Drought-induced Losses in Fruit Orchards

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SUMMARY

Scientists investigating the causes of the extremities of climate that have become quite frequent in the Carpathian Basin over the past few years are quite often in doubts as to whether increased atmospheric warming and the shortage of rainfall are to be seen as recurrent natural phenomena under our climate, or the first signs of global warming. Climate anomalies have, to a certain extent, always been common in the Carpathian Basin. However, statistical data of the past few decades indicate that the rise in temperature and the fall in precipitation have, by now, become a tendency, which requires further in-depth scientific research.

The series of articles to be published in continuation of this paper endeavors to synthesize the research results and many years of experiences, in order to give an analysis of

I. The economic effects and the symptoms of drought in tree cultures
II. The possibilities of reducing the adverse affects of drought

I. The economic effects and the symptoms of drought in tree cultures

INTRODUCTION

It has been observed that, unlike non-bearing young establishments, bearing orchards are not detrimentally affected by droughts.

When applied, irrigation can result in a 20-30% increase in the quality and the quantity of yields, which, in turn, implies that the responsibility of droughts for reduced yield safety cannot be more than 30%.

The significant differences in the performance of fruit plantations of similar types and ages are much rather due to the differences in the types of the soil and the production technology applied (pruning, nutrient supplementation, plant protection), than to the use or the lack of irrigation.

1. The economic effects of drought

In Hungary, the main actors of fruit production in the forthcoming years are foreseen to be small producers who by joining their efforts in production/marketing co operatives will be expected to produce and market large quantities of *evenly excellent quality* fruits.

Evenly and continually high quality and quantity fruit yields cannot be ensured without irrigation. One must be aware, though, that *part of the home consumers and a considerable proportion of fruit processing enterprises will still continue to be supplied by fruits coming from orchards where the conditions of irrigation are not and will not be available.* Realistically, these „dry enterprises" cannot even dream of competing with their irrigated counterparts in respects of yield security, quality and quantity. *Research results and practical experiences, however, offer alternative ways by which non-irrigated fruit production can considerably be improved, even in times if shorter or longer spells of drought.* There are several practical techniques and tools known by which –except for extremities – the negative effects of drought can be lessened or neutralised. Several of the research studies made in the previous decades were conducted and their results were implemented under dry conditions. As a result of experimentally applied irrigation, the investigated fruit species in the years of the experiment achieved an average annual yield growth of 20-30%, which in certain cases was also accompanied by a similar rate of quality improvement.

The 20-30% increase was almost exclusively generated by supplementary irrigation in the months of July-August. The occasional frost guarding effect of the sprinkling irrigation was an additional benefit. In other words, the results suggest that on the average of several years, *yield security in the Alföld region is affected by droughts by not more than 30%, at a maximum*. While this may, unfortunately, imply the loss of many tons of fruits, the percentage figures above are still worth considering. *The implementation of techniques that producers failed to use so far can significantly reduce the above indicated proportion of losses in the future.*

Almost all of the research results and practical experiences that were gained over the past decades have also somehow contributed to the improvement of drought management. The results gained from rootstock/cultivar experiments conducted under non-irrigated conditions, and the results of the production technology experiments (pruning, nutrient supplementation, etc.), have contributed to the improvement of the general condition, resistance and stress tolerance of the tree and, in final issue, they helped to open up the hidden potentials of the plant.

Controversial results have, however, been achieved concerning the balance of the yields. This implies that irrigation does not considerably help to correct yield fluctuation, which is understandable for the simple reason that droughts did not come in succession in the years of the experiment, i.e. every 1-2 years of drought were followed by a wet year, which in itself established a considerable level of balance.

It was found that:

- *tree cultures respond to drought slowly,* which is due to their large root systems and to their *improved* nutrient storing capacity (woody nature).

- *dry, but not extreme drought periods in summer encourage flower bud differentiation* in the majority of the fruit species, *improving thereby their yield potentials in the consecutive year.*
- *dry weather in summer accelerates ripening,* which generally leads to early harvests: *the trees get rid of their fruit load earlier, and* with a regularly *wet* autumn coming afterwards, they will have better conditions for a *long-drawn flower formation*, which will improve their yield potentials in the consecutive year.
- *dry autumns inhibit the regrowth of the pre-dormant buds,* which makes *the foliage less vulnerable to early autumn frosts and protects the nutrient transportation routes from damage by winter frosts*.

