Pollen morphology of fruit species

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Key words: pollen, morphology, fruit species

Summary: Size and surface morphology of pollen has been studied in 87 truit varieties of 10 fruit species during the period of 1990-1995. No preceding work of that type came to our knowledge, yet.
The samples comprised a wide variety of cultivars included male sterile, self-incompatible, partially self-fertile stone fruits, diploid and hexaploid plums, diploid and triploid apples.
The large number of species and varieties facilitated the comparison of items within and between the respective species.
It was stated that the size, shape and surface morphology of pollen is genetically determined and those data, combined with other variety characters, are suitable for the classification and distinction of varieties.
In assessment of pollen size and shape, their moisture content is crucial. The major diameter of the swollen pollen as well as the length and width of the dry grains are characteristic to species and/or to variety.
The width and shape changes largely with moisture content. Large grains are proper to quince, apricot, peach and almond, medium sizes are found in apple, sweet cherry, sour cherry, European plum, whereas small size is typical to Japanese plums.
The low number of varieties studied does not allow conclusions concerning differences within pears, quinces and almonds as species. In the rest of species, valid differences have been registered as between varieties.
Within species, as apple and plum, the effect of ploidy (i.e. number of chromosomes) was expressed in the size of their pollen.
In stone fruit species, the correlation between size of anthers and size of pollen grains was positive.
Genetic relations between the self-fertile sour cherry varieties of the *Pándy* type (*Debreceni bőtermő, Kántorjánosi, Újfehértói fürtös*) as well as the self-incompatible apricots of "giant" fruit size are supposed to be analysed by pollen studies but there did not turn out any decisive conclusion, yet. Other characters also should be considered.
The assembly of pollen characters is decisive in the determination of the variety. The ratio of empty pollen grains, the grain size and the density as well as the size of the pits on the surface are best suited to distinguish pollen lots.

Introduction

Morphology of flowers was the basis of classification of fruit species since long.

The morphology of pollen in fruit species was a matter of study since the 70-ies, only. *Erdtman* (1966) then *Schwerdtfeger* (1978) stated that the size and shape of the pollen grains was not sufficient to distinguish between varieties, therefore, the surface of the pollen grains should be observed.

The surface morphology of the pollen, however, species and genera are distinguished easier (*Fogle,* 1977/a, 1977/b, *Maas,* 1977, *Westwood & Challice,* 1978, *Martens & Fretz,* 1980) but for the distinction of varieties within species it is much more difficult (*Fogle* 1977/a, *Maas,* 1977). The surface patterns and physiology may lead to the distinction of standard and spur types within the apple varieties (*Marcucci* et al., 1984). In Hungary, pollen patterns of grape varieties have been analysed first by *Kozma & Scheuringné* (1968) and *Tompáné & Kozma* (1978).

Recent findings marked the difference between sweet and sour cherries (*Kocsisné Molnár* G. et al. (1993) and *Nyéki* et al. (1996), moreover, between apricot varieties (*Davary-Nejad* et al. (1995) by pollen analysis.

Material and methods

During the period of 1990–1995, pollen samples of as many as 87 fruit varieties comprising 10 fruit species have been studied.

Anthers of fully developed flower buds have been removed in the laboratory and dried for some days at room temperature. Measurements are made on the University of Horticulture and on the Semmelweis Medical University.

The **diameter** of pollen has been measured on 50 grains. The anthers (100 per variety) kept in exsiccator burst and released pollen. Pollen grains swell in 40% glycerol-water mixture, then covered by a glass slide and measured by an ocular-micrometer of a light microscope. Later, measurements were made by canning electron microscope (SEM).

For that purpose, from the naturally opened anthers air dry pollen grains are spread on the objective and coated with 30 μm gold by Klazers SCD 040 cathode sprayer. The SEM apparatus used was TESLA BS 300 type. Measure and shape of pollen cannot be assessed exactly until the moisture content hasn't been standardised (*Feagi & Iversen*, 19(4). Detailed comparison of varieties has been made on air dry pollen grains. The characters observed were the length, width and shape index (length/width), rate of empty grains, depth of pores, width of furrows, depth of furrows, width, length and course of ridges, density and size of pits. For technical purpose, different magnifications have been applied (500–10000 time). In 500 x, the rate of empty grains is fixed, in 1000 to 2000 x the measures, shape, depth of pores of the grains are assessed, whereas 5000 to 10000 x is suitable for the measurement of furrows, ridges and pits.

Morphological properties of pollen grains are summarised by the following components:

1. pollen diameter: the largest measure of the moist (swollen) grain in μm
2. pollen length: the longest measure of air dry grain in μm
3. pollen width: the shortest measure of air dry grain in μm
4. shape index: the quotient of length and width of the dry grain
5. rate of empty, underdeveloped, abnormal, grains estimated. Groups: no, rare, frequent
6. depth of the pores: those are this-walled openings where pollen tubes emerge. Estimated groups: shallow, medium deep, deep,
7. width of furrows: distance between the ridges. Estimates: narrow, medium narrow, wide.
8. depth of furrows: estimated as shallow, medium deep, deep.
9. width of ridges: elevations running along the grain surface. Measurements are taken on SEM copies taking in account the magnification of the pictures.
10. length of ridges: are related to the length of the grain. Estimated as short, intermediate, long.
11. course of ridges: the mutual relation of ridges as estimated: straight, winding, entangled.
12. density of pits: pits are perforations on the surface of furrows. Estimates: lacking, rare, medium density, high density.
13. size of pits: estimated as: small, intermediate, large, or measured on SEM pictures.

As far as pollen grains of the same sample gave variable values of one character, the latter has been judged to be unstable or variable.

Results

Differences between species and varieties.

The measures of the pollen grains

The 10 species investigated are classified according to their characters measured on the pollen grains. In *Table 1* the maximal diameter of the swollen grains is presented. The length values obtained of dry pollen grains show similar tendencies *(Table 2)*. The sequence of values in decreasing order did not change: apricot (largest), European plum, sour cherry, sweet cherry, oriental plum.

Measurements on dry pollen grains have been performed on apple, quince and almond varieties too. According to the classification of Erdtman (1966), quince and almond pollen is considered as large (more than 50 μm), apple pollen as intermediate.

Length and width, as well as their ratio, i.e. the shape index of the dry pollen-grain, revealed equally differences between species.

Sweet cherries fell into the category between 30–51.8 μm, the majority in the interval of 33.9–35 μm. *Bigarreau Burlat* pollen was exceptionally large (51.8 μm).

Table 1 Diameter of the pollen grains in stone fruit species (Kecskemét and Helvécia, 1990)

Species	Number of varieties studied	Diameter of pollen grains (μm)		
		minimum	maximum	mean
Sweet cherry	5	32.6	51.8	36.9
Sour cherry	8	34.9	45.3	39.6
European plum	10	42.4	48.4	45.6
Japanese plum	3	26.4	34.2	31.0
Apricot	10	35.5	59.2	50.3
Peach	10	47.5	70.1	58.7

Table 2 Size and shape of pollen grains in fruit species (1990–1995)

Species	Number of varieties	Size of pollen grains								
		Length (m)			Width (m)			Shape index		
		minimum	maximum	mean	minimum	maximum	mean	minimum	maximum	mean
Apple	17	34.1	51.2	44.0	19.4	27.6	23.1	1.23	2.21	1.9
Quince	2	50.4	54.4	52.4	23.6	24.1	23.9	2.1	2.26	2.18
Sweet cherry	1			43.9			23.2			1.89
Sour cherry	8	45.3	56.5	49.8	25.2	29.6	26.7	1.62	2.2	1.87
European plum	5	43.9	54.6	50.0	23.8	28.5	27.1	1.54	2.29	1.85
Japanese plum	1			40.8			22.5			1.81
Apricot	7	49.6	59.2	54.4	26.8	29.8	28.2	1.81	2.07	1.93
Almond	2	51.9	54.0	53.0	29.5	31.2	30.4	1.66	1.83	1.74
Mean of species	**43 (gross)**			**48.5**			**25.6**			**1.90**

Table 3 Size of pollen grains in stone fruit varieties (Kecskemét and Helvécia. 1990)

Sweet cherry		Sour cherry		European plum		Japanese plum		Apricot		Peach	
Variety	μ	Variety	μ	Variety	μ	Variety	μ	Variety	μ	Variety	μ
Bigarreau Burlat	51.8	Cigánymeggy 7.	34.9	Cacanska lepotica	46.4	Duarte	32.5	Bergeron	35.5	Babygold	49.9
Germersdorfi óriás	32.9	Cigánymeggy 59.	45.3	Cacanska rodna	48.4	Friar	26.4	Borsi-féle kései rózsa	45.1	Independence	47.3
Jaboulay	33.3	Debreceni bőtermő	37.8	Cacanska rana	43.0	Elephant Heart	34.2	Ceglédi bíbor kajszi	52.6	J.H. Hale	70.1
Szamolyai fekete	32.6	Érdi bőtermő	37.1	Althann ringló	44.8			Ceglédi óriás	48.6	Loadel	58.7
Van	33.9	Kántorjánosi I.	43.8	Besztercei Bb.416	47.7			Gönci magyar kajszi	45.8	Nectared 4.	67.2
		Meteor korai	44.6	Bluefre	44.6			Kései rózsa	57.1	Redhaven	49.9
		Pándy	36.5	Debreceni muskotály	45.6			Mandulakajszi	54.4	Springtime	52.2
		Újfehértói fürtös	35.2	Gras ameliorat	48.8			Nagykőrösi óriás	57.3	Stark Sunglo	60.8
				President	44.6			Pannónia	47.2	Suncrest	61.1

Sour cherry varieties were between 34.8 μm as *Cigánymeggy* and 46.61 μm as *Meteor korai*. This latter variety was distinct from the rest of that species with its stable size.

In diploid oriental plums were found the smallest dimensions, 31.0 μm as a mean, and within the group, *Duarte* with 26.4μm, as an extreme.

European plums as hexaploids showed more than 40 ìm and a rather even distribution in the varieties.

Apricots, however, displayed variable pollen sizes. The smallest, 35.3 μm was in *Bergeron*, the largest, 59.2 μm, in *Szegedi mammut* variety. For self-incompatible varieties, values around 50 μm or higher were typical, whereas the rest of varieties fell into the interval between 45 to 50 μm, *Bergeron* being an exception.

Pollen samples of peaches produced the largest sizes between 47.4 and 70.1 μm. The grains of *J. H. Hale*, a male sterile variety, represented the top but most of them were enucleated. There were three varieties only below 50 μm: *Babygold 5* (49.9), *Independence* (47.4), *Redhaven* (49.9).

Significant differences between varieties have been found in apricots and peaches.

Our results prove that the pollen grains of fruit species belonging to the Rosaceae family are prone to be distinguished from each other according to their quantitative traits of morphology (diameter of the swollen grains, length and width as well as their ratio or shape index of the dry grains). Larger differences within the species are associated with some of the varieties.

Diameters of the swollen pollen grains in stone fruit varieties are summarised in *Table 3*. Species are distinguished according to their quantitative data. Peaches are on the top (58.7 μm), apricots (50.3 μm) follow, European plums are intermediate (45.6 μm). Sour cherries, sweet cherries and oriental plums produced less than 40 μm diameters.

A comparison with earlier findings (*Kovácsné Molnár* et al., 1995) allow the statement that measures of anthers and pollen grains are positively related with each other. Peach and apricots have larger anthers, and varieties within those species show the same tendency which is valid between and within other species: sweet and sour cherries, European and oriental plums having different size of anthers too.

Measurements made on dry pollen samples are presented in *Tables 4* to 7. The majority of apple varieties is diploid, *Maligahibrid* and *Malus sp*, however, have not be checked yet. The assortment of triploids: *Jonagold, Mutsu, Red Jonagold (Figure 1)* and *Red Winesap* were all different, significantly, from the average in measures of pollen grains. The first three had larger, Red Winesap smaller and less elongated grains. In most sour cherries and plums, the length of dry grains trespassed the diameter of the swollen grains, on the contrary, in apricot this relation was reversed.

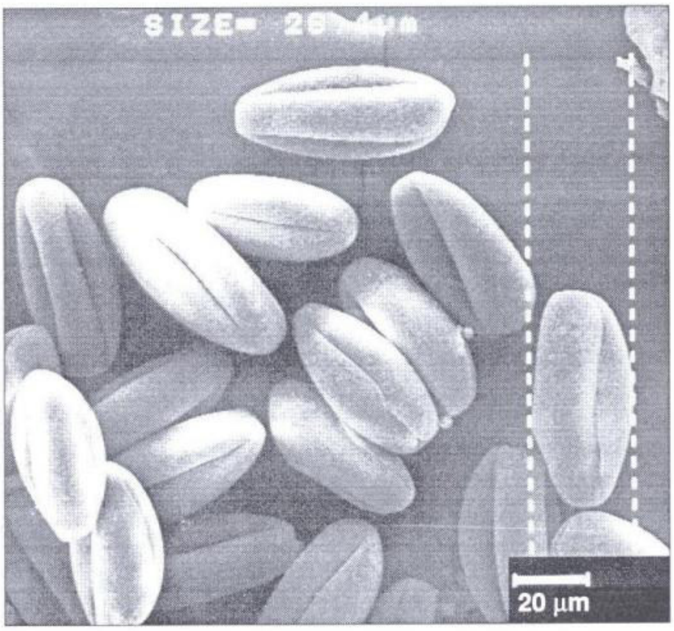

Figure 1 The pollen of the apple, *Jonagold*, is relatively large and elongated

The surface morphology of the pollen grains

Characteristics appearing on the surface of pollen grains are presented in *Tables 4* to 7. Patterns of the surface look different depending on the point of view, being either equatorial or polar (*Marcucci* et al., 1984). The analysis was focused on the equatorial view. The course of the ridges on apple pollen grains was either straight (*Gloster*), or interlaced (*Idared*) or even show branching patterns (*Malus sp*). The presence, density and size of pits on the grains also are indications of varieties, e.g. on *Red Winesap*, pits are rare.

Table 4 Morphological properties of pollen grains in apple varieties (1990–1995)

Variety	Pollen grain length (μm)	Pollen grain width (μm)	Shape index	Empty grain frequency	Depth of the pores	Width of furrows	Depth of the furrows	Width of ridges (μm)	Length of ridges	Course of ridges	Density of pits	Size of pits (μm)
Ananász renet				frequent	shallow	narrow		0.25	long	straight	lacking	
Duncan Red	45.3	22.9								straight	rare	small
Delicious Elstar	47.0	22.9	2.05							interlaced	intermediate	large
Golden Delicious Dánia)	41.2	24.1	1.71							straight	dense	large
Granny Smith	45.8	24.1	1.90							straight	dense	large
Gloster	46.5	23.5	1.98							straight	rare	small
Idared	44.1	21.7	2.03							interlaced	rare	
Jonagold	48.5	23.4	2.07	lacking	deep	large		0.2–0.4	long	straight	intermediate	01.–0.2
Jonathan M41	43.5	21.0	2.07		deep		intermediate	0.3	long	straight	rare	0.25
London pepin	43.6	20.7	2.11	lacking	shallow	narrow		0.25–0.3	long	straight	dense	0.15
Mutsu	51.2	25.4	2.01							interlaced	rare	large
Maliga hibrid	36.5	24.7	1.48							straight	intermediate	
Red Winesap	34.1	27.6	1.23							interlaced	lacking	
Red Jonagold	49.4	23.5	2.10							interlaced	dense	large
Redspur Delicious	40.6	23.5	1.70							interlaced	rare	small
Starking Nm 251				lacking	shallow		shallow		long	straight	lacking	
Summered	42.9	19.4	2.21							straight	intermediate	large
Téli piros pogácsa					lacking	shallow	narrow			short	interlaced	rare
Watson	45.2	21.7	2.08							interlaced	rare	
Jonathan	42.3	22.9	1.85							interlaced	intermediate	
Malus sp												

Table 5 Morphological properties of pollen grains in sweet and sour cherry varieties (1990–1995)

Variety	Pollen grain length (μm)	Pollen grain width (μm)	Shape index	Empty grain frequency	Depth of the pores	Width of furrows	Depth of the furrows	Width of ridges (μm)	Length of ridges	Course of ridges	Density of pits	Size of pits (μm)
Sweet cherry												
Bigerrau Burlat					intermediate	large				straight	intermediate	
Germersdorfi óriás	43.9	23.2	1.89	frequent	deep	large	deep	0.7	long	straight	variable	0.2
Jaboulay				frequent		narrow			short	undulate	lacking	
Szomolyai fekete					deep	intermediate				straight	rare	
Sour cherry												
Cigánymeggy 7	45.3	27.9	1.62	frequent	intermediate	large	intermediate	0.7	long	straight	intermediate	0.2
Debreceni bőtermő	47.6	25.2	1.89	frequent	intermediate	large		0.4	intermediate	interlaced	variable	0.1
Érdi bőtermő					deep	large	deep		long	straight	rare	
Kántorjánosi	50.8	29.6	1.72	frequent	intermediate			0.4–0.6	intermediate	interlaced	rare	0.1–0.3
Pándy 7	48.8	27.7	1.76	rare	intermediate	variable	variable	0.8–0.9	long	straight	Rare	0.1
Pándy 114	56.5	25.7	2.20	frequent	intermediate	intermediate		0.6	long	straight	Rare	0.1–0.2
Pándy 279	52.4	25.6	2.05	frequent	deep			0.4–0.6	intermediate	interlaced	Lacking	
Sárándi S/GY	48.0	26.4	1.82	frequent	shallow			0.4–0.6	short	interlaced	Dense	0.2–0.3
Újfehértói fürtös	48.7	25.8	1.89	frequent		large	shallow	0.4-0.9	intermediate	straight	Lacking	

Low density of pits is proper to *Redspur Delicious*, whereas high density to *Red Jonagold (Figure 2)*. Very small pits are found on *Gloster*, the largest ones on *Granny Smith* pollen.

Differences between diploid and tetraploid varieties cannot be detected in surface-morphology alone. The shape, size and surface markers together, however, are suited to establish identities of some varieties as well as groups of varieties. The variation of ridges is less pronounced then the size and density of pits. Genetic kinship of varieties is expressed in properties of the pollen grains too.

The *Red Delicious* group of varieties (*Duncan Red Delicious, Gloster, Redspur Delicious*) bear few and small pits, whereas in the *Golden Delicious* (*Elstar, Golden Delicious Dania", Mutsu, Summerred*) large and dense pitting is common on the grains.

In **pear and quince**, the low number of samples does not allow conclusions concerning varieties.

Table 6 Morphological properties of pollen grains in European and Japanese plum varieties (1990–1995)

Variety	Pollen grain		Shape index	Empty grain frequency	Depth of the pores	Width of furrows	Depth of the furrows	Width of ridges (µm)	Length of ridges	Course of ridges	Density of pits	Size of pits (µm)
	length (µm)	width (µm)										
European plum												
Althann ringló	54.6	23.8	2.29		shallow			0.6–0.8		straight	rare	
Besztercei szilva	43.9	28.5	1.54	rare	intermediate	large	shallow	0.5	intermediate	undulate	dense	0.2–0.5
Cacanska najbolja	52.6	27.7	1.90	rare	intermediate	narrow	shallow	0.5–0.6	intermediate	straight	dense	0.2–0.3
President	53.4	27.4	1.95	frequent	variable	narrow		0.4–0.6	long	straight	dense	0.1–0.2
Stanley	45.7	27.9	1.69	rare	intermediate	narrow		0.6–0.7	long	undulate	variable	
Japanese plum												
Burbank				frequent		narrow		0.5		straight	intermediate	
Duarte					shallow				short	undulate	rare	
Elephant					deep				short	straight	dense	
Friar					deep	narrow			short	straight		
Laroda	40.8	22.5	1.81	rare	variable	narrow		0.3–0.4		straight	intermediate	0.1–0.2

Table 7 Morphological properties of the pollen grains in apricot varieties (1990–1995)

Variety	Pollen grain		Shape index	Empty grain frequency	Depth of the pores	Width of furrows	Depth of the furrows	Width of ridges (µm)	Length of ridges	Course of ridges	Density of pits	Size of pits (µm)
	length (µm)	width (µm)										
Bergeron					shallow	narrow	deep		short	straight	rare	
Borsi féle kései rózsa				straight	deep rare	narrow	shallow					
Ceglédi bíbor-kajszi	54.6	26.8	2.05	rare	variable	narrow		0.4–0.5	long	straight	intermediate	0.15–0.2
Ceglédi óriás	54.9	28.3	1.95	rare	variable	narrow	shallow	0.6	variable	variable	variable	0.1–0.3
Gönci magyar kajszi	55.5	29.8	1.88	rare	variable	narrow		0.4–0.6	long	straight	rare	0.1
Ligeti óriás	52.1	28.8	1.81	rare	variable			0.4–0.6	long	variable	variable	0.1–0.3
Magyar kajszi C235	49.6	26.8	1.85	rare	shallow	narrow			long	straight	lacking	
Nagykõrösi óriás	59.2	28.5	2.07	rare	intermediate	narrow	shallow	0.4–0.6	long	variable	intermediate	0.1–0.2
Szegedi mammut	55.0	28.3	1.95	rare	deep	narrow	shallow		intermediate	variable	intermediate	0.1–0.2

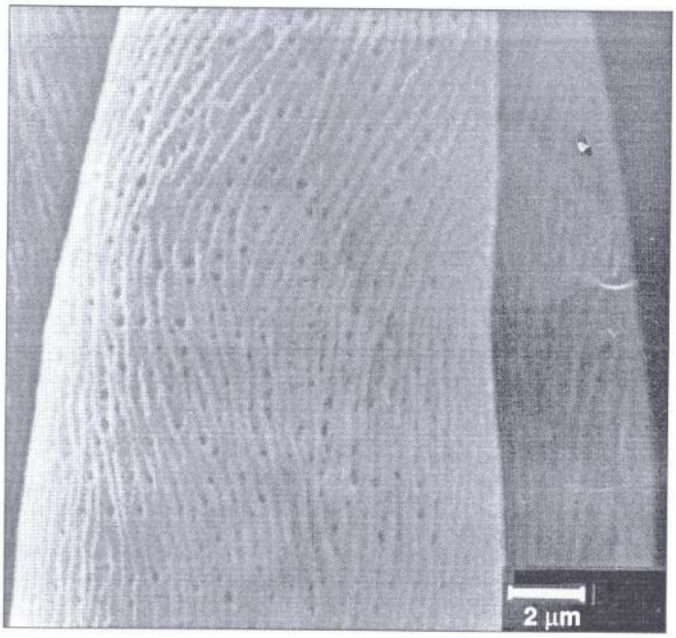

Figure 2 Pits on the pollen of *Red Jonagold*

In samples of the **sweet cherry** *(Figure 3)* varieties, *Jaboulay* and *Szomolyai fekete,* the high frequency of empty pollen grains was observed. The pore of the tube is extended to the whole length of the grain and is intermediate or deep in all sweet cherry varieties. Ridges are pronounced, except in *Jaboulay*. The furrows are parallel, in general, which is true for *Szomolyai fekete.* Whirls of variable size are to be found on the pollen grains of the other three varieties. Pits (perforations of the coat) are common on all varieties except on *Jaboulay.* They are most pronounced in *Szomolyai fekete,* whereas the pits in *Bigarreau Burlat* are a great deal less frequent and shallow. The irregular and off shape pollen grains are frequently met in samples of sour cherry varieties, except the *Pándy 7.* The pore is in the majority of varieties deep and longitudinally extended to the whole surface.

The ridges are straight, and whirls of different size are appearing near to the pore on grains of *Újfehértói fürtös,* **sour cherry**. On the pollen of *Pándy 7 (Figure 4),* on the other hand, furrows are branching and there are no whirls. The furrows are long and their ending is not very thin. The surface is distinct, in

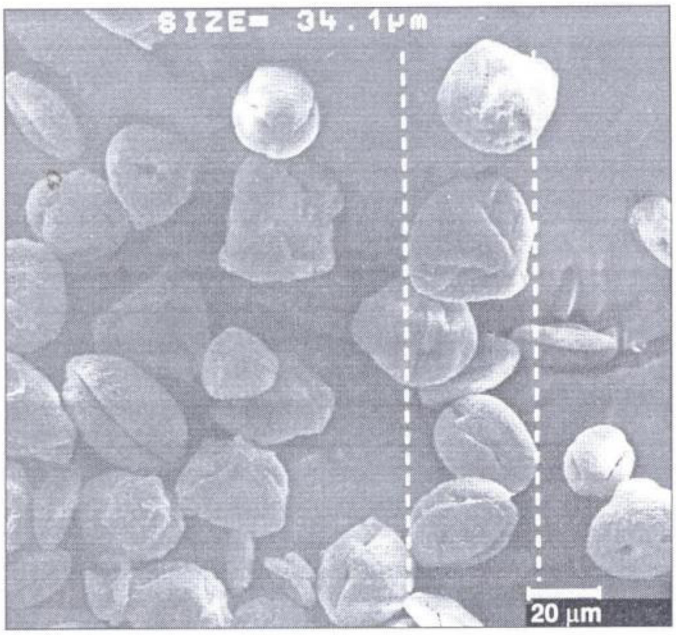

Figure 3 Normal and underdeveloped pollen grains of the sweet cherry *Germersdorfi óriás.*

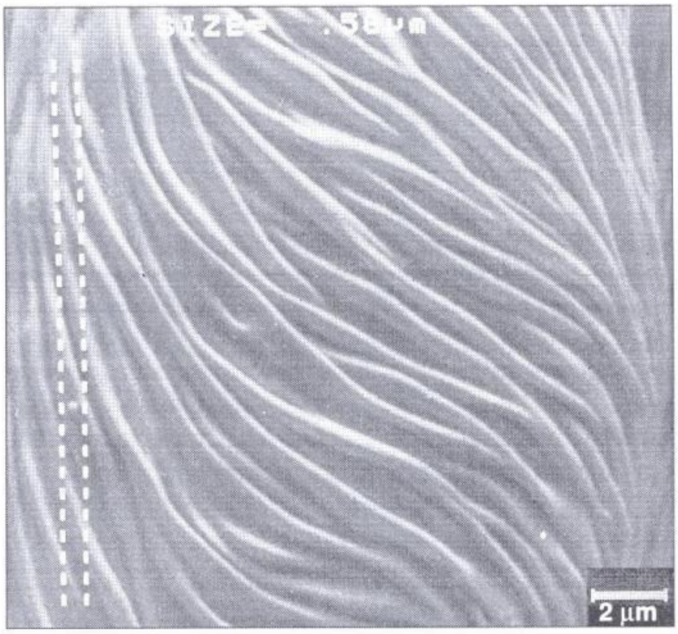

Figure 4 The ridges are branching on the pollen grains of the sour cherry *Pándy 7.*

case of *Cigánymeggy 7* "abraded". Pits are lacking or rare in most varieties, *(Figure 5)* but dense in *Sárándi S/Gy.*

Among **European plums,** *Althann ringló,* is excelling from the majority of varieties with its pore on the grain not being depressed. The ridges show frequently whirling patterns on *President* pollen grains *(Figure 6).* The ridges (laths) are tightly packed and their surface is "abraded" on grains of *Althann ringló.* Pits are densely found on grains of European plums except on *Althann ringló (Figure 7).*

The pore on pollen grains is variable in **Japanese plums.** Ridges are short and tightly arranged in *Duarte* and *Friar.* Surface of the furrows is "abraded" and there are small whirls. Conspicuous pits are visible on grains of *Elephant Heart,* only.

In **apricot** samples contain few empty pollen grains. There is less marked ruggedness, furrows are shallow and narrow *(Figure 8* and *9).* Ridges are straight, whirls are not typical. The presence of pits is variable according to varieties.

Size and shape of pollen grains is very variable in **peaches.** The ridges are straight, whirls are larger or smaller in case of *Springtime.* Pits are rare. The nectarine variety *Independence,* grew knobs on the surface of furrows of the pollen grain *(Figure 10).*

The two **almond** varieties had very similar, indistinguishable pollen grains *(Figure 10).*

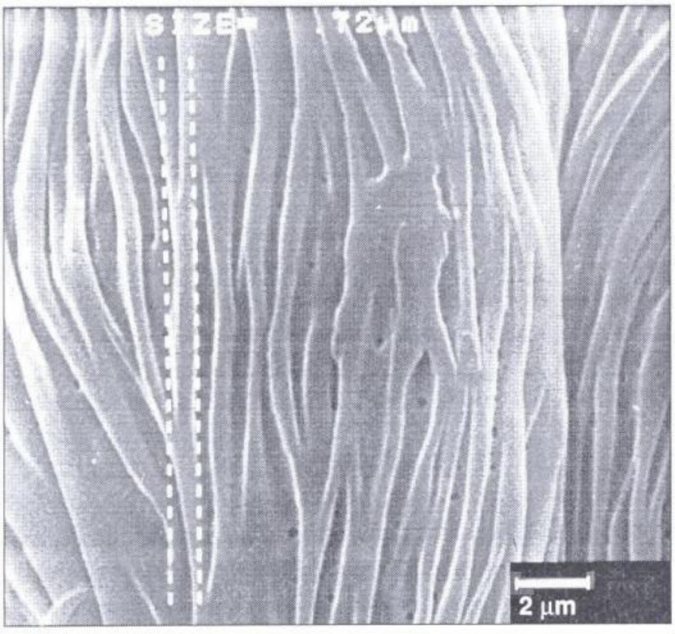

Figure 5 Pits are rare on the pollen of the sour cherry *Újfehértói fürtös*

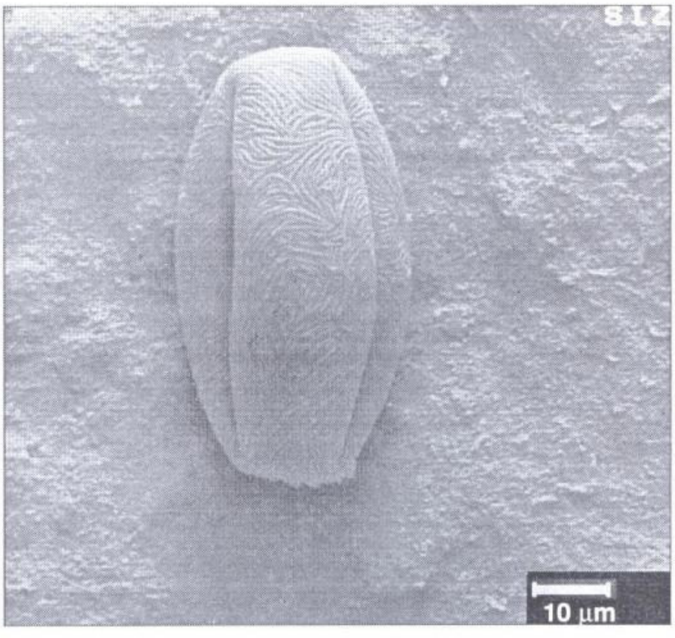

Figure 6 The pollen of the plum cultivar, *President,* is remarkable of the whirling ridges

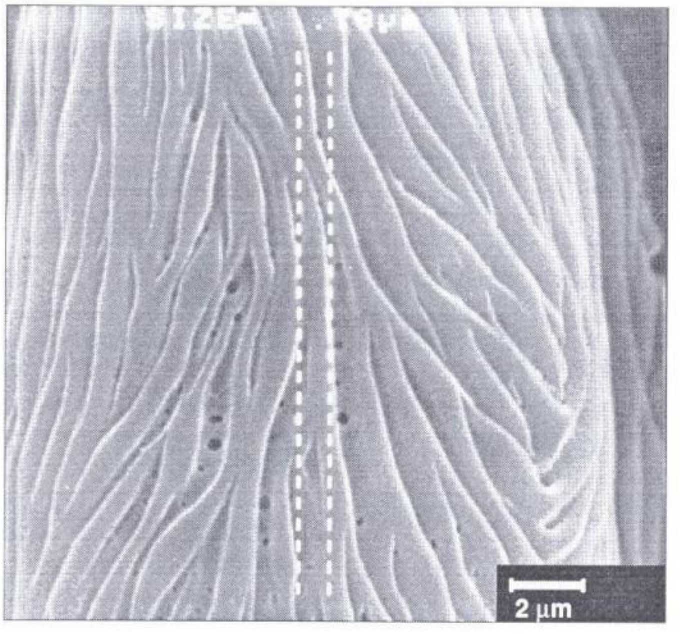

Figure 7 Pollen of the plum cultivar, *Althann ringló*, has few pits, only

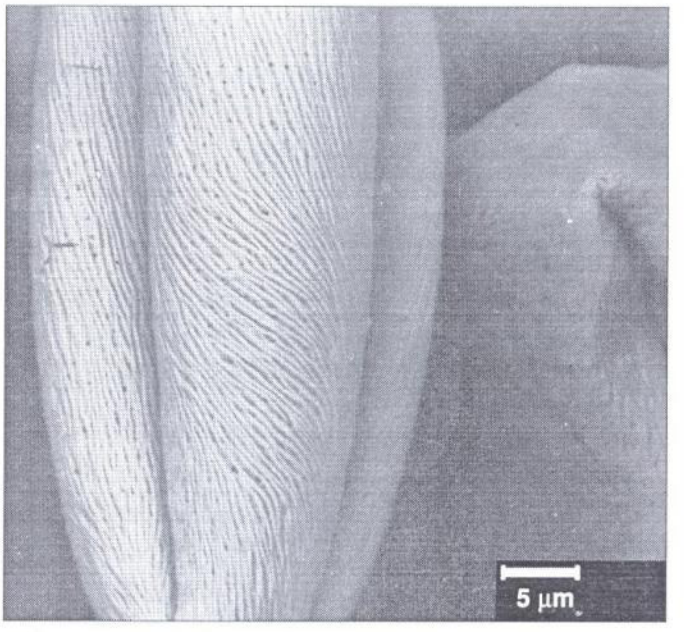

Figure 8 Pollen grain of *Ceglédi bíborkajszi*, apricot variety with long, relatively straight ridges and narrow furrows

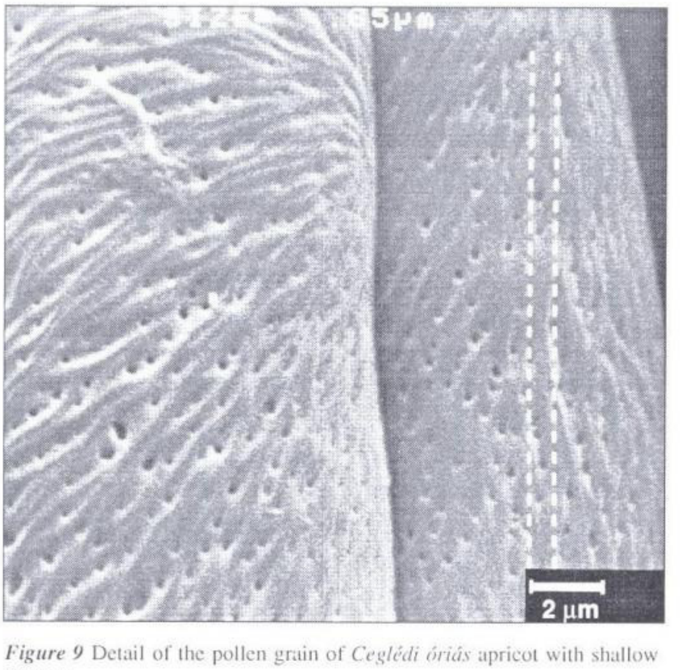

Figure 9 Detail of the pollen grain of *Ceglédi óriás* apricot with shallow furrows

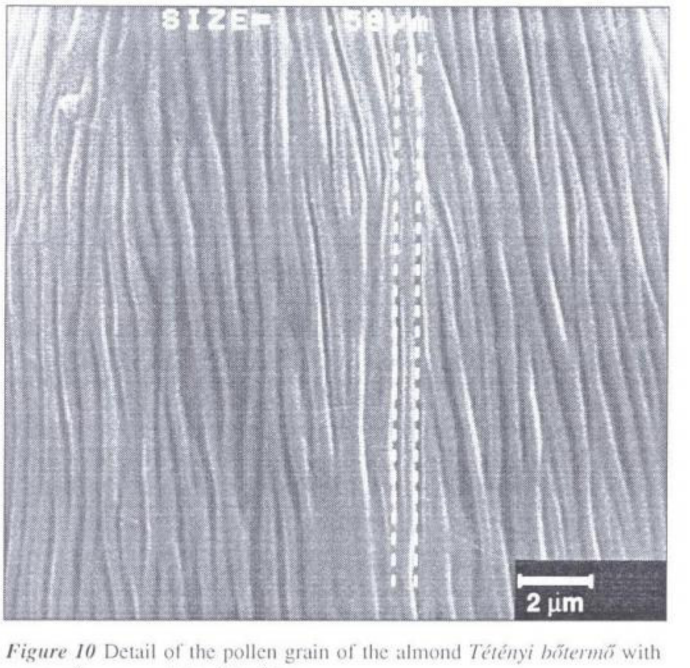

Figure 10 Detail of the pollen grain of the almond *Tétényi bőtermő* with narrow furrows and straight ridges

Characterisation of variety-groups

The sour cherry varieties, *Debreceni bőtermő, Kántorjánosi* and *Újfehértói fürtös*, self-fertile and *Pándy*, self-incompatible, are relatives of each other according to proofs presented by *Nyéki & Szabó* (1995) in morphological terms as their vegetative organs, flowers and fruits, moreover, by their mutual fertility relations. Their pollen morphology proved to be equally similar the frequency of empty grains included. The pollen size of those four varieties as well as the presence of empty grains is the same. No essential difference has been found in the width and depth of furrows, as well as in the width, length and course of ridges. The density of pits, however, showed significant variation. There are no pits on the samples of *Pándy 279* and *Újfehértói fürtös*, whereas rare or variable density of pits was found on *Debreceni bőtermő*.

