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NECTAR PRODUCTION AND SOME SITE-RELATED ISSUES OF SUNFLOWER HYBRIDS UNDER DIFFERENT AGRO-ECOLOGICAL CONDITIONS

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1. INTRODUCTION AND MAIN OBJECTIVES

Sunflower (*Helianthus annuus* L.) is primarily utilised by the oil industry, but it is also one of the most important bee pasture plants in our country, serving as nectar and pollen source. For the majority of apiaries the exploitation of sunflower as a bee pasture is essential, which is allowed by its outstandingly large and continuous sowing area among melliferous plants (559 thousand hectares, www.ksh.hu 2009), its long blooming time and its abundant nectar- and pollen production. Sunflower honey can also be an important food for bee colonies preparing for the winter. The plant is cultivated in each region of the country, although it is not evenly distributed, encouraging beekeepers to wander in the hope of a better honey crop (RUFF 1991, FARKAS and ZAJÁCZ 2007). Currently sunflower hybrids have a large selection, with more than 40 hybrids grown at present. Three quarters of the sowing area are occupied by 10 leading sunflower hybrids, which can be relied on as the main honey sources for beekeepers. Excellent hybrids remain in cultivation for years, as opposed to weaker ones, whose rotation is quite fast.

1.1. Basic problem

Since the production of sunflower has been extended to the whole territory of the country, opinions about its nectar production are different. In contrast with the excellent honey yield of Hungarian and foreign cultivars and hybrids which were cultivated in the 1980s and ‘90s, sunflower nectar production has been a controversial issue among beekeepers since 1999. While some apiarists have an outstanding honey crop, others complain about the reduction or complete absence of nectar production.

Although several authors have previously carried out nectar studies on sunflower, this issue is still on the agenda due to the huge diversity of environmental factors, seasonal effects, production areas and new hybrids. Fulfilling the aims of the present research can contribute to our understanding of nectar production in new sunflower hybrids, expanding our knowledge based on available literature to date. My research results related to the apicultural value and nectar production of each hybrid can provide important information for beekeepers, making it easier for them to choose between numerous hybrids. For crop producers the pollen producing capacity, ensuring more effective fertilization of hybrids, can serve as useful information.

1.2. Aims of the work

The research aimed at answering the following questions:

1. **Nectar investigations**
    - How much and what quality of nectar do the investigated sunflower hybrids produce; what is their sugar value and apicultural significance?
    - Do seasonal and production site effects significantly influence nectar production?
    - What kind of effects do weather conditions (temperature, humidity, rainfall, sunshine) have on the quantity, sugar content and composition of the nectar?
    - Do the age of the flower and the time of the day influence the nectar production of sunflower hybrids and the sugar content of nectar?
    - Which sugars does sunflower nectar contain?
    - Does the ratio of nectar sugars change with the advance of blooming time and can the differences among the hybrids be demonstrated according to the examined parameters?
2. **Flower- and inflorescence morphology investigations**
    - Does the corolla tube length of the sunflower hybrids allow the access of nectar by domestic honey bees (*Apis mellifera carnica*)?
    - What is the characteristic diameter of the flower head in the sunflower hybrids?
3. **Pollen production investigations**
    - What is pollen production like in the sunflower hybrids, and does the year influence the examined feature?

2. MATERIALS AND METHODS

2.1. Materials of the investigations

The experiments involved 17 state qualified sunflower hybrids, which belonged to the very early, early and medium maturing groups.

2.2. Time and place of the investigations

Nectar studies were conducted in two different agro-ecological districts from 2002 to 2006. Each investigation district comprised production sites with the same climatic conditions, thus the first examination district included Kerekharaszt, Hatvan and Verseg in the years 2002, 2003 and 2004-2006, respectively. The second investigation district was in Mezőhegyes in 2002-2004.

Laboratory investigations were carried out in the Institute for Small Animal Research and Co-ordination Centre for Gene Conservation, Institute for Bee-breeding.

2.3. Nectar studies

2.3.1. Measurement of the quantity and refraction of nectar

1. Investigation district

The 24-hour nectar production of the disc florets was measured according to the identical method of HALMÁGYI and SUHAYDA (1963) and PÉTER (1978). Inflorescences were covered with tulle net for 24 hours prior to nectar sampling, in order to exclude insect visitors. Following isolation for 24 h, sunflower flower heads were cut off the plants and transported to the laboratory. Nectar was extracted with a previously weighed capillary from 5 male-phase disc florets, and then its mass was measured with analytical scales. The same method was applied for female-phase florets. The amount of nectar (mg) produced by a single disc floret in 24 hours was calculated from the mass data, whereas the dry matter content of nectar was determined with a refractometer. Sugar value was calculated according to the following formula:

$$\text{Sugar value (sugar mg /disc floret)} = \frac{\text{nectar weight (mg)} \times \text{sugar concentration of nectar (\%)}}{100}$$

Nectar sampling was done for 8, 6 and 5 consecutive days in 2002, 2005 and the other years of the study, respectively. Three parallel measurements were done daily for each hybrid,

sampling (3x) 50 male-phase disc florets each day in 2002, 2003 and 2005; while 4 parallels per day were measured in 2004 and 2006.