More than 80% of the large fruit plantations established in the previous decades *did not have irrigation systems installed, which caused fluctuations in their production, and, particularly in the prolific years, induced fruit quality degradation* (reduced fruit diameter size). There were, however, *significant differences of levels seen among the individual orchards established in similar ecological environments, which was caused by their different levels of expert knowledge, of the technological discipline applied and of several other aspects of "management"*. It is enough to consider the different techniques of nutrient supplementation, plant protection, pruning, soil cultivation applied to understand the causes of the significant differences in nutrient and water uptake and, resultantly, in organic matter formation. Consequently, there were considerable differences in the annual yield quantity and quality between plantations standing in the same region on identical rootstocks of the same variety and age. In addition, the *poor range of choice of the rootstocks and cultivars* inhibited the adaptation to the environmental specificities of the site too. *Tree and crown shapes monotonously resembled each other*.

Conversely, *the intensity and the methods of pruning* – the most important technological tool for growth and yield regulation – *varied on a wide scale*, which, in turn, resulted in plantations ranging from those receiving zero or partial pruning to heavily over-pruned examples with trees developing woods of suckers.

The points discussed above explain the causes of the unevenness of yield quality and quantity common in those years. However, the distorted market conditions of that economic system, the yields were "successfully" channeled through home and international markets, no matter how high a proportion of poor quality fruits they had.

Bearing orchards are usually not detrimentally affected by drought, unlike their young, non- bearing counterparts. Drought only slowly destroyed the older plantations – even those that for several years received no pruning, fertilisation, soil cultivation or weed control. As a rule, one or two main branches of a tree dried out first, which than was followed by entire trees dying in dry soil patches or on slopes; but no spectacular, rapid termination of plantations was seen. As a result of heavy nutrient deficiency, these trees first lost their conceiving capacity, and eventually even failed to produce flowers. They are known to be very persistent, give up hard, and *due to their deeply penetrating roots* and recurrent recovering by occasional rains, *their demise is delayed. The safest indicator of their decay is the appearance of secondary pathogens* (fungi, bacteria, wood-borers, etc.), which, as a rule, accompanies the weakening of the organism. However, *insufficient plant care* (pruning, pest and disease control) *is responsible for their appearance, rather than water insufficiency*. For many years, large-scale plantations in Hungary used to be reputed for having 2-3 meter wide *rows of trees surrounded by a sea of weeds* and by tracks between the rows cultivated by disc harrows. Hungarian specialists used to wonder why their *Western colleagues* managed their orchards in an opposite way, i.e. they *kept the tree rows clean of weeds by chemical or mechanical control, or by applying mulch, and had grass in the interrows.* The reason is that, although Western countries have more favourable conditions of rainfall – so that producers can sometimes even avoid irrigating the grassed interrows in the plantations –, they are also aware that heavy stands of weed invading large areas of the root zone in the rows are highly undesirable.

Now that Hungary functions in a market economy, it is essential to revise our conventional practices, to rely on the achievements of foregoing research and practice, and to pave the way for advanced research and the implementation of research results. Fruit production today is undergoing a phase of change, i.e. the appearance and spread of new rootstocks and cultivars. The use of these high performance propagation materials *imperatively requires improved technological discipline* and sound expertise in everyday tasks.

The adverse effects of drought can be successfully reduced by the implementation of both long existing (but neglected) and newly achieved research results. These will assure that *well-balanced and high quality yields are harvested in every year*. This requires that all the major elements of production strategy be synergetically focused on combating drought, which involves:

- *the use of drought resistant rootstocks and cultivars of high biological value,*
- *up-to-date expertise and awareness in the application of each element of production technology* (plant protection, plant care operations, soil resources management, etc.).