Pollen properties are considered as proofs of genetic relation in apricot varieties too. The "giant" type group of varieties (*Ceglédi óriás, Ligeti óriás, Nagykőröst óriás, Nagykőrösi óriás*) represent the same type of fertility (*Nyéki & Szabó* 1995). The study of their pollen proves that the yearly variation of the size and shape is higher than the difference between the varieties. The very cause of the differences may find an explanation in seasonal effects, different moisture content, low number of replicates as well as in the subjectivity of the observations. The available data do not exclude the hypothesis of close kinship of the respective varieties.

Discussion and conclusions

It was stated on the base of data obtained that the values of the measurements made on the pollen grains as well as the properties observed on the surface morphology are suitable for establishing groups of varieties coincident with those based on other traits serving as criteria of classification.

For the evaluation of data we should keep in mind the influence of circumstances like moisture content which may modify the values (width, length, depth of pore, etc), substantially. Thus the preparation of samples requires much care and uniformity. The values of the pollen-size are obtained, alternatively, in moist (swollen) or in air dry condition. The fact of obtaining the same sequence of samples if the values of diameter of swollen grains and on the other hand of length and width of air dry pollen grains are taken in account, is convincing. The basic pollen patterns of all stone fruit varieties are the same, the dry grains are long-elliptic. As stated by *Fogle* (1977a) and *Marcucci* et al. (1984), the raising of ploidy is related to increasing size of the pollen grains. Triploid apples, like *Jonagold, Red Jonagold, Mutsu,* have larger than average pollen size (pollen of the *Red Winesap,* however, is the smallest). Hexapoid European plums produce larger pollen grains than the oriental plums.

In *Table 8*, the characteristic traits of the species are presented. More than 75% of coincidence of observations has been considered as decisive.

The frequency of empty grains in the sample was rather a specific trait as within the species, between varieties, differences are less pronounced. The density, length and whirls of ridges marked differences between varieties. The number of pores on the grain was three in each species. The depth of the pore depended on the degree of swelling (moisture content). The width, depth of furrows and the length of the ridges was assessed by estimation, though measurement of the dimensions may furnish more exact information. The course of the ridges on the parts of the pollen grain was different.

The density and size of pits on the surface of pollen was useful in the distinction of varieties as stated by *Fogle* (1977a) and *Marcucci* et al (1984) earlier.

Summing up our results, we state that properties, size, shape, surface morphology of pollen grains are genetically determined traits suitable for the purpose of differentiate between species, groups of varieties, moreover, in some cases, to identify individual varieties. The effect of seasons, the physiological status (condition) of the plant, however, may modify those traits.

The values of the parameters obtained by the measurement made on pollen grains are largely dependent on the method of sampling. The validity and reliability of the statements concerning morphological relations may be enhanced by replications over several seasons and individuals of the same varieties.

Individual morphological indices of pollen grains are not sufficient to distinguish between varieties or other types, we need the ensemble of more traits.

Suggestion for further investigations

For the enhancement of reliability of the morphological study of pollen grains, the following suggestions are attempted:

1. As weather conditions are acting decisively on the quantity and morphology of pollen grains, each variety should be sampled through several seasons.
2. In order to decide on the differences between species, more than 5 varieties should represent one species.
3. The groups of varieties should be explored further on.
4. Flower morphology is largely dependent on the position of the fruiting organ on the tree. Consequently, in sampling of flowers one has to consider that relation too.
5. Patterns of the surface morphology are analysed on pictures. Ten grains, at least, should be compared in each sample.
6. The furrows, ridges and pits to be characterised should be selected from the same regions of the grains to be compared, objectively.

Table 8 Morphological properties of the pollen grains in fruit species (1990–1995)

Variety	Number of varieties	Frequency of empty grains	Depth of pores	Width of furrows	Depth of furrows	Width of ridges (μm)	Length of ridges	Course of ridges	Density of pits	Size of pits (μm)
Apple	20	may occur	shallow	narrow		0.2–0.4	long	straight or interlaced	variable	0.1–0.25
Pear	3	may occur	shallow	narrow			long	straight	lacking	
Quince	2						long	straight	intermediate	0.2–0.4
Sweet cherry	4		deep	variable				straight	variable	
Sour cherry	9	frequent	intermediate	large		0.4–0.9	variable	variable	variable	0.1–0.3
European plum	5	rare	intermediate	narrow	shallow	0.4–0.8	variable	variable	dense	0.1–0.5
Japanese plum	5	variable	variable	narrow		0.3–0.5		straight	variable	
Apricot	9	rare	variable	narrow	shallow	0.4–0.6	long	straight	variable	0.1–0.3
Peach	3		variable	narrow	variable		long	straight	rare	
Almond	2	rare	shallow	narrow		0.6	long	straight	rare	0.1–0.2

It is important to reduce the subjective components of the characterisations. Instead of estimation, exact measurements and counts should substitute the assessment of depth and width of furrows, width and length of ridges, density and size of pits.

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