International Journal of Horticultural Science 2006, 12 (2): 59–67
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Fruit drop: I. Specific characteristics and varietal properties of fruit drop

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Summary: The basic conditions of fruit set (synchronic bloom, transfer of pollen, etc.) still do decide definitely the fate of the flower in spite of the best weather conditions. Beyond a set quantity of fruits, the tree is unable to bring up larger load. A system of autoregulation works in the background and causes the drop of a fraction of fruits in spite of the accomplished fertilisation and the equality of physiological precedents. This study discuss this physiological process based on the international specific literature. The further development of fruits maintained on the tree depends mainly on the growing conditions (e.g. water, supply of nutrients, weather adversities, pruning, fruit thinning, biotic damages, etc.), which may cause on their own turn fruit drop especially at the time of approaching maturity.

Key words: fruit drop, dropping periods, "June drop", varietal properties

Dynamics and periods of fruit drop

Natural drop of fruits is not a continuous phenomenon between fertilisation and maturity, but there is well-determined periodicity recognised in most fruit species (*Stösser*, 2002). Biochemical and physiological changes during the growing season are in the background of the waves of drop (*Szalay*, 2003), whereas the number of successive waves and their severity depends on the intensity of fruit set (*Soltész*, 1997). The fruit was set the higher number of fruit drop periods is expected (*Soltész*, 2002). *Figure 1–2* show two different cases of fruit drop in apple.

According to the professional literature, this number depends also on species or variety, but also on the opinion of the authors, which seems to be rather scattered:

- 1 (*Surányi & Molnár*, 1981),
- 2 (*Timon*, 1992; *Jauron*, 1995; *Stern & Gazit*, 2003; *Puskás*, 2004; *Tari*, 2004c),
- 3 (*Nyéki*, 1978; *Nyéki*, 1989; *Thompson*, 1996; *Soltész*, 1997, 2002; *Molnár*, 2004b; and
- 4 (*Jackson*, 2003).

According to the importance of the successive waves, we may consider the three main periods being the most accepted ones: (1) at the end of bloom (cleaning drop); (2) June drop; and (3) preharvest drop. The first, cleaning drop was divided into two periods by some authors, i.e. they speak of four drop-periods (*Dorsey*, 1919; *Bradbury*, 1929; *Bowman*, 1941; *Gardner* et al., 1952; *Kobel*, 1954; *Sparks & Madden*, 1985; *Wood*, 2000).

The periods of fruit drop are not independent on each other. In the first phase, a high number of flowers, which were not pollinated, are shed together with the petals of the fertilised fading flowers. The second wave is usually less conspicuous. The reverse may occur, when in the first phase less expressed. It is also possible that during the first two drops more fruits were spared, subsequently, the third, pre-harvest fruit drop became more important (*Thompson*, 1996).

Brain & Landsberg (1981) analysed and compared the dynamics of fruit drop in apple and other fruit species by means of mathematical models in order to estimate the number of fruits expected at harvest. *Gardner* et al. (1952) found the dynamics of fruit drop very similar in apple, pear and sweet cherry. *Blasse & Barthold* (1972) claimed that in apple and pear, fruit yield depends on the first and the second fruit drop only. In sweet cherry and pear, the first phase was

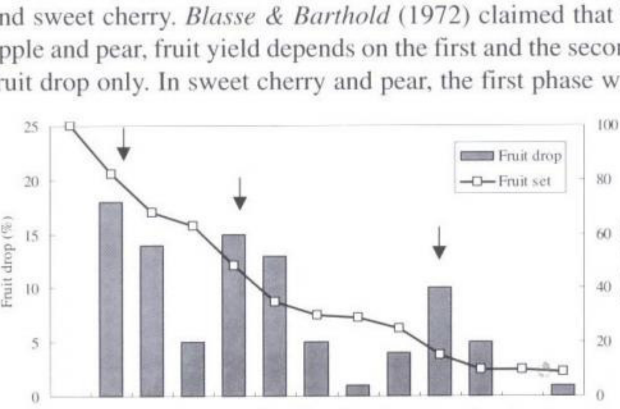

Figure 1. Seasonal changes of fruit drop and fruit set in apple cv. 'Boskoop' on rootstock MM106 (2005). This cultivar show a typical curve of fruit set (fruit drop) with 3 dropping waves

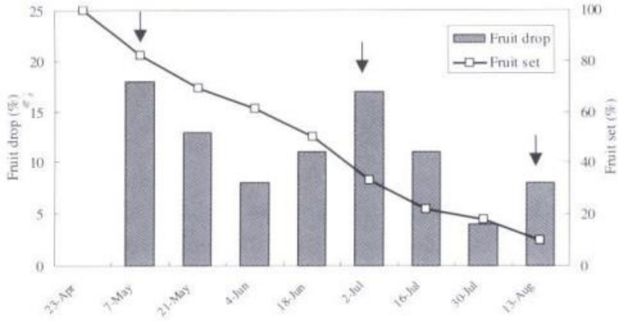

Figure 2. Seasonal changes of fruit drop and fruit set in apple cv. 'Vista Bella' on rootstock MM106 (2005). This cultivar is a typical case of preharvest dropping type

more important, in sour cherry and plum, the severity of the first and second fruit drop was nearly equal (*Soltész*, 1997).

Nyéki (1978) emphasised the importance of studies concerning the dynamics of fruit drop from the point of view of fruit production:

- procedures in order to regulate yield by interventions (enhancing fruit set, prevention of fruit drop) should be timed accurately;
- as to predict the volume of the harvest expected;
- if the cause of fruit drop were recognised, the prevention of the loss could be attempted by agricultural means (pruning, irrigation, nutrition) in order to shape the rate of fruit set according to the conditions and capacity of the tree.

Fruit drop after bloom

This phase of fruit drop ensues, depending on fruit species and variety, after the faded petals of the flowers are shed within an interval of 1.8 weeks. Fruit growers call it the "cleaning drop" of the trees.

Pomaceous fruit species shed the flowers, which were unable to continue growing (*Stösser*, 2002), whereas in apricot, 1 or 2 weeks after bloom (*Surányi*, 1981), in sour and sweet cherry, 1.5–2.5 weeks may elapse (*Thompson*, 1996). In the latter species, the cleaning fruit drop was divided into two phases, the first lasts after the shed of petals 1.5–4 weeks long, the second between the 4–6 weeks (*Kamlah*, 1928; *Stösser*, 1966). The two phases overlap each other generally. At that time, the fruitlet attained a diameter of 4–5 mm (*Stösser*, 2002). *Nyéki* (1989) called that period in sour cherry „initial" fruit set. The most critical period of fruit drop is this cleaning drop after shed of petals. The inhibition of this type of fruit drop is rather difficult to accomplish by chemical means (e.g. by inducing parthenocarpy), more promising is considered the enhancement of the rate of fruit set (*Surányi*, 1981).

The cleaning fruit drop correlates with the rate of the fertilised flowers (negatively) or the number of flowers being pollinated (positively) (*Timon*, 1992) – whereas the following June drop depends on the loading capacity of the trees. As a rule, the first period of fruit drop is the most intense one. The flowers not being fertilised are shed or by other reasons of sterility and do not bear viable seed primordia (*Szalay*, 2003). According to *Surányi* (1981), the defective and poorly fertilised fruit primordia are also exposed to be shed in this phase. However, at a low initial flower density, after a frost spell or a purposeful thinning of flowers, the remaining fertilised flowers may have the chance to be maintained and grow to ripe fruit, so the first period of fruit drop may be suppressed almost totally (*Thompson*, 1996).

The extent of cleaning fruit drop is largely dependent on the variety, year and growing site. The higher the rate of the initial fruit set, the more difficult is the exact estimation of the final fruit load (*Roemer*, 1969; *Soltész*, 1997; *Soltész*, 2002). After the cleaning fruit drop, the influence of temperature on the rate of fruit set diminishes and the significance of nutrition and water supply in the maintenance of fruits increases (*Soltész*, 2002).

The physiological background of the cleaning fruit drop is manifold. After beginning of the differentiation of endosperm, the fruit primordium is not able to furnish further amounts of growth substances across the fruit stem to the tree because it is needed for its own growth. Many of the fruitlets are shed at this moment (*Friedrich*, 2000). The post-bloom fruit drop ended with the moment when in the first phase of seed development the multinucleate endosperm started to develop cell walls between the nuclei followed by a second boom of hormone (auxin) synthesis (*Tari*, 2004c).

In apple, it was stated that the more developed were the buds and flowers of the tree, the lower is the intensity of the cleaning fruit drop, and the drop of supernumerary fruitlets ensues later, during the June drop or may be omitted entirely especially in the apple variety of a strong fruit-maintaining tendency as 'Golden Delicious' (*Soltész*, 2002).

In stone fruit species (sweet cherry, plum, sour cherry), *Puskás* (2004) recognised a couple of causes being responsible for the cleaning fruit drop. Some of them are the belated pruning, lack of nutrients – mainly nitrogen - and drought in the soil. In sour cherry, *Nyéki* (1978) analysed the rate of flowers, which failed to be fertilised and of those, which started to grow fruit (*Table 1*).

Fruit drop in apricot is tending to increase after bloom attaining 1–3% per day around the end of April and early May. At time of lignification of the stone, about 55–82% of fruitlets (including flowers) are already lost (*Surányi & Molnár*, 1981). Considering that the differentiation of fruit primordia precedes the drop by several days, the loss is decided already at the time of cell division. Consequently, we may conclude that the drop was not triggered by the development of the embryo, but rather stopped by it. Most likely, the mechanism coordinates the processes of development in favour of the remaining fruits, where the most energy consuming embryo-development occurs in the fruits, which the tree is able to maintain up to maturity (*Surányi & Molnár*, 1981).