In conclusion, it can be established that *the harmonisation of the biological, technological and human-related issues of production are the key elements of successful drought management.* To provide for this, the implementation of the latest developments of production technology and the renovation of biological bases are mandatory. Although both these issues are equally important, production technological developments (high standards of expertise, production awareness), will certainly have a higher priority in the initial phase of change.

2. The symptoms of drought in fruit plantings

In this section we examine the most commonly expressed symptoms of damage caused by drought to tree fruits. It has to be noted, though, that symptoms of drought such as a long lasting, dry period of weather usually accompanied by high temperature, develop gradually, and can temporarily or even permanently be eliminated by occasional rainfall.

As a result of damage by drought

- *Terminal bud formation is accelerated, shoot development is slowed or reduced.*
- *The healthy, fresh colour of the foliage turns dull and blunt.*
- *The shoots are thin and short with small sized leaves.*
- *The number of terminal and lateral buds is relatively high, but the buds are underdeveloped.*
- *Untimely defoliation begins* (especially older leaves).
- As a result of leaf falling, leaf rolling and decolorisation, *the general vegetative conditions of the plant are deteriorated.*
- *The foliage wilts.*
- *The pace of fruit growth is reduced or growth is stopped.*
- *Signs of sun burning appear on the fruits* (atmospheric drought).
- *Leaf wrinkling and bladdering resemble the symptoms of frost damage on primary leaves* (atmospheric drought).

The development of the symptoms is accompanied by a *heavy drop in organic matter production, which induces significant depression and degradation of the under-surface plant parts* (reduced transpiration, poor nutrient production and root nutrition and resultant poor foliage conditions).

The symptoms are qualitative rather than quantitative, it is probably only sun burning that provides quantitative proof of the damage caused by the very low air humidity and very high temperature and the resultant moisture shortage. Burning, naturally, is the heaviest in fruits growing on the peripheries of the canopy. The yellowish-brownish colouring that overshadows the original cover colour heavily reduces the market value of the fruit.

Sun burning is considerably more frequent with pome fruits that bind in clusters, and of those apple tree species with poor general characteristics are the ones most heavily prone to injury by burning. Trees with proper growth conditions rarely if at all show signs of burning. This phenomenon has nothing to do with the shading effect of a well-developed canopy. Rather, the effects of the drawn-out fruit development phase result from the tree's insufficient nutrient supply. Stunted in growth (poor canopy and root development, reduced nutrient and water absorption), these trees are more susceptible to the effect of burning.

Furthermore, *after summer pruning, when fruits begin to receive more light, injuries from sun burning almost never happen.* This can, of course, be partly explained by the fact that after the time of summer pruning, in August, excessively hot and dry spells are rare, which reduces the incidence of sun burning. The most typical period when *sun burning is the heaviest is July*, whereas in June and in August injuries from burning are less serious.

It has been observed that the proportion of fruits damaged by burning does not even in the most severe years exceed 5% of the total of the fruit load. Not more than 1 or 2 pieces in a fruit cluster growing on the peripheries of the canopy are affected by burning, albeit the rest of the fruits is none the less exposed to damage. *Usually, it is the fruits developing from the terminal buds that are most likely to suffer the heaviest damage*. There are significant differences observed among cultivars concerning their vulnerability: '*Idared', 'Jonagold' and 'Elstar' cultivars are highly susceptible, whereas 'Jonathan' and 'Gala' are very rarely affected by sun burning.* Fruits developing from the lateral buds (bound in clusters) tend to be more protected, which is due to their beneficial location close to the primary, transpirating leaves. However, the microclimate around the fruits developing from terminal buds (high temperature, perpendicular light incidence, low humidity) exposes them to considerably heavier burning injuries. Another indication supporting the assumption that humidity shortage in the environment is primarily responsible for heavy burning is that fallen fruits are sun burnt within 24-36 hours after falling on the soil surface. The heat radiated by the soil and the low humidity content of the air layer close to the surface also add to the risk of burning. Also, fruits on the western aspect of the canopy are more likely to be affected by burning.

It can be concluded that the fruits most exposed to sun burning are those situated centrally, i.e. that have relatively poor foliage, with insufficient nutrient resources around.

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