2. Investigation district

More extensive nectar studies, including several aspects, were carried out in the second production site. The methodology at the second site differed from that at the first site in measuring the quantity of nectar in the field and determining the dry matter content with hand refractometer. In order to study the effect of the time of the day on the quantity and sugar content of nectar, nectar samples were taken from disc florets on two occasions during the day, between 9-11 a.m. and between 1-3 p.m. Four hours before the morning nectar measurements nectar was withdrawn from the florets with a capillary, to allow the same time period for nectar production. Repeated nectar sampling was always done from the same floret.

2.3.2. Sugar composition investigations

Sugar composition studies (Mezőhegyes, 2002-2003)

The following three kinds of sugars were investigated with HPLC in sunflower nectar (DAVIS et al. 1998): fructose, glucose and sucrose. Nectar samples were taken from 10 male-phase disc florets per plant with Whatman No. 1 filter paper (McKENNA and THOMSON 1988), on consecutive days. Directly before the measurements the filter paper stripe was placed into an Eppendorf tube, and nectar was dissolved in 100 µl eluent. Then samples were kept in ultrasonic water bath and centrifuged, following which 20 µl of the supernatant was injected into the HPLC. Each nectar sample was injected twice. As the original amount of the nectar absorbed by the filter paper could not be determined, sugar concentration results were expressed as the relative ratio (%) of total sugar content (GILLESPIE and HENWOOD 1994).

Sugar composition studies (Verseg, 2006)

The investigation of sugar components in sunflower nectar was completed with the analysis of turanose and maltose in 2006. The applied method differed from the above one in the following. 5 mg of the nectar extracted from disc florets with capillaries was frozen in Eppendorf tubes until the analysis (JAKOBSEN and KRISTJÁNSSON 1994). After thawing, nectar samples were dissolved in 100 µl of the eluent. Following ultrasonic water bath treatment and centrifuging, 20 µl of the supernatant was injected. Sugar concentration results were expressed as mass percentage (m/m%).

2.4. Flower- and inflorescence morphology examinations

The head diameters (cm) of the inflorescences used for the nectar analysis (Mezőhegyes, 2002-2004) were measured with a tape for each hybrid. After having taken the nectar samples, disc florets were stored in 70 % ethanol until further analysis, including corolla tube length measurements (TORRES and GALETTO 2002). In order to measure corolla tube length (mm), florets were recorded with a digital camera connected to a microscope and measured with SPOT Advanced Programme.

2.5. Pollen production analysis

Pollen quantity of sunflower was determined in 2005 and 2006, according to the pollen-counting method of FRANK et al. (1985) and NIKOVITZ and SZALAINÉ (1983). The number of pollen grains was always counted from florets in the stage just before opening. Flower samples were preserved in 1:1 glycerol:96% ethyl-alcohol. 10 anthers per hybrid were placed into a test tube, then 100 µl cc. sulphuric acid was added to them. After 24 hours, the solution was filled up to 4 ml with 1:1 distilled water:polyethylene-glycol-400 for homogenization. After dispersing and centrifuging the pollen grains, one drop was placed into a *Fuchs-Rosenthal* chamber and the number of pollen grains per two cells was counted under light microscope. The pollen quantity produced by one floret was determined according to the following formula (NIKOVITZ and SZALAINÉ 1983):

$$Pn = \frac{V * a}{v_1 * x}$$

Pn = number of pollen grains per floret (piece)
V = examined volume of the solution (ml)
a = average number of pollen grains per cell (piece)
v_1 = volume of one cell (3,2 mm^3)
x = number of anthers (piece)

2.6. Data processing and evaluation

Data were processed with MS Excel 2007 spreadsheet programme, and statistical analysis was done with SPSS 11.0 for Windows software. Analysis of variance was applied for demonstrating differences among hybrids and analysing the effects of the year, the production site, as well as the main weather conditions. Possible correlations were analysed with the Pearson's correlation test and linear regression analysis.

3. RESULTS

3.1. Nectar studies

3.1.1. The effect of the hybrid on the quantity, sugar content and sugar value of the nectar

In the first investigation district the data sets were evaluated taