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Effect of Metaxenia on the Fruit Quality of Scab Resistant Apple Varieties

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Abstract

Fruit quality of apples is influenced by the metaxenic pollen effect of the pollinators. At RIFG Pitesti, the flowers of two scab resistant cultivars ('Topaz' and 'Dalinette') were hand pollinated with other apple cultivars: one scab resistant ('Priam') and two scab susceptible ('Golden Delicious' and 'Idared'). Morphological parameters of fruit (diameter, weight, seed number, skin colour) and quality parameters (firmness, refraction) was investigated at the harvesting time in the Genetic and Breeding Department in order to prove the metaxenic effect. 'Topaz' fruits obtained from pollination with 'Priam' and 'Golden Delicious' were recorded good size parameters (diameter, weight) and flesh quality (firmness and refraction). In case of 'Dalinette' fruits, among cultivars used as pollinator, 'Idared' caused the biggest fruits with flesh firmness.

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Keywords: fruit colour, fruit set, fruit size, Malus x domestica, seed number

1. Introduction

Most apple cultivars are considered self-incompatible, that the cross pollination is very important. When choosing the apple varieties for a new orchard some aspects, like blooming time, compatibility, harvest time, resistant/susceptibility of pest and diseases should be taken into consideration (Bodor et al., 2008). Also, metaxenia effect of the pollen helps to select apple parents (paternal) in order to improve the quality of pollination (Liu et al., 2000; Lukic et al., 2013; Rejman, 1983).

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The term ”xenia” (first description by Wilhelm Focke, in 1881) was originally coined to describe such differences in the size, shape, color, developmental timing and chemical composition of seeds and fruits found as a result of fertilization by different pollens. These effects on tissues of purely maternal origin, rather than on parts resulting from syngamy, have also been named ”metaxenia” (Swingle, 1928; Bodor, 2009). Both,”xenia” and ”metaxenia”, are based upon a Greek root, xenos, meaning ”a foreigner or guest”.

The effects of the phenomenon was proved at different species for qualitative characteristics, like color (Castanea, Citrus, Diospyros, Malus, Pyrus, Rubus, Vitis), shape (apple, pear, grape), sugar content (apple, peach, corn), other internal chemicals (sunflower, olive, bean), time of maturity (cotton, pistachio, sweet cherry) by numerous scientists (Crane et al., 1980; Denney, 1992).

The aim of this study was to determinate the effect of the pollen on fruit quality of some new apple varieties resistant to scab.

2. Material and method

Our experiment was made at Research Institute for Fruit Growing Piteşti, Genetic and Breeding Department. The orchard was planted in spring 2009 with apple trees grafted on M9 rootstock. It is irrigated and trained to slender spindle. In Spring 2014, was released 9 cross combinations using apple cultivars resistant to scab ('Topaz', 'Dalinette Choupette®', 'Golden Lasa' and 'Priam') and susceptible to scab, like 'Idared' and 'Golden Delicious' (Table 1). As mater genitors was used only scab resistant cultivars and by hand pollination was prepared about 980 flowers (Table 2).

Table 1. Information about apple varieties involved in the experience

No.	Cultivar	Origin	Genitors	*S*-genotip	Pollen germination capacity*
Apple varieties resistant to scab					
1	Dalinette Choupette®	INRA Angers, France	Sel. X 4598 x Sel. X 3174	-	+
2	Priam	INRA Angers, France	Complex hybrid (*M. floribunda* 821, Rome Beauty, G. Delicious, Jonathan)	-	◦
3	Golden Lasa	ISF Trento, Italy	Ed Gould Golden x Sel. PRI 1956-6		+
4	Topaz	Institute of Experimental Botany, Czech Republic	Rubin x Vanda	S_2S_5	◦
Apple varieties susceptible to scab					
5	Golden Delicious	Westvirginia, USA	James Grieve x ?	S_2S_3	+
6	Idared	University of Idaho Agricultural Experiment Station, USA	Jonathan x Wagener	S_3S_7	+

* ++ very good (over 60%); + good (between 40-60%); ◦ moderate (between 10-40%); - poor (below 10%)

At optimal harvest time, the fruits of all combinations were evaluated regarding fruit quality parameters: weight, firmness, refraction, skin color.

The average fruit weight was determined by weighing every fruit from crossing using the digital balance.

The flesh firmness was determined using manual penetrometer and expressed in kg cm-2.

The refraction was measured from homogenous filtered juice reached fruit-press and the results were expressed in Brix%.

The color of the fruits was determined using Konica Minolta CR 400 colorimeter, based on Hunttel System L*, a*, b* (CIELAB) and the measurements were made on both sides of the fruit (the well and less colored, so the sun exposed and shaded side). The CIELAB colour scale is organized in a cube form. The L* axis runs from top to bottom, with the maximum 100, which represents a perfect reflecting diffuser. The minimum for L* can be zero, which represents black color. The a* and b* axes have no specific numerical limits: positive a* is red, negative is green; positive b* is yellow, negative is blue. The chromatographic index (C*) was determined according to the formula C*= (a*2 + b*2)1/2 and the hue angle (redness) of the formula h*= (b*/a*).

The results were statistically calculated by Duncan's Multiple Range Test (p = 0.05).

3. Results and discussions

In order to investigate the compatibility of combinations, fruit set and number of viable seeds were counted inside 2 type of cross combination: resistant x resistant, resistant x susceptible.

So, in April, 2014, 980 flowers (2 flowers / cluster) of three scab resistant apple cultivars ('Topaz', 'Dalinette Choupette®', 'Golden Lasa') were hand pollinated with pollen of some traditional cultivars: 'Idared' and 'Golden Delicious', very susceptible to scab, and 'Priam', resistant to scab. Fruit set was good (more than 50%) in case of 'Topaz x Golden Delicious' and 'Golden Lasa x Idared'. Low seed number refers to compatibility problems, although it is not supported by the previous results published in the topic of S-allele investigation (Broothaerts et al., 2004; Keulemans, 1996; Kozma et al., 2003; Sakurai et al., 2000; Swingle, 1928; Tufts and Hansen, 1933).

In our experiment, the hybrid fruits produced 6.95 to 8.9 seeds per fruit, exception the fruits coming from 'Topaz x Golden Delicious' crosses with over 10 seeds per fruit. These results show a good compatibility between genitors (Table 2).

Table 2. Cross combinations, fruit set, average seed number

Genitors ♀ x ♂	Flowers crossed (number) April, 2014	Fruit set July, 2014		Fruits harvested September, 2014		Average of viable seed number (piece/fruit)
		number	%	number	%	
Topaz x Priam	94	38	40.42	35	37.23	8.26
Topaz x Golden Delicious	58	35	60.34	33	56.89	10.02
Topaz x Idared	205	94	45.85	89	43.41	8.05
Dalinette x Priam	103	24	23.30	21	20.39	7.93
Dalinette x Golden Delicious	95	43	45.26	42	44.21	8.80
Dalinette x Idared	149	21	14.09	21	14.09	8.90
Golden Lasa x Priam	97	27	27.83	19	19.58	8.23
Golden Lasa x Golden Delicious	105	30	28.57	27	25.71	7.11
Golden Lasa x Idared	80	50	62.50	44	55.00	6.95
Total	**986**	**362**	**38.68**	**331**	**35.17**	**8.25**

The metaxenic effect to fruit size was previously justified; fruit size reducing effect was proved in the case of Malus sp. (Church et al., 1983; Tóth et al, 1985, 2005) and smaller sized cultivars (Keulemans et al., 1996; Kumar et al., 2005).

Regarding the fruit diameter, four groups (<50; 55-60; 65-70; 75-80 mm) were created according to European market demands. The apples obtained from 'Topaz x Golden Delicious' cross have a good diameter (63.64 % apples with diameter between 65 and 70 mm). On the other hand, in the case 'Golden Lasa x Idared' results 56.82 % smaller fruits (less than 50 mm) (Table 3).

Table 3. Diameter of fruits influenced by different pollinators

Genitors ♀ x ♂	% of fruits grouped by the diameter (mm)			
	< 50	55-60	65-70	75-80
Topaz x Priam	0	31.43	45.71	22.86
Topaz x Golden Delicious	0	0	63.64	36.36
Topaz x Idared	6.89	55.18	37.93	0
Dalinette x Priam	23.81	52.38	23.81	0
Dalinette x Golden Delicious	26.19	40.47	33.34	0
Dalinette x Idared	19.05	42.85	38.10	0
Golden Lasa x Priam	26.31	47.38	26.31	0
Golden Lasa x Idared	56.82	43.18	0	0
Golden Lasa x G. Delicious	48.14	48.14	3.72	0

The differences of fruit weight influenced by different pollinators are shown in table 4. According with our analysis 'Idared' cultivar in crosses with 'Topaz' and 'Golden Lasa' caused smaller fruits than 'Priam' and 'Golden Delicious', but the average weight is not correlate with flesh firmness and solid soluble content.

Flesh firmness and refraction are two attributes which can influence the taste quality. Effect on flesh firmness influenced by different pollinators is considered as a metaxenic effect by Kovacs (1976). 'Idared' cultivar in crosses with 'Dalinette' and 'Golden Lasa' caused apple fruits with firm flesh (7.46 kg f/cm2 in case of 'Dalinette' and 8.06 kg f/cm2 in case of 'Golden Lasa').

Regarding the refraction, four groups (refraction: ⩽8; 8-10; 10-12; >12%) were created according to statistical analysis in case of our experiment. The least fruit dry matter was measured in the case of 'Dalinette x Priam' fruits (7.25 % Brix) and the higher values in case of 'Topaz x Golden Delicious' fruits (13.49% Brix). 'Idared' pollinator produced the lowest refraction values in the case of 'Golden Lasa' fruits (8.76% Brix) and 'Priam' pollinator in case of 'Dalinette' fruits (7.58 % Brix).

Table 4. Fruits quality parameters influenced by 'Priam', 'Golden Delicious' and 'Idared' pollinators

Genitors ♀ x ♂	Average weight (g)	Flesh firmness (kg cm^{-2})	Refraction (Brix%)
Topaz x Priam	116.51 b	8.11ab	12.34 a
Topaz x Golden Delicious	143.51 a	8.30 a	13.49 a
Topaz x Idared	92.76 d	8.01 abc	12.06 a
Dalinette x Priam	82.85 f	7.16 d	7.58 d
Dalinette x Golden Delicious	86.19 e	7.34 cd	9.84 bc
Dalinette x Idared	98.85 c	7.46 bcd	10.00 bc
Golden Lasa x Priam	94.52 d	7.68 bcd	10.10 b
Golden Lasa x Idared	65.41 h	8.06 ab	8.76 c
Golden Lasa x G. Delicious	70.44 g	7.55 bcd	8.90 bc

*Duncan's Multiple Range Test ($P \leq 0.05$)

Fig. 1. The influence of pollinators to fruit weight

The results on skin color parameters showed significant differences between the fruits obtained by different cross combinations. Also, the differences of 'Topaz', 'Dalinette Choupette®' and 'Golden Lasa' fruits color influenced by pollinators are shown in table 5.

Average values of L* for each cross combinations were ranging between 53.702 (‘Dalinette’ – mother genitor) and 64.205 (‘Golden Lasa’ – mother genitor), values which represents a good reflecting diffuser.

In case of ‘Topaz x Priam’ and ‘Topaz x Idared’, the values of axis a* were negative which means green colour; the highest values occurring at ‘Topaz x Golden delicious’ fruits, 2.918 (red skin colour).

For ‘Dalinette’ cultivar value of axis a* was negative only in crossing with ‘Priam’, similar with all the crosses of ‘Golden Lasa’ (Table 5).

Average values of b* for all cross combinations were positive which means yellow colour.

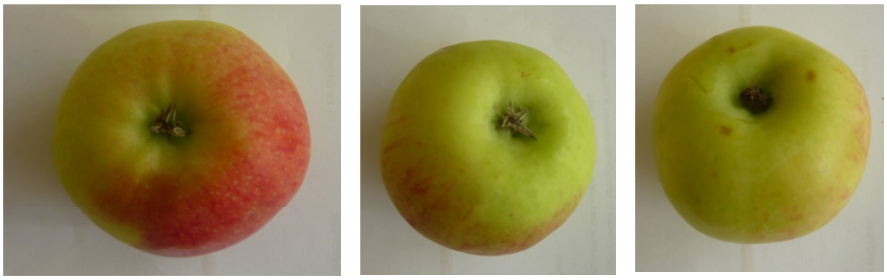
The chromatographic index (C*) recorded positive values and showed significant differences between the fruits obtained inside same cross combinations (Table 5).

The hue angle (redness) was recording positive and negative values in correlations with value of axis a* (Table 5).

Table 5. Skin color parameters influenced by pollinators

Genitors ♀ x ♂	L*	a*	b*	C*	h*
Topaz x Priam	58.390 ab	-0.820 ab	23.832 abc	27.158 abcd	-20.760 a
Topaz x Golden Delicious	55.886 ab	2.918 a	22.780 abc	26.804 bcd	7.768 a
Topaz x Idared	57.670 ab	-0.053 ab	22.782 abc	26.766 bcd	-19.538 a
Average	**57.315**	**0.682**	**23.131**	**26.909**	**-10.843**
Dalinette x Priam	62.332 a	- 14,808 b	26.690 ab	30.542 abc	-61.030 a
Dalinette x Golden Delicious	49.276 b	3.950 a	19.998 c	25.194 d	2.896 a
Dalinette x Idared	49.498 b	1.718 a	20.370 bc	25.838 cd	8.116 a
Average	**53.702**	**-3.047**	**22.353**	**27.191**	**-16.673**
Golden Lasa x Priam	64.572 a	-15.878 b	28.020 a	32.210a	-60.460 a
Golden Lasa x Idared	63.034 a	-15.624 b	27.486 a	31.646 ab	-60.504 a
Golden Lasa x G. Delicious	65.008 a	-15.660 b	27.962 a	32.054 a	-60.776 a
Average	**64.205**	**-15.721**	**27.823**	**31.970**	**-60.580**

*Duncan's Multiple Range Test ($P \leq 0.05$)



a. Topaz x Golden Delicious *b. Topaz x Priam* *c. Topaz x Idared*

Fig. 2. The influence of pollinizer to skin color

4. Conclusions

The apples obtained from 'Topaz x Golden Delicious' cross have a good diameter (63.64 % apples with diameter between 65 and 70 mm), but in the case 'Golden Lasa x Idared' results 56.82 % smaller fruits (less than 50 mm).

'Idared' cultivar in crosses with 'Topaz' and 'Golden Lasa' caused smaller fruits than 'Priam' and 'Golden Delicious', but the average weight is not correlate with flesh firmness and solid soluble content.

'Idared' cultivar in crosses with 'Dalinette' and 'Golden Lasa' caused apple fruits with firm flesh.

'Idared' pollinator produced the lowest refraction values in the case of 'Golden Lasa' fruits and 'Priam' pollinator in case of 'Dalinette' fruits.

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