New and Unusual Report

Occurrence of Fruit Doubles in the 2004 Season Associated with Heat and Drought Stress in Previous Year

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Abstract

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A higher than normal incidence of fruit doubles occurred in the Czech Republic in the 2004 season. Fruit doubles or twinning was most frequently observed among plum fruits sold in town markets, in mirabelle in small gardens in Prague and environs, and in apple, variety James Grieve, on the experimental plots of the Research Institute of Crop Production, Prague-Ruzyně. In other cases, only the terminal fruits were fully developed, usually in one apple spur, while basal fruits were retarded. Based on meteorological data and literature reports, it can be concluded that the higher incidence of fruit doubles in the CR in 2004 is correlated with heat and drought stress in 2003. The period between August 3 and August 15, 2003, was the time during which differentiating and developing flower buds might have been stressed and injured. In this period, there were high temperatures (30 to 38.9°C) each day and trees suffered water stress.

Keywords: environmental disorder; fruit doubles; *Prunus domestica* L.; *Prunus insititia* convar. *syriaca*; *Malus domestica* L.; Czech Republic

Fruit doubles (doubles, fruit doubling) or fruit twinning (twins) (hereafter referred to as fruit doubles) has been reported for many fruit crops including apple, pear, peach, nectarine, sweet and sour cherry, and plum in many fruit-producing areas of the world, especially in more arid climates. Even quadruple fruit have been observed in peach and sweet cherry (Larsen 2003).

At the beginning of the last century, Smolák (1913) ranked fruit doubles under abnormalities of non-parasitic origin. He mentioned the doubles in plum, sweet cherry and apple in the Czech Lands and noted that many consumers regard doubles in plum as something impure or harmful that is not suitable for consumption.

Fruit doubles is now known to be related to stress of the tree during the time the flower buds are being initiated and developed for the next season. Therefore, the phenomenon is considered an environmental disorder. In sweet cherry, exposure of the buds to high temperature or direct solar radiation during floral induction often results in formation of double pistils. If both pistils of an affected flower are pollinated and eggs are fertilized,

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the seed ovaries fuse along the ventral sutures and develop into doubles. If only one pistil develops, the other forms a spur. Some cultivars are more prone to doubling than others. Apricot and peach buds form double pistils if trees are water-stressed late in the floral induction period. Decreased transpiration rate and high temperature have been implicated as causes of this disorder (Patten *et al.* 1981; Johnson *et al.* 1992, Ryugo 1995).

The phases of floral induction (i.e. the transition of meristem development from vegetative status to reproductive status) and flower initiation (when a series of histological changes are underway, but no visual difference can be observed) are very difficult to distinguish. They are both used to describe the critical period when the buds are sensitive to stimuli which determine their ultimate development. When a bud is induced to be reproductive, it will irreversibly undergo the process of floral organ development, regardless of the internal/external conditions that could affect floral induction. Floral induction and flower initiation is followed by floral differentiation which is characterized by morphological changes in the buds. They start with the appearance of floral primordia, and end with the development of the primordia of other parts of the floral organ. The entire process of differentiation may take 54–112 days depending on species: peach 54–65, sour cherry 56–100; sweet cherry 86–112, plum 48–66 days (Anonymus 2005). Microscopic examination of developing peach buds shows that carpel differentiation occurs in late August and early September (Johnson & Handley 2002). In apples, if the drought persists for a full season, flower bud formation and flower development for the next year may be reduced (Flore & Dennis 1990).

The aim of this paper was to determine whether heat and drought stress on fruit trees during time of bud differentiation and development in 2003 could have lead to doubles as occurred in plum, mirabelle and apple in the Czech Republic in 2004.

MATERIAL AND METHODS

To determine whether stress from heat and drought on fruit trees during time of bud differentiation and development could have been the cause of fruit doubles, the meteorological data from May to August 2003 from 12 locations throughout the Czech Republic were analyzed (Table 1, Figure 1).

RESULTS AND DISCUSSION

In the Czech Republic, a higher than normal incidence of fruit doubles was observed in 2004. Doubles were observed most frequently among plum fruits (*Prunus domestica* L.) at town markets (Figures 2 and 3), in mirabelle (*Prunus insititia* L. convar. *syriaca* (Borkh.) Dostál) in small gardens in Prague and its environs (Figure 6), and in apple (*Malus domestica* Borkh.), cultivar James Grieve, on experimental plots of the Research Institute of Crop Production, Prague-Ruzyně (Figure 8). Spurred plum fruits were also seen (Figures 4 and 5). These probably result when one pistil of the syncarp develops fully while the other develops

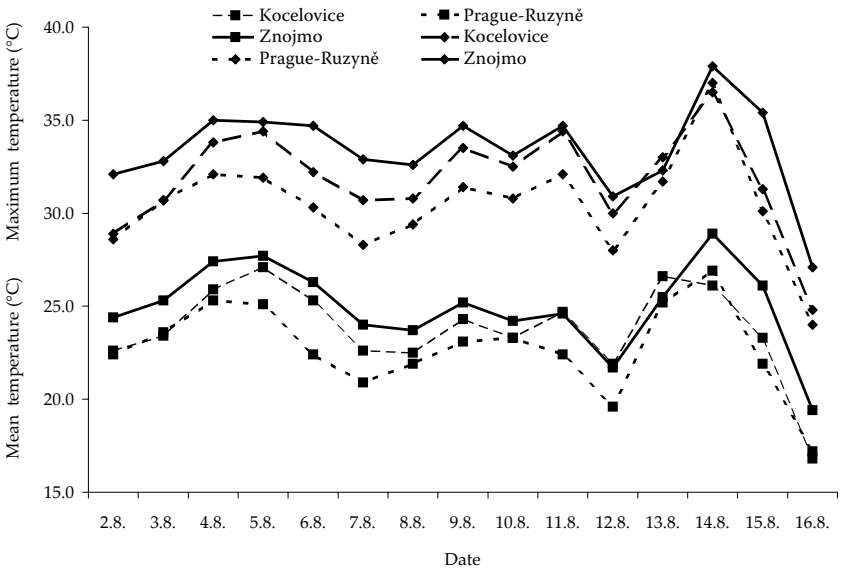

Figure 1. Timing and duration of critical environmental stress at three meteorological stations during 2003 which was probably responsible for fruit doubling in 2004

Table 1. Selected meteorological data for the Czech Republic in the year 2003

Parameter		Month				
		May	June	July	August	September
Monthly mean air temperature compared to normal (°C)	T	15.2	19.6	18.5	20.2	13.3
	Nt	12.3	15.5	16.9	16.4	12.8
	D	2.9	**4.1**	1.6	**3.8**	0.4
Maximum air temperature	°C	32.4	34.5	35.4	**38.3**	30.8
Monthly precipitation compared to normal (mm/m^2)	P	77	40	82	31	31
	Np	74	84	79	78	52
	%	104	**48**	104	**40**	**60**
Sunshine duration (h)	České Budějovice	247.9	311.1	246.8	302.5	210.0
	Praha-Ruzyně	266.4	**333.7**	237.1	311.3	195.9
	Velké Pavlovice	286.2	323.2	256.7	**333.3**	213.6

T – monthly mean air temperature (°C); Nt – longterm normal (1961–1990) (°C); D – deviation from normal (°C); P – monthly precipitation (mm/m^2); Np – longterm normal (1961–1990); % – precipitation as percentage of normal (Sr/N × 100)

Source: Czech Hydrometeorological Institute, Prague; critical data are printed in bold

partially. In apple, fruit twinning was associated with retarded growth of both fruits. In other cases, only the terminal fruits were fully developed, quite often in one apple spur or brachyblast, while basal fruits were retarded in growth (Figure 8).

The analysis of meteorological data indicated that the developing buds might have been stressed and injured during August of 2003. In that month, the mean air temperature was 3.8°C above normal, the maximum air temperature reached 38.3°C, while mean precipitation was 60% lower than normal, and sunshine duration reached 302 to 333 h (Table 1).

A more detailed analysis of meteorological data from three locations in southern Bohemia, central Bohemia and southern Moravia showed (Figure 1) that in the period between August 3 and August 15 the daily maximum temperatures were 28.0 to 37.9°C. It should be emphasized that according to Tucker in 1936 (as cited by Taylor 2004), temperatures on exposed twigs of sweet cherry can easily be 5 to 8°C warmer than the air temperature and reach the sub-lethal range of damage to tender plant tissues. This is especially likely if foliage becomes water stressed and no longer cools the canopy well with transpiration.

Considering the results of our analyses of meteorological data and literature reports, it can be concluded that the higher incidence of fruit doubles in plum, mirabelle and apple in the CR in 2004 was related to heat and drought stress in the previous year. The developing flower buds might have been stressed and injured during the period between August 3 and August 15, 2003, when there were consistently high temperatures of 28 to 37.9°C, and trees suffered water stress.

In apples, quite often only the terminal fruits were fully developed on one spur, while basal fruits were retarded (Figure 8). This may have been connected with the drought persisting for the whole 2003 growth season, with the mean precipitation 60% below normal.

Fruit doubles at harvest are not that easy to handle because of their shape, and they do not market well. Though they can be removed during thinning, the cost of thinning is high. However, the number of fruit doubles on water-stressed trees can be reduced by relieving the stress shortly before and during bud differentiation.

In more arid climates the occurrence of a high percentage of fruit doubles has been associated with water stress due to drought or deficit irrigation. In cherries, the use of overhead sprinkling when the temperature exceeds 30°C has reduced the problem. Another means of amelioration in sweet cherries has been to foster lateral budbreak (spur formation) and maintain the shoots in an upright position to maximize shading of the flower buds in axils of leaves. Yet, once the pistils begin to differentiate, these treatments are ineffective (Ryugo 1995).

Figure 2. Fruit doubles of plum (Photo K. Veverka)

Figure 3. Cross section through a fruit doubles in plum (Photo K. Veverka)

Figure 4. Spured fruit of plum (Photo K. Veverka)

Figure 5. Cross section through spured fruit of plum (Photo K. Veverka)

Peach trees which were well watered during August and September had significantly fewer fruit doubles than trees which were under stress during those months. Growers reported increased

Figure 6. Fruit doubles of mirabelle (Photo V. Kejzar)

Figure 7. Apples spur with fully developed terminal fruit while basal fruits are retarded (Photo K. Veverka)

Figure 8. Fruit doubles of apple. Both fruits were smaller than normal, and their development remained retarded (Photo K. Veverka)

problems with fruit doubles, providing further evidence to support the critical need for timely irrigation in successful peach production (Johnson *et al*. 1992; Striegler 2000).

The occurrence of fruit doubles in the CR in 2004, associated with heat and drought stress in 2003, can be regarded as a relatively rare malady and was unimportant economically. However, we know that temperatures in the summer of 2003 were the highest in Europe of the last 500 years. Similar high temperatures could become more frequent if global warming trends continue. By the middle of this century, many summers could be hotter than 2003, and we might expect more frequent and higher incidences of fruit doubles in Central Europe in the future than in the past.

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Abstrakt

Kůdela V., Krejzar V. (2005): **Výskyt zdvojených plodů v roce 2004 spjatý s teplotním a suchostním stresem v předcházejícím roce**. Plant Protect. Sci., **41**: 27–32.

V roce 2004 se v České republice vyskytla větší četnost zdvojených plodů. V tomto roce jsme zdvojené plody nejčastěji zaznamenali u švestek prodávaných na tržištích, u mirabelek v zahradách v Praze i okolí a u jablek odrůdy James Grieve na pokusném pozemku Výzkumného ústavu rostlinné výroby v Praze-Ruzyni. V některých

případech se na jednom brachyblastu jabloně vyvinul pouze terminální plod, zatímco bazální plody zůstaly zakrnělé. Na základě meteorologických údajů a literárních pramenů jsme došli k závěru, že větší výskyt zdvojených plodů švestky, mirabelky a jabloně souvisel s teplotním a suchostním stresem v roce 2003. Vyvíjející se plody mohly být stresovány a poškozeny v období mezi 2. a 15. srpnem 2003. V této době byly každý den vysoké teploty (30 až 38,9 °C) a stromy trpěly vodním stresem.

Klíčová slova: abiotické poruchy; zdvojené plody; *Prunus domestica* L.; *Prunus insititia* convar. *syriaca*; *Malus domestica* L.; Česká republika

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