At the start of hardening stones (during May) of apricot, the dropped fruits still grew in the first (cell division) phase

Table 1. The ratio of flower and fruitlet drop for sour cherry cultivars (*Nyéki,* 1978)

Cultivar	1972 From total drop		1973 From total drop	
	Flower drop (%)	Fruitlet drop (%)	Flower drop (%)	Fruitlet drop (%)
Pándy meggy-114	7.6	92.1	15.0	81.4
Pándy meggy-10	1.2	97.7	38.3	57.7
Pándy meggy-279	1.7	95.5	20.2	65.5
Pándy meggy-13-1	1.7	91.1	16.3	74.8
Pándy meggy-11-1	6.7	81.1	18.3	67.2
Pándy meggy-48	6.1	79.6	18.9	74.9
Schattenmorelle	16.7	61.7	6.7	53.7
Montmorency	17.1	59.7	15.9	41.8
Parasztmeggy	0.8	70.7	25.4	40.2
Cigánymeggy-59	3.8	55.2	32.1	57.5
Pándy meggy-50	–	–	20.7	74.5
Báró Jósika (P-21)	–	–	8.3	85.3
Kőrösi meggy (P-26)	–	–	21.7	65.4
Pándy meggy-38	–	–	17.4	68.8
Cigánymeggy-7	–	–	41.5	32.7

Table 2. Fruit drop of sour cherry cultivars in different years (*Nyéki,* 1978)

Cultivar	Fruit drop (%)		Difference between years
	1972	1973	
Pándy meggy-114	99.7	96.4	−3.3
Pándy meggy-10	98.9	96.0	−2.9
Pándy meggy279	97.2	85.7	−11.5
Pándy meggy-13-1	92.8	91.1	−1.7
Pándy meggy-11-1	87.8	85.5	−2.3
Pándy meggy-48	85.7	93.8	+8.1
Schattenmorelle	78.4	60.4	−18.0
Montmorency	76.8	57.7	−19.1
Parasztmeggy	71.5	65.6	−5.9
Cigánymeggy-59	59.0	89.6	+30.6

at the same rate as the fruits maintained. The hardening process slowed down, then the fruits are shed within 10–25 days (*Molnár,* 1974 cit. *Surányi & Molnár,* 1981).

In peach, the first period of fruit drop usually deals with the non-fertilised and damaged flowers (*Fideghelli & Cappellini,* 1978). The further fate of the fruits depends on moments of nutrition and the competition of growth substances. All those depend on the phytotechnical interventions and on the variety, of course (*Bellini & Mariotti,* 1976).

The first period of fruit drop ensues in the case of pecan nut 14 days after pollination and lasts for 45 days at most (*Smith & Romberg,* 1941). As being coincident with the drop of the unpollinated flowers, therefore, the lack of fertilisation may accepted to be the cause of abortion (*Sparks & Madden,* 1985). The same drop is also expected if the trees are self-fertile. In this period, to fruit drop also the low quality of pollen may contribute (*Wood,* 2000).

In litchi, most fruit primordia are shed first during the month after pollination (*Mustard* et al., 1953; *Joubert,* 1986; *Stern* et al., 1995, 1997; *Stern & Gazit,* 1999, 2003). In Israel, during the fifth week after pollination the majority of the fruitlets were dropped, i.e. 90% ('Mauritius'), 96% ('Floridian') and 99% ('Kaimana'). The main reason of it was the high rate of abnormal female flowers.

„June drop"

The second period of fruit drop ensues in pomaceous fruit during the 6–8th week after bloom, which means on the northern hemisphere the month June. During this period the embryos are growing vigorously and consume the endosperm tissue, which synthesised the auxin, consequently the reduced auxin production starts fruit drop (*Figure 3*). Meanwhile, the growth of embryos is completed and a secondary endosperm is formed, which synthesises a lot of auxin again. That is the reason of the end of June drop (*Friedrich,* 2000; *Tari,* 2004c).

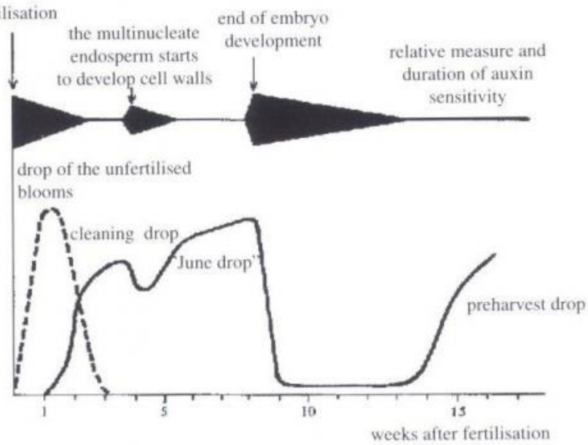

Figure 3. Relationship between hormonal activity and fruit drop in apple (after *Luckwill,* 1953, in: *Westwood,* 1993)

There is no distinct separation between the first, cleaning drop and June drop, as minor drop may occur between, which cannot be assigned to neither of them. The quantitative relation of cleaning and June drop may change yearly, but the rate of cleaning drop cannot be utilised as to estimate the rate of June drop expected. The first prediction of yield could be attempted after the June drop only. At favourable conditions of fertilisation, the cleaning drop is expected to be minor, whereas the June drop more important (*Soltész,* 1997).

According to *Nyéki* (2002), a clear estimate of frost damage after bloom cannot be made in apple but after the June drop only. Eastern Hungary, the insurance is paying the growers after frost damage according to inspection made at that time.

