

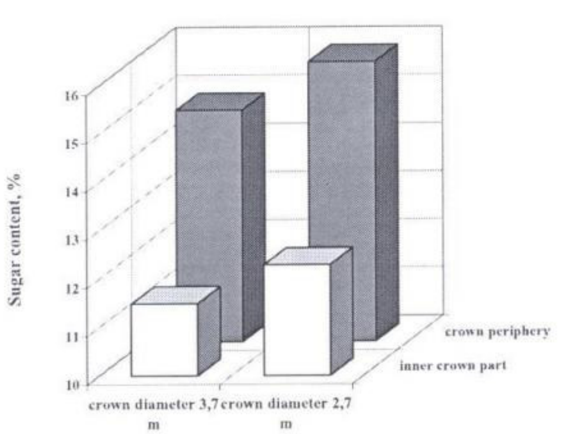

Figure 3 The relationship between fruit position and the sugar content of sour cherry fruits grown on trees with differing crown sizes, Debrecen-Pallag, 2001

The removal of the shoot tips

After weather shocks that reduce the performance of the flowers (partial freezing), due to the hormonal affect that the vigorously growing shoots have on the flowers and because the shoots withdraw considerable amounts of nutrients, fruit set is heavily reduced, which culminates in excessive fruit shedding in June. To prevent this, shoot growth in the secondary phase of fruit setting should be stopped temporarily (*Quinlan &Preston,* 1971, *Grauslund,* 1978).

In 1995 heavy frosts hit the apples at flowering time. In a 5-year-old Elstar/M9 rootstock apple plantation we removed the tips of 20–25 cm long shoots. The statistical data showing the degree of removal and the dynamics of fruit shedding in this plantation are demonstrated in *Figure 4*.

Apical dominancy of shoot tips effects nutrition supply of competing organs. Beside the inhibiting affect of the hormones produced at the tips of the shoots and the withdrawal of the nutrients by the shoots also have adverse effect on the development of the young fruits. Apical dominancy is clearly correlated to higher sink power of shoot tips, therefore the cessation of apical dominancy by removing shoot tips may increase fruits set due to the

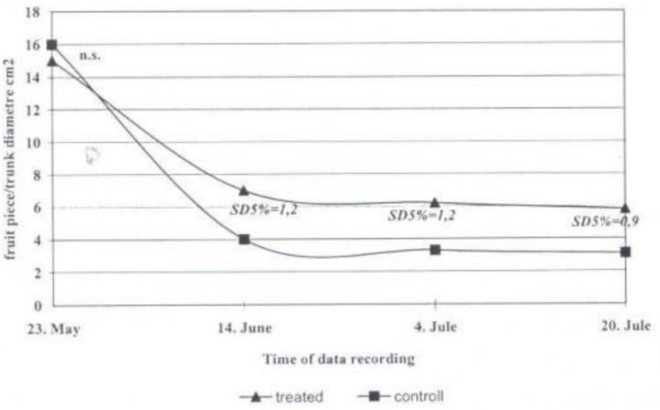

Figure 4 The effect of shoot tip removal on fruit setting of Elstar/M9, Debrecen-Pallag, 1995

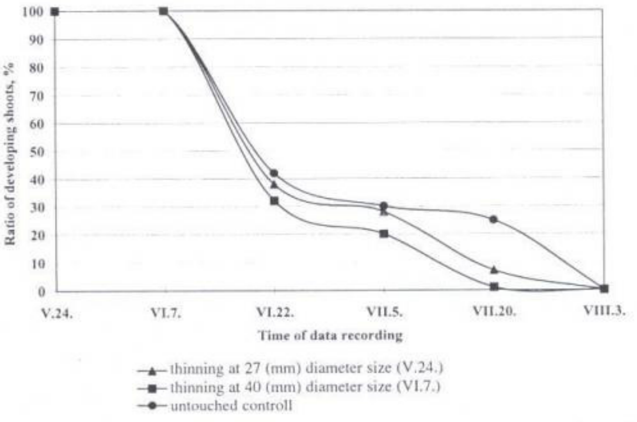

Figure 5 The effect of fruit thinning on the shoot growth dynamics of 7-year-old Idared/M26 apple fruit, Debrecen-Pallag, 1996

enforcement of their sink power. This application reduces the likelihood of the occurrence of extremely low yield formation (low blossoming years), even if the plantation is heavily hit by weather, thus it may reduce alternation of crop in the forthcoming years.

Fruit thinning

Thinning is an essential tool of establishing optimal foliage: fruit ratio, which provides optimal vegetative conditions for plant growth. It enhances the nutrient utilization potential of the remaining fruits and creates better conditions for other tree parts (buds, shoots, flowers, woody organs, roots etc.). The acceleration of the terminal bud formation is an indirect effect *(Figure 5)*. The earlier the surplus amount of fruits is removed, the sooner the growth of the shoots is finished. After advanced terminal bud formation, less assimilata are used for plant growth and before leaf fall, a longer period of time is available for flower formation and development and for filling up the organic reserves.

References

Gonda, I. (1979): A metszés időzítése, mértéke és a fák kondíciójának kölcsönhatásai. Újabb kutatási eredmények a gyümölcstermesztésben. 6: 21–28.

Gonda, I. (1980): A metszési elvek differenciált alkalmazása, valamint a vízhajtásképződés vegyszeres gátlása. Újabb kutatási eredmények a gyümölcstermesztésben. 8: 11–15.

Grauslund, J. (1978): Effect of temperature, shoot tipping and carbaryl on fruit set of apple trees. Acta Horticult. 80: 207–211.

Zatykó, I. (1979): Az almafák kondícióját és termőképességét befolyásoló tényezők összehangolása. Újabb kutatási eredmények a gyümölcstermesztésben. 2: 7–19.

Quinlan, J.D. & Preston, A.P. (1971): The influence shoot composition on fruit retention and cropping of apple trees. Journal of the American Society for Horticultural Science. 4. 525–533.