1. INTRODUCTION

Sour (*Cerasus vulgaris* Mill.) and sweet cherry (*Cerasus avium* (L.) Moench) are very important fruits in Hungary. In our country the average percentage of sour cherry among fruit trees is 10-12 % (GULYÁS, 1985). According to GONDA and DREMÁK (2004) sour chery production is between 35,000 and 75,000 tons by years.

The majority of our fruit cultivars are allogamous (TERPÓ, 1980). Because of the uncertainty of wind, in the case of allogamy it is essential to ensure insect pollination, resulting in higher fruit set, the condition of which is an appropriate primary attractivity of flowers.

Among sour cherry cultivars there are more and more **autofertile** ones, whose pollination often takes place also without any pollen vector (where anthers touch the stigma within flower). However, foreign pollination can improve quality even at these varieties. There are also **autosterile** cultivars (e.g. the *Pándy* clones), which remain in cultivation due to their outstanding fruit quality, although their fruit set is not always satisfactory. These cultivars can receive fertilising pollen by the transmission of wind or insects. Thus, if a successful fertilisation should be achieved even at autosterile sour cherry cultivars, all details of their pollination biology should be known.

The main floral biological types of sour cherry are known from the works of OROSZ-KOVÁCS (1988, 1991, 1992, 1996a, 2001), and OROSZ-KOVÁCS et al. (1987, 1988, 1989, 1992, 1993). These authors distinguish **homogamous** and **dichogamous** types. In dichogamy there are sour cherry varieties with **protogynous** flowers. One type of **delayed homogamy** is **delayed autogamy**, which is well known from the above mentioned papers and the work of HORVÁTH (2003). Flower stages of protogynous *Prunus*es were written by GOTTSBERGER (1977).

Applying biological techniques we can improve the association of cultivars, so probably safety of production can be increased. It is the main cause why we started our experiment in fields of Research and Extension Centre for Fruitgrowing in Újfehértó, where there is a high amount of sour cherry cultivars.

For overall knowledge of flower and pollination biology of sour cherry, we have to know the morphology of flowers, histology of nectary and stigma, nectar secretory rhythm, apicultural consequences, nectar composition, pollen viability, and the resistance of flowers – this is the phenolic metabolism (secondary metabolites).

It has a high importance to know the weather conditions because of flowers and the floral secretory product - that is why we studied the samples in two-six years.

2. OBJECTIVES

In my work I studied the followings:

- floral morphological differences among sour cherry cultivars;
- histological properties of nectary and stigma according to floral biological and ecological types;
- relationships between histological, cytological features, the size of flowers and chemical properties of floral secretory product;
- pollen viability of sour cherry cultivars;
- the amount, the quality and the refraction of nectar;
- floral biological types of sour cherry varieties according to the daily rhythm of nectar production and anther dehiscence;

- nectar composition and apicultural importance of sour cherry cultivars;
- differences in nectar composition at different flower ages, between autosterile and autofertile varieties, and between the daily and nightly nectar;
- the quality and quantity of phenolic compounds in the parts of the flowers of sour cherry cultivars; the role of these substances in the life of the flower;
- differences of features in age-groups.

3. MATERIAL AND METHODS

3.1. Place and time of experiments

Material was sampled in the cultivar collection of Research and Extension Centre for Frutgrowing, Újfehértó.

Samples were processed in laboratories of Újfehértó and of University of Pécs, Department of Botany.

For investigation of nectar composition we used samples from six years: **1997-2000**, and **2003-2004**; for other jobs we used samples from two years: **2003-2004**.

3.2. Microclimatic relations

In Újfehértó, there is a complex computer controlled microclimatic apparatus. It recorded the main data every hour during the whole flowering period: average air temperature at minimum and maximum values and the amount of precipitation. In the years of 2003 and 2004 we used hand thermometer and humidity-meter too.