In some stone fruit varieties, the ripe fruits may drop already around the end of May. Sweet and sour cherry, the second period of fruit drop may ensue earlier than June, 6 weeks after bloom, whereas their third fruit drop finishes in June.

In sweet and sour cherry, the third period of fruit drop is called also "red drop", which means that the fruits dropped started to ripen (*Blasse & Barthold,* 1970; *Nyéki,* 1978). More than 90 % of those fruits contained an embryo, but their size was smaller than average, which means some kind of defeat (*Thompson*, 1996). In those species, fruit set is most accurately decided before maturity as a sign of self-fertility or auto-incompatibility (*Nyéki*, 1989).

According to *Stösser* (2002), the main cause of June drop is some kind of trouble in the translocation of nutrients, but at this stage of fruit development the requirement of organic substances is culminating. In addition to that weather conditions take also part in the processes though at a lower significance (*Coit & Hodgson*, 1919). The drop is the consequence of insufficiency of nutritive capacity for developing fully all fruits set after bloom (*Szalay*, 2003). Consequently, an abundant June drop is expected every time, when the leaves of the tree were damaged by frost, disease or pest, and cannot photosynthesise the due amount of organic matter (*Friedrich*, 2000).

Preceding the June drop, the abscission started with the physiological processes (*McCown*, 1939, 1943). The dropped fruits display completely developed abscission layers, which started to form earlier as an irreversible process, but at a speed depending on the season. Therefore the severity of June drop is yearly variable (*Soltész*, 1997).

Soltész (1997, 2002) claims that the relative strength of cleaning and June drop is a varietal character. As a rule, the latter is more typical for the persistent varieties, which develop the abscission layer at slower rate (e.g. 'Golden Delicious'). It is more frequent, when "oversetting" occurs, but less probable when chemical fruit thinning was exercised, which reduces the risk of oversetting. The persistent are less exposed to fruit drop because their system of autoregulation is less alert, therefore the frequency of underdeveloped (small) fruits is their major risk, which in turn ought to be counteracted by fruit thinning.

In pomaceous fruits the June drop may considered rather as desirable phenomenon in order to avoid overloading if neither alternate bearing nor adverse weather conditions did not diminish fruit set during bloom. In other fruit species, e.g. sweet cherry ("red drop") or in black currant, the June drop impairs the yield (*Stösser*, 2002).

The June drop expression has been applied often to the 'Navel' orange, but it is a mistake because it occurs in Florida during May and on the southern hemisphere during November and December. *Webber* (1923) stated that at dry growing sites of California the (second) fruit drop might cause heavy losses up to 25% of the crop.

The second period of fruit drop in pecan is related to the first and second cell division of the zygote (*McKay*, 1947). It is supposed that the drop ensues because of the ill cell division and subsequent abortion of the embryo. Those troubles are more frequent in the case of autopollination of flowers (*Sparks & Madden*, 1985).

Preharvest drop

After June drop a vigorous growth of the fruits is starting, which means that the auxin flow synthesised in the fruit is moderated, consequently, a third period of fruit drop is threatening in many varieties. This is called the preharvest fruit drop, which is also founded on the consumption of the secondary endosperm as a source of growth substances (*Tari*, 2004c). It is introduced by biochemical changes at the basis of the fruit stem but no cell division forming an abscission layer occurs (*Soltész*, 1997).

As expressed by its designation, the third phase ensues near to the terms of harvest. If the fruit is already technically ripe, heavy economic losses are at stake (*Szalay*, 2003).

The chance of fruits being detached is difficult to estimate in this phase because the ecological hazards of shaking off the fruits weakly anchored is imminent even at careful interventions (*Soltész*, 2002) (*Figure 4*).

The preharvest drop is especially onerous in cases, where the harvest is timed after the optimal maturity of the respective variety. In Florida, the harvest of 'Navel' orange used to be performed soon at optimal terms; therefore, no losses are risked (*Lima & Davies*, 1981).

In sour cherry, preharvest fruit drop is rare, only at excessively heavy fruit load (*Soltész*, 2003). Preharvest drop is aggravated by the wind depending on the fruit species and variety (*Roemer*, 1968–70; *Way*, 1973; *Gautier*, 1974). The most exposed species are in diminishing order apple, pear, plum, peach and black currant, whereas cherry is less endangered (*Stösser*, 2002).

Preharvest fruit drop is favoured by high number of fruits per inflorescence. Where the fruit stem is short (peach, apricot, some apple varieties), the fruits may kick one another as a consequence of growth (e.g. apple varieties as 'Idared' or 'Jonathan') mainly as members of the same inflorescence (*Soltész*, 1997).

The third period of fruit drop is called "green drop" in apricot by *Surányi & Molnár* (1981). As causes, ecological components, also diseases and pests are recognised.

In pecan, that drop is less important than the former two or three drops, and it is caused by embryo abortion, which is obvious from the shrivelled and discoloured tissues within the shell. This drop of fruits also could be attributed to auto-incompatibility or inter-incompatibility (*Wood*, 2000).

Drop due to natural senescence

The fruit grower experiences the fourth period of fruit drop rarely, which occurs practically after the optimal harvest time. Apple is detached after full physiological maturity because the ethylene level of the AZ tissues increases excessively (*Dávid*, 1980). The ripening fruit produces lots of ethylene, which flows to the fruit stem (*Blanpied*, 1972). The lime fruit remains attached to the tree for even a whole month because the ethylene production does not start and is lacking entirely also in the AZ tissues.

The gooseberry is inclined to drop the overripe fruits (*Harmat*, 1987), and the detached fruits maintain their stem (*Papp*, 1984a). Green (unripe) gooseberry fruits are never dropped (*Harmat*, 1987).

Raspberry fruits ripen quickly. They are overripe after 2-3 days already, the glossy colour gets dull, they shrivel and

Figure 4. Different types of preharvest fruit drop. A: weak ('Greensliws'), B: moderate ('Earligold'), C: heavy ('Vista Bella') and D: very heavy ('Priam').

are detached from the receptacle and are dropped (*Papp*, 1984c). On the contrary, blackberry fruits remain attached when overripe (*Papp*, 1984d).

The detachment of fully ripe fruits is a natural phenomenon and cannot be considered as an anomaly, it is expression of senescence like that of the leaves in the autumn (*Soltész*, 1997; *Tari*, 2004c).

Specific and varietal properties of fruit drop

The relevant professional literature displays rather different opinions regarding the varietal peculiarities of fruit drop. There are examples, which report experiment, where some combinations of pollinating varieties produced a fairly good fruit set, initially, but the fruit drop continued until harvest time, when all fruits were lost (e.g. the giant apricots). For that reason, data reported in the literature ought to be accepted with severe criticism. Taking into account the economical point of view, the susceptibility to preharvest fruit drop has been considered to be most important.

Let alone the former reservations, we may state that in several fruits, fruit drop is haunting the producers heavily: apple, pear, sour cherry (*Puskás*, 2004), European plum or litchi. In the latter species, the harvested fruit is about 4% of the fruit set experienced after bloom (*Stern & Gazit*, 2003).

There are fruit species, which are almost free from the danger of fruit drop (red currants, walnut, chestnut, *Aronia*, cornelberry, black elder), others are slightly exposed to the phenomenon or the fruit are firmly attached to the plant (e.g. sand berry *Hippophae*, strawberry), which is dissolved at full maturity only as in raspberry and blackberry. In fruit species with little fruit drop, the expected crop, or number fruits is easily predicted after bloom, risking only unexpected damages and ill technological mistakes (*Soltész*, 2003).

In apple varieties 'Berlepsch' or 'Goldenparmäne' close to harvest time, the auxin flow diminishes suddenly, and the abscission layer is formed already when even a mild waft of wind may cause heavy losses. Others – as 'Golden Delicious' or 'Landsberger Renet' – produce auxin continuously, so the harvest requires considerable energy to pick the fruit (*Friedrich*, 2000).

In several apple varieties, harvest is coincident with abscission of fruits. The summer ripe varieties (e.g. 'Julyred', 'Vista Bella') are prone to drop according to several authors (*Way*, 1973; *Soltész*, 1997; *Soltész & Szabó*, 1998). This statement is not valid for all summer ripe varieties, as proving the contrary as 'Snygold'. *Soltész* (2003) claimed that the varieties ripening in the first part of summer are more prone to drop than those of ripening in late summer.

There is a detailed information referring to the fruit drop properties of some important varieties 'Red Rome' (*Faedi & Rosati*, 1973), 'Stayman' (*Faedi & Rosati*, 1975b), 'Jonathan' (*Faedi & Rosati*, 1974; *Gaash* et al., 1993), 'Golden Delicious' (*Rosati* et al., 1977), 'Red Delicious' (*Faedi* et al., 1978; *Gaash* et al., 1993) and related varieties perform variably from the point of view of preharvest fruit drop. 'Red Elstar' is susceptible to drop before maturity, but *Soltész* (2003) assigns to the same group some of the triploid varieties (e.g. 'Mutsu', 'Boskoop'), moreover 'Winter Gold Parmain', 'Šampion' and 'Rubinette'. The same was reported in 'Karmijn de Sonnaville' (*Engel*, 1982), 'Suntan' (*Silbereisen*, 1983), 'Close', 'Jerseymac', 'McIntosh', 'Quinte', 'James Grieve', 'Cox's Orange Pippin' (*Faedi & Rosati*, 1974; *Soltész & Szabó*, 1997). Fruit drop is generally moderated by the spur character, compared with the standard variety (*Gautier*, 1973). For instance, 'Red Delicious' being weak in the rate fruit set, its spur variant is less afflicted by preharvest fruit drop. (*Soltész*, 2002). In Hungary, fruit drop is conspicuously low (55.2–70.4 %) in 'Pink Lady', and it is less dependent on the rootstock used (M9, MM106 and crab or seedling) (Racskó, non published). *Soltész & Szabó* (1998) attribute a low incidence of preharvest fruit drop to the following apple varieties 'Gala', 'Snygold', 'Fiesta', 'Redaphough' and 'Ozark Gold'. The most drop of fruit ensues during the first (post bloom) period in 'Winesap', 'Delicious' and 'Arkansas', whereas 'Baldwin', 'Wealthy' and 'Rome Beauty' shed their fruit mainly in June. It is not a rarity when more than 95 % of the fruits were dropped; all the same, a normal yield and good quality could be harvested n the respective year.

At an earlier harvest, the fruit of 'Jerseymac' is difficult to pick, but later the short fruit stem let the fruit drop easily. The mediocre inclination to drop is met in 'Summerred'. No preharvest drop is imminent in 'Granny Smith', 'Jonager', 'Mollie's Delicious', 'Elstar', 'Kr. 5' and 'Fuji' (*Soltész & Szabó*, 1998).

In pear varieties bearing more fruits per inflorescence, the incidence of preharvest fruit drop is less threatening (e.g. 'Arabitka', 'Général Leclerc', 'Mirandino Rosso', 'Bergamotte d'Esperen', 'Bonne Louise d'Avranches'). Several other pear varieties as a rule drop many fruits before harvest (e.g. 'Passe Crassane', 'Highland', 'Beurré Bosc', 'Pringall') as stated by *Soltész* (1997) and *Molnár* (2004). *Miranda* et al. (2005) compared two pear varieties from the point of view of susceptibility to fruit drop: 'Blanquilla' was less afflicted than 'Conference'. *Göndörné* (1998, 2000) rated 'Beurré d'Hardenpont', 'Alexander Lucas', 'Beurré Diel' and 'Beurré Hardy' as susceptible. *Molnár* (2004) claimed that 'Williams' shed many fruit before getting fully ripe. On the contrary, 'Packham's Triumph' was resistant physiologically and neither drought nor wind could harm to the fruits.

Out of the stone fruits, 'Pándy meggy' was the object of studies on fruit drop by *Murawski & Endlich* (1962), *Molnár* (1963), referring to other sour cherry varieties data were published by *Bradbury* (1929), *Haritonova & Spicyn* (1967), *Spicyn* (1967), *Blasse & Barthold* (1970) as well as *Nyéki* (1978) (*Figure 4*).

Bradbury (1929) and *Thompson* (1996) concluded that sour cherry varieties are prone to fruit drop – especially the self-fertile ones. In the experiment, 'Montmorency' lost 64 %, 'Early Richmond' 70 % of the fruit load until harvest. High rates of fruit drop were observed by Nyéki (1978) in Hungary: in 'Pándy meggy-114' (99.7%), 'Pándy meggy-10' (98.9%). As for the dynamics of fruit drop, early and late types were distinguished; „early" fruit drop was found in 'Cigánymeggy-7', 'Pándy meggy-10' and „late" in 'Báró Jósika', 'Schattenmorelle' as distinct varieties or clones. The sour cherry 'Érdi bőtermő' is especially remarkable by its system of autoregulation, which is expressed in the "yellow" drop, which means that when the fruit was grown to the size of 6-8 mm diameter, a fraction of the load got yellowish and dropped. The fruits maintained on the tree grow to a final size without lagging behind the standard size of the variety (*Apostol*, 1998).

In peach, there are a couple of varieties being inclined to shed fruits heavily (e.g. 'Sunglo', 'Flavortop', 'June Gold', and the hairy clingstone varieties), moreover, that type of fruit drop is difficult to prevent (*Soltész*, 1997). *Szabó* (1998) also mentioned some, which are prone to preharvest fruit drop: 'Fantasia', 'Cresthaven' and 'Loadel'. Heavy occasional losses of fruits were mentioned in 'Sunhaven' by *Timon* (1992). Among nectarines, some varieties are

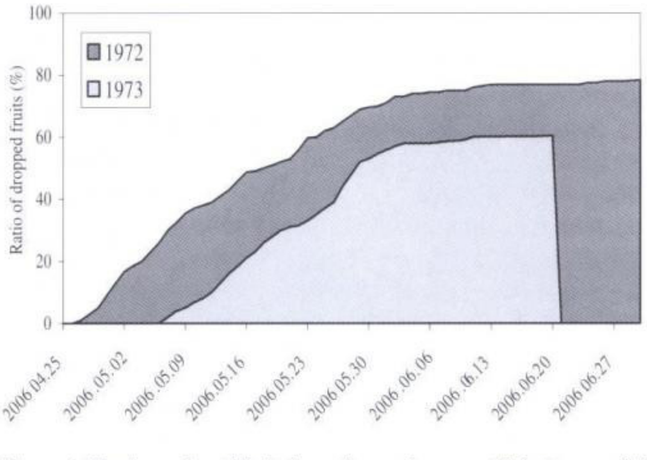

Figure 4. The dynamics of fruit drop of sour cherry cv. 'Schattenmorelle' (*Nyéki*, 1979)

outstanding in fruit drop, as 'Nectaross', 'Prairie Dawn', 'Ozark', 'Madison', 'Golden Jubilee', 'and McKunee'. 'Independence' (*Timon*, 1992), moreover 'Armking', 'Nectaross' and 'Independence' shed fruits until full maturity (*Szabó*, 1998).