3.3. Material

25 cultivars were studied **between 1997 and 2004**:

Highly autofertile variety (value of autofertility is above 20 %, NYÉKI et al., 2003):
Oblacsinszka

Autofertile variety (value of autofertility is between 10,1 and 20 %, NYÉKI et al., 2003):
„R" (Petri)

Partially autofertile varieties (value of autofertility is between 1,1 and 10 %, NYÉKI et al., 2003):

„D"
„K"
„T" (Éva)
Cigánymeggy 59
Cigánymeggy C.404
Debreceni bőtermő
Érdi bőtermő
Érdi jubileum
Favorit
Kántorjánosi
Korai pipacs
Körösi korai
Mej Djuk
Meteor korai
Meteor
Montmorency
Nefris
Sárándy S/Gy
Újfehértói fürtös

Autosterile varieties (value of autofertility is between 0,1 and 1 %, NYÉKI et al., 2003):
„Z”
Érdi nagygyümölcsű
Pándy 48
Pándy Dunavecse

3.4. Methods of flower morphology

We investigated the flowers with a hand magnifying glass (6x). In 2003 we measured 100-100 flowers, in 2004 20-20 flowers per cultivar. In addition we noted the following items: a) diameter of flowers, b) number of anthers in flowers, c) colour of petals, d) color and shape of anthers, e) color and shape of stigma, f) color of nectary.

3.5. Methods of histology of nectary

After fixation we dehydrated flowers (SÁRKÁNY and SZALAI, 1957). After it we used paraplast for sectioning. We made 5-10 μm thick sections with a microtome. Toluidine-blue was applied to staining and canadabalsam to covering.

We measured the following parameters on the longitudinal sections of flowers:

A, area of nectary;
B, thickness of nectary;
C, thickness of glandular tissue;
D, thickness of subglandular parenchyma (B-[C+N]);
E, percentage of glandular tissue ([C/D]*100);
F, thickness of cuticle;
G, area of stomatal chamber (it occurred only in some cases);
H, number of cellular rows of glandular tissue;
I, area of cells of glandular tissue (without cell wall);
J, area of cell-nuclei of glandular tissue;
K, area of cell-cytoplasm of glandular tissue (I-J);
L, determination of citoplasm – caryon (cito-kar) ratio (K/J) and the glandular nucleus percentage (GNP) (J/I*100);
M, length of epidermal cells;
N, height of epidermal cells;
O, extent of epidermal cells (length x height [**L*H**]) = (M*N);
P, ratio of epidermal cells (height / length [**H/L**]) = (N/M).

Histological examinations were passed by ’NIKON H600L Eclipse 80i’ researching microscope, records were shot by ’RT KE/SE Spot (Diagnostic Instruments Inc.) Model 7.3 Three Shot Color’ – image analyzing system. Digital recording were finished off by ’SPOT 4.0.4’ computer program. For data recording we used the ’UTHSCSA ImageTool 3.0’ computer program, for data processing ’Microsoft® Excel 2002’ in turn.

3.6. Scanning ElectronMicroscopical examinations of flowers

Preparations were made in 2003. Fresh materials were praefixated in 0,2 M formaldehyde, and postfixated in 0,5 % osmiume-tetroxide solution. Samples were dehydrated in ethyl-alcohol and dried in critical point in iso-amyl-acetate. Goldshielding were made in Yeol vacuum-steam. Microrecords were made by Yeol 100 C-adapted

ASID-4 SEM in University Medical School of Pécs, in Central Electronmicroscope Laboratory.

3.7. Examinations of endogene rhythm of flowers

Nectar production, secretion of stigma and the pollen shedding were studied in every hour. Nectar was sampled from flowers with calibrated microcapillaries from 20-20 flowers per cultivar per year. We noted the number of dehisced anthers and the time of secretion of stigma. Early in the morning (at 6-7 o'clock) flowers contained mainly nectar produced in night. We used hand thermometer and refractometer for investigations of nectar and anthers. We noted the visiting insects or the absence of these animals, but we could not do detailed apicultural monitoring because the lack of time.

3.8. Examination of nectar

3.8.1. Measuring the production of nectar

Nectar, produced by flowers during 24 hours, was measured with calibrated microcapillaries. Flowers were isolated with isolator-net.

We calculated the sugar-value of nectar according to CRUDEN and HERMAN (1983):

(nectar µl x refraction %)/100

3.8.2. Determination of nectar sugar composition

10 µl of samples were stored in Eppendorf-tubes, then in exsiccator, or desiccated in Eppendorf-concentrator.

Nectar sugar components were determined by thin layer chromatography (TLC) (GRÖSZ and BRAUNSTEINER, 1989), quantitative evaluation was carried out by densitometry (CAMAG TLC Scanner II. at 510 nm wavelength). Samples were diluted to 200 ml (20x dilution) in the mixture of ethanol : water 7:3. A known amount of the solution was applied to a 20 x 20 silica gel coated plate with microcapillaries. The distance between sample spots was the same, 15 mm being the minimum. The start line was 15 mm from the edge of the plate, the front line 30 mm from the edge. Plates were developed twice without saturation, using ethyl-acetate : ethanol : 60% acetic acid : water saturated with boric acid (50:20:10:10) as developing agent. Plates were dried at room temperature, then treated with a thymolic reagent (0.5 g thymol dissolved in 95 ml ethanol, with 5.0 ml cc sulphuric acid) for 3 sec. Finally densitometric evaluation was carried out.

3.9. Determination of pollen viability

Pollen grains were desiccated at 90 ^{o}C during 10 minutes.

Pollen viability was investigated by isatine-method (PÁLFI and GULYÁS, 1985), which is based on the free proline content of pollen grains. We counted pollen grains according to their stainability. Color groups were: black or **dark blue** – **viable** pollen grain; **red**: **hardly or not viable** (very little amount of proline); **yellow** (this is the original color of pollen grain) **or wizened**: surely **non-viable** pollen grain. We counted minimum 500 pollen grains per cultivar in the studied two years.

3.10. Examination of phenolic compounds in flower partitions

Fresh flowers were taken apart into five fractions: sepals, petals, anthers, stigmas, hypanthiums. From flowers we extracted the phenolic compounds by methanol and hot water bath. The development was made by TLC as in the case of nectar. Densitometric evaluation was carried out in UV-range at 366 nm.

4. RESULTS AND DISCUSSION

4.1. Morphology of flowers of sour cherry cultivars

The pentamer, actinomorph, corysepal perianthiums of flowers in the studied varieties were heterochlamydeus, the **calyx** was green, and the sepals were leaf-shaped. **Petal**s were white-colored, but during the aging of flowers they may be transformed into pink (e.g. *Oblacsinszka* cultivar). Anthers of some cultivars became petals; this phenomenon is the "fullbloomness" (*Érdi bőtermő*, *Meteor korai*). **Androeceum** is triplostemon. Filaments are long, thin, and often white or rarely pink (*Oblacsinszka*). Color of anthers is a feature of the latter variety. It may be pale-yellow, yellow, butter-yellow or greenish-yellow. Stigma may be various like the anthers. Some cultivars had so called **stigma-mimicri** (*Cigánymeggy 59*, *Újfehértói fürtös*), the color and the shape of anthers and stigmas were the same. We could rarely observe **twin stigmas** (*Érdi bőtermő*). The color of hypanthial **nectary** was green or yellowish green at the majority of varieties.

Depending on year and variety, the **diameter of flowers** was **between 25 and 39 mm**, and the **number of anthers** varied **between 28 and 41**. According to the average of the two seasons, the biggest diameter we found was at *Újfehértói fürtös* and *Debreceni bőtermő.* The cultivar *Oblacsinszka* had the smallest flowers.

We found **positive linear correlation** between the two seasons by the diameter of flowers. We observed negative linear correlation in point of variability of diameter of flowers and the number of anthers. Thus, **the more variability in the number of anthers, the less variability in the diameter of flowers,** depending on cultivars.

4.2. Secretional structures of flowers of sour cherry cultivars

4.2.1. Surface of the stigma

In sour cherry cultivars the surface of the stigma has **epidermal cells with papillas**, and it is coverd with **a thin layer of cuticle**. In **dichogamous, protogynous** cultivars (*Érdi nagygyümölcsű*) these papillas are intact at the stage of **exposed stigma,** but they become degradated at the stage of pollen shedding and the surface looses its texturalization.

Flowers with **delayed homogamy** (*Újfehértói fürtös*), papillas of the stigma keep their turgor or become **partially degradated,** so the stigma functions during the whole period of pollen shedding.

4.2.2. The nectary

The **nectary covers the whole receptacle**; its type is **reproductive, receptaculary, hypanthial**.

The surface of the nectary was **between $2{,}7*10^5$ and $7{,}9*10^5$ μm^2**, and the **thickness** of it was approximately **100-200 μm**. According to the average of the two seasons **biggest nectary surface** takes place in ***„T”*, smallest in *Cigánymeggy***; ***Debreceni bőtermő*** cultivar has the **thickest gland**, ***Cigánymeggy 59*** cultivar has the **thinnest one**.

The seasons have an effect on the size of nectary too.

In 2003 there was a positive linear correlation between the size of nectary and the diameter of flowers, but the thickness of nectary correlated with the size of flowers in

every two seasons. So, **the greater flower, the thicker nectary**. In 2003 there was a **positive linear correlation between the whole size of the nectary and the nectar production**.

4.2.2.1. Histology of the nectary

With cuticle and stomatas, epidermis covers the adaxial surface of the nectary. We found no trichomas. **Cuticle** had **furrows**, its **thickness** varied **between 2,4 and 4,4 μm.** It is a rather **stable feature**, seasons had no or a little effect on the thickness of the cuticle, and thus it **can be used to the identification of cultivars** too. *Pándy 48* had the thickest cuticle and *Cigánymeggy 59* had the thinner one.

Anomocitic stomatas of the nectary can be **mesomorph** (*Favorit*), **meso-xeromorph** (*Újfehértói fürtös*), **a little bit xeromorph** (*Debreceni bőtermő*), **xeromorph** (*Cigánymeggy* cultivars) and **strongly xeromorph** (*Meteor korai*). *„T"* had the biggest epidermal cells and *Újfehértói fürtös* had the smallest ones. According to the **H/L index**, the majority of **epidermal cells** have an **iso-diametric shape**. The area of **stomatal chamber** varied **between 0 and 160 μm^2**.

The small, iso-diametric cells of glandular tissue were in parallel rows (5-10 rows) in the majority of varieties. In some cultivars the gland tissue had a mosaical structure (*Újfehértói fürtös*). **The glandular tissue** of the whole nectary **was 60-70%**, it was **65-135 μm**. *Debreceni bőtermő* had the thickest glandular tissue and a *Cigánymeggy 59* had the thinner one.

According to **citological measurements, the area of cells of the gland tissue** varied **between 140 and 220 μm^2, the area of cell nuclei** was **between 30 and 48 μm^2**. The **cito-kar ratio was between 3,3 and 4,5**. The "(area of cell nucleus / area of cell)*100" ratio (glandular nucleus percentage - **GNP**) varied **between 20 and 25 %**. ***Debreceni bőtermő*** had the **biggest glandular cells,** it **mainly** consisted of **cytoplasm.** ***Érdi bőtermő*** had the biggest GNP. We found two **correlations**: **1, the bigger cell, the bigger cytoplasm; 2, the bigger GNP, the smaller sugar value of nectar.**

4.3. Floral biological types, the daily rhythm of flowers

The majority of studied cultivars had **delayed homogamous** flowers.

In the case of **proterogynia brachybiostigmata** the stigma is often at an exposed position. Then the stage of pollinational chamber takes place. The stigma becomes receptive before the dehiscence of anthers, its gland secrates. The functioning of the androeceum and the gynoeceum differentiate completely in time. Nectar secretion starts at the stage of anther dehiscence. Flowers of only *Érdi nagygyümölcsű* showed real protogyny.

In the case of **proterogynia macrobiostigmata** (= delayed homogamy) the initiative dichogamy becomes homogamy (*Újfehértói fürtös, Favorit*). Nectar secretion may start in young flower or at the stage of anther dehiscence.

Flowers of minority of cultivars showed **homogamy**, but only in 2004. Nectar secretion started in the young flower (*Pándy 48*).

In some varieties we found flowers with **different floral biological strategy**. One part of flowers showed protogyny, other part showed delayed homogamy (*Oblacsinszka*).

4.3.1. Daily rhythm of flowers of sour cherry cultivars

Every studied varietiy produced nectar during the day, but their rhythm was different according to season and cultivar.

Majority of sour cherry cultivars had **periodic nectar secretion**. Protogynous flowers of *Érdi nagygyümölcsű* had a 12-hour rhythm, delayed homogamous flowers of *Kántorjánosi* had a 6-hour rhythm at the stage of homogamy, and in 2004 the homogamous flowers of *Érdi bőtermő* showed a 3-hour rhythm, according to its hybrid character (sour cherry x sweet cherry). In some cultivars the maximums of pollen shedding and the maximums of nectar secretion concur (*Cigánymeggy 59*, *Érdi jubileum*, *Kántorjánosi*), in other varieties they are shifted (*Meteor korai*, *Debreceni bőtermő*). Others showed no synchronity (*Cigánymeggy C.404*). In utmost cases refraction of nectar exceeded the 10 %, which is the bee visitational threshold value (*Debreceni bőtermő*, *Oblacsinszka*).

4.4. Pollen viability

Pollen of sour cherry has a vely little viability, which is supported by literature (FABBRI et al., 1983; MIAJA et al., 2000). It is because of the **tetraploid feature of sour cherry. Pollen viability was smaller than 50 % in every two studied year** (in 2004 it was smaller than 40 %).

Best pollen viability we found (more than 25 %) at ***Oblacsinszka*, *Kántorjánosi*, *Meteor korai* cultivars**, they can be pollen donors in the case of sufficient compatibility. ***Oblacsinszka* had highly viable pollen among sour cherry varieties** (40,6 %), the fewest viable pollen grain we found at the **autosterile *Pándy 48*** cultivar (11,3 %). **The pollen viability of autofertile cultivars were much better (1,87x) than autosterile ones.**

4.5. Nectar production of flowers of sour cherry cultivars

Meteor korai (10,27 µl, 13,96 %) and ***Debreceni bőtermő*** (7,21 µl, 16,6 %) were the best nectar productors, where the **refraction of nectar was satisfactory** too, so the insect attraction was ensured. Distinctly the literature ***Cigánymeggy* varieties** poduced **watery** and a **small amount** of floral secretory product (*Cigánymeggy 59*: 0,54 µl, 8,08 %; *Cigánymeggy C.404*: 1,8 µl, 6,76 %). In addition we found that **with aging of flower, the amount and the refraction of nectar increased**, and the **nectar being produced during the day was concentrated** in the majority of the cultivars (except *„R"* in 2003 and *Érdi jubileum*, *Favorit*, *Pándy Dunavecse* in 2004).

4.6. Primal sugar components of the nectar

The nectar of both studied cultivars contained all **three major sugar components**: **sucrose, glucose and fructose**. Flowers produced mainly sucrose-rich nectar, but sucrose-dominant occurred too (1997: *Érdi jubileum*; 1998: *Érdi nagygyümölcsű*; 1999, 2000: *Pándy 48*; 2004: *Érdi jubileum*, young flowers of *Meteor korai* and flowers with dehisced anthers of *Cigánymeggy 59*, *Érdi bőtermő*, *Érdi jubileum*, *Meteor korai*). We found fewer cultivars with hexose-rich floral secretory product (1998: *Korai pipacs*; 1999: *Kántorjánosi*; 2000: *Montmorency*; 2003: *Cigánymeggy C.404* and old flowers of *Oblacsinszka*; 2004: young and old flowers of *Érdi nagygyümölcsű*). There was no hexose-dominant nectar among sour cherry cultivars.

We measured the most concentrated nectar in the flowers of ***Érdi bőtermő*** and ***Érdi jubileum***, and the less concentrated in the flowers of ***Meteor korai*** and ***Pándy 48***, but there was a **high ratio of disacharid** in the nectar of every four cultivars, so they were all **attractive for pollinators**.

In the case of autosterile cultivars there were **more sucrose in nectar with aging** (*Érdi nagygyümölcsű*, *Pándy 48*), so the insect attraction was ensured at the end of blooming.

Except sugars, there were other components in the nectar of sour cherry (for example pollen) and the amount of these components increased with aging.

4.7. Apicultural ranking

The nectar of sour cherry cultivars can be well characterized by the **sugar content** (amount x refraction / 100). On the base of sugar content and the S/(G+F) ratio, an apicultural ranking we can lay down. The ranking is: *Meteor korai, Debreceni bőtermő*, *Pándy 48*, *Oblacsinszka*, *Újfehértói fürtös*, *„R"*, *Cigánymeggy C.404*, *Cigánymeggy 59*. The floral secretory product of ***Meteor korai*** and ***Pándy 48*** was often sucrose dominant and the sugar value of these cultivars was very good too, so they are the best nectar productors. These cultivars are the most attractive for bees. The nectar of old flowers of *Favorit* and ***Kántorjánosi*** was perfect too. **The old flowers** of the latter variety **had the most valuable** (high amount, concentrated, perfect composition) **nectar**.

4.8. Phenolic features of flowers of sour cherry cultivars

Flowers of **sour cherry** contained relatively a **high amount of phenolic compounds**: mainly **rutin**, **caffeic acid** and **procianidins**. The **highest concentration** of these substances occured **in petals**, but the rutin content of anthers was remarkable too. The highest amount of phenolic compounds was found in flowers of ***Cigánymeggy* varieties**, ***É. nagygyümölcsű*, *É. bőtermő***, ***Kántorjánosi***, ***Oblacsinszka*** and ***„R"* cultivars**. We observed **procianidins** only in petals, thus these compounds **protect anthers and the stigma in the flower buds from the UV-light, decreasing the citotoxical oxidative stress.**

5. SUMMARY OF RESULTS AND CONCLUSIONS

- There is a **negative linear correlation** between the seasonal variability of **diameter of flowers** and the **number of anthers** in sour cherry cultivars.
- One part of papillas of stigma is turgorous in the nectary of delayed homogamous flowers.
- Based on the position of **anomocitic stomatas of nectary** there are ecotypes in sour cherry cultivars: **mesomorph, xeromorph**, and transient types.
- **The glandular tissue** of the whole nectary of sour cherry cultivars **is 60-70%**. There is a **positive linear correlation** between the **thickness of the nectary** and **the diameter of flowers**, like between the **size of the nectary** and the **nectar production**.
- The "(area of cell nucleus / area of cell)*100" ratio (glandular nucleus percentage - **GNP**) varied **between 20 and 25 %**. There is a **negative linear correlation** between the **GNP** and the **sugar value of the floral secretory product.**
- Among sour cherry cultivars, the floral biological type of ***Érdi nagygyümölcsű*** was **protogynous**, in 2004 ***Érdi bőtermő*** and ***Pándy 48*** was **homogamous**, while the **other varietes** had flowers with **delayed homogamy**.
- In some varieties we could observe flowers with different floral biological strategy. These cultivars were ***Cigánymeggy 59***, ***Oblacsinszka*** and in 2004 ***Debreceni bőtermő***.
- Some flowers of *Érdi nagygyümölcsű* were protogynous, while the others were delayed homogamous in a small amount.

- In the case of **proterogynia macrobiostigmata (= delayed homogamy)** and **homogamy, nectar production** may start **in young flowers** or **at the time of pollen shedding**.
- Majority of sour cherry cultivars had **periodic nectar secretion**; they may have a **6- or 12-hour rhythm.** Flowers with **3-hour rhythm** refer to sweet cherry x sour cherry **hybrid**.
- **Maximums of pollen shedding can overlap with maximums of nectar secretion** in some cultivars. In others **it may shift or has no synchronity**.
- **Sour cherry cultivars had very poor pollen viability. It was under 50 % in each studied seasons.** However **pollen donor can be** three cultivars: ***Oblacsinszka***, ***Kántorjánosi*** and ***Meteor korai***.
- One part of the studied cultivars produced only a little amount of nectar; however the **majority of varieties had an enough amount of nectar with satisfactory refraction**. It is favourable in the aspect of apiculture. **The amount and the refraction of nectar usually grow with aging of flowers. Nectar**, which was **produced during the day**, was **more concentrated** than during the night.
- **In autosterile cultivars the sucrose- and the whole sugar concentration of nectar grow with the aging of flowers,** so **insect attraction is ensured until the end of inflorescence.**
- There were other components in the floral secratory product too. The amount of them grew with the aging of flowers.
- Among the studied sour cherry cultivars ***Meteor korai*** **and** ***Pándy 48*** **were the best nectar productors,** since they are **the most attractive varieties for bees** according to the amount, the concentration of nectar and the ratio of nectar sugar components.
- Flowers of **sour cherry** contained relatively a **high amount of phenolic compounds**: mainly **rutin**, **caffeic acid** and **procianidins**. The **highest concentration** of these substances was **in petals**, thus these compounds **protect anthers and the stigma in the flower buds from the UV-light, decreasing the citotoxical oxidative stress.**

6. LIST OF PUBLICATIONS

Papers based on the thesis:

- OROSZ-KOVÁCS, ZS.; SZABÓ, L.GY.; BUBÁN, T.; FARKAS, Á. AND **BUKOVICS P.** (2000): Sugar composition of floral nectar in sour cherry cultivars. Horticultural Science – International Journal of Horticultural Science 6. (3): 109-114.
- **BUKOVICS, P.**; OROSZ-KOVÁCS, ZS.; SZABÓ, L.GY.; FARKAS, Á.; BUBÁN, T. (2003): Composition of floral nectar and its temporal variability in sour cherry cultivars. Acta Botanica Hungarica 45 (3-4): 259-271.
- **BUKOVICS, P.**; SZABÓ L. GY.; OROSZ-KOVÁCS, ZS. AND FARKAS Á. (2005): Nectar composition in ’Pándy 48’ and ’Újfehértói fürtös’ sour cherry cultivars. Acta Botanica Hungarica. (in press).

Presentations based on the thesis:

- OROSZ-KOVÁCS, ZS.; SZABÓ, L.GY.; BUBÁN, T.; FARKAS, Á. AND **BUKOVICS P.** (2000): Sugar composition of floral nectar in sour cherry cultivars. The 8th international pollination symposium. Előadás. Mosonmagyaróvár, 2000. július 10-14.

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- **BUKOVICS, P.**; SZABÓ L. GY.; OROSZ-KOVÁCS, ZS. AND FARKAS Á. (2003): Nectar composition in two Hungarian sour cherry cultivars. Poszter. 2nd European Scientific Apicultural Conference. Balatonlelle, 2002. szeptember 11-13.
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- ZS. OROSZ-KOVÁCS, **P. BUKOVICS**, T. BUBÁN, Á. FARKAS, L. GY. SZABÓ, A. HORVÁTH AND H. DÉRI (2004): Influence of Bioregulators on Apple Nectar Characteristics, in Relation to Fireblight Infection. Acta Horticulturae. (in press)

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