Among stone fruits, apricot is the less inclined to drop fruits (*Smykov*, 1974; *Fideghelli & Cappellini*, 1978), especially the varieties 'Veecot' and 'Pannónia' (*Soltész*, 1997), as well as the variety candidate '1553/54' (*Kerek & Nyujtó*, 1998). *Mády & Szalay* (2003) pointed out the 'Orange Red' variety, as the fruits are firmly fastened to the tree and are not shed. On the contrary, 'Magyar kajszi', 'Harcot', 'Bergeron', 'Korai piros' and 'Ceglédi óriás' are varieties afflicted by some fruit drop (even without being infected by the sharka virus). In that case, nocturnal temperature minima (-1 °C) after fruit set are responsible. The major concern in apricots is caused by the shed of flower buds before bloom, according to *Clanet & Salles*, 1974).

Tóth (1966, 1967, 1968) compared different plum varieties from the point of view of fruit drop. The varieties most prone to fruit drop were: 'Althann ringló', 'Vörös nektarin', 'Pacific', 'Italian Blue', 'Ageni 2' and 'Paczelt' varieties (*Figures 5–7*).

According to *Surányi* (1978), 'Italian Blue' is also prone to fruit shed. *Erdős* (1998) reported heavy preharvest fruit drop in 'Čačanska rana', 'Herman', 'Debreceni muskotály', 'Ruth Gerstetter', 'Emma Leppermann', 'Bódi szilva' and 'Besztercei szilva'. 'Sermina' is, on the other hand, slowly ripening and shed fruit gradually along the harvesting period.

Japanese plums, 'Shiro' and 'Black Amber', are not prone to preharvest fruit drop, moreover, fruits may dry on the tree during a spell of drought. Fruit drop occurs mainly in rainy weather as a consequence of *Monilia* infection (*Holb*, 2003, 2004). In that case, abscission layers are not formed at the basis of the peduncle and the fruit is detached from the end of the fruit stem. The abscission layer develops later, after days or even a week in the barren fruit stems (*Racskó*, not published).

Red and black currants are distinct from that point of view and that is generally accepted (*Porpáczy*, 1987). Red

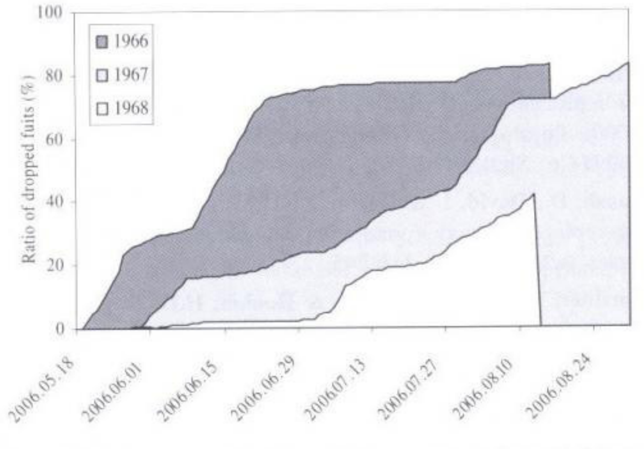

Figure 5. The dynamics of fruit drop of plum cv. 'Olaszkék' (*Tóth*, 1968)

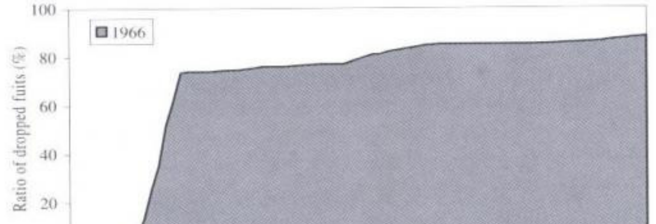

Figure 6. The dynamics of fruit drop of plum cv. 'Pacific' (*Tóth*, 1966)

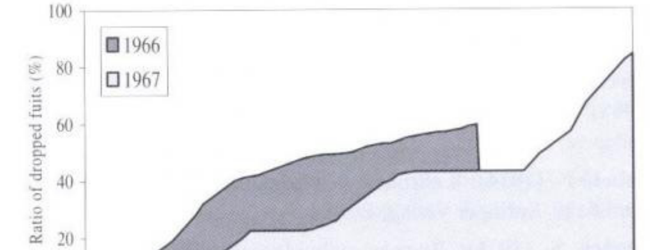

Figure 7. The dynamics of fruit drop of plum cv. 'Vörös nektarin' (*Tóth*, 1967)

currant berries are strongly fastened to the inflorescence (*Papp & Porpáczy*, 1999), whereas the black currant berries are prone to fruit drop. In the progress of ripening, fruit drop is aggravated until all berries may get lost (*Papp*, 1984). The author compared currant varieties from this point of view. The less danger to lose fruits in red currants is experienced in the varieties 'Jonkheer van Tets', 'Heinemanns rote Spätlese', Rondom', 'Redwing' and 'Red Lake'. Even overripe berries remain strongly attached to the inflorescence, which interferes with attempts of mechanised harvest. 'Eva', 'Fertődi 1', 'Hidasi bőtermő', 'Daniel's September', 'Brötorp', 'Silvergieter F.59', 'Pobieda', 'Wellington XXX', 'Tsema', 'Biya', 'Vystavochnaya', 'Willoughby' and 'Neosypayushchayasya' are black currant varieties less prone to shed fruits (*Papp*, 1984; *Porpáczy*, 1998; *Papp & Porpáczy*, 1999), which is praised as an opportunity to prolong the harvesting period (*Kovács*, 1976). 'Aranka', 'Altayskaya desertnaya' are medium susceptible and may drop fruit especially in overripe stage (*Papp*, 1984). *Porpáczy* (1998) claims that 'Ben More' may drop fruit as over ripe. 'Mendip Cross' and 'Ben Sarek' shed fruits heavily when fully ripe (*Porpáczy*, 1998).

Brózik & Nyéki (1975) analysed fertility relations of black currants and their inclination to drop fruits. According to their results, the varieties less inclined to drop fruits are self-fertile, which means that their fertilisation is more efficacious. Intermediate fertility types are also intermediate in their tendency of fruit drop, which means that the fruits of apical position are most affected to be dropped. In autoincompatible varieties all berries on the truss are equally exposed to fruit drop.

Harmat (1987) reported that the variety 'Josta', an interspecific hybrid of currant and gooseberry, is less inclined to fruit drop.

Papp (1984) observed that the gooseberry 'Pallagi óriás' is susceptible to fruit drop, especially in overripe stage. *Harmat* (1998) maintains that a drop of fruit primordia is expected especially when during bloom or subsequently, temperature minima of –3, –5 °C occur. Ripe fruits are easily dropped in the varieties 'Piros ízletes' (*Harmat*, 1998) and 'Gelbe Triumph' (*Papp*, 1984). 'Hönings Früheste', on the contrary, resists to fruit drop even after full maturity and keeps fruits attached for a long time (Harmat, 1987).

Porpáczy (1998), as well as *Porpáczy & Porpáczyné* (1999) studied fruit drop in black elder varieties and stated that in 'Haschberg', 'Donau' varieties and the hybrids 'Fertődi 33', 'Fertődi 479', 'Fertődi 480' and 'Fertődi 481', fruits are firmly attached to the inflorescences, drop neither in adverse weather.

Highbush blueberry (e.g. 'Bluecrop') and *Aronia* (e.g. 'Albigowsky', 'Altayskaya Krupnoplodnaya', 'Viking', 'Rubina', 'Nero' and 'U2') are less prone to drop fruits. The peduncles keep the fruits firmly attached and do not drop. The sandthorn (*Hippophae*) varieties ('Tchuyskaya', 'Obilnaya', 'Oranzhevaya', 'Yantarnaya 4') too do not drop their fruit, moreover, the berries are kept on the tree all over the winter (*Porpáczy & Porpáczyné*, 1999).

Almonds – especially the variety 'Peerless' – and walnuts release their stone fruit by splitting the mesocarp when getting ripe. The fruit utilised consists of the lignified endocarp with the seed (pit) inside, which is dropped. The drop of the stone comprises the phenomenon of maturity. As exceptions are mentioned the almond varieties 'Tétényi kedvenc' and 'Budatétényi 70', which keep attached for a long time on the tree (*Apostol*, 2003). *Ortega* et al. (2004) studied the fruit drop of four almond varieties. After bloom (30 or 60 days later) checking the fruit set, the frequency of fruit drop was the highest in the variety 'Ramillete'.

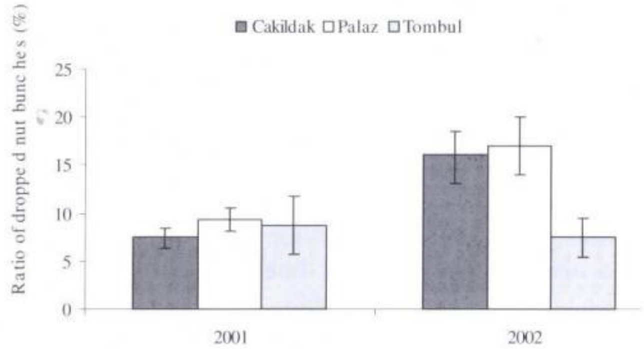

Figure 8. Ratio of dropped nut bunches for different hazelnut varieties (*Serdar & Demir,* 2005)

Serdar & Demir (2005) observed three hazel varieties in Turkey ('Cakildak', 'Palaz', 'Tombul') how the fruit bunches are shed. Though no significant differences were found, but 'Palaz' dropped the most (*Figure 8*).

In Cuba under tropical climate, fruit drop was more frequent in the parthenocarpous grape fruit 'Marsh Seedless' and in the auto-incompatible 'Ortanique' tangor (tangerine) varieties than in the 'Valencia Late' orange bearing many seeds (*Pozo* et al., 1996; *Pozo*, 2001). In California, high frequencies of fruit drop were found in 'Navel' orange (*Coit & Hodgson*, 1919; *Webber*, 1923; *Davies*, 1986)

Acknowledgements

Present study was partially supported by the grant OMFB 00909/2005. of the National Office for Research and Technology (NKTH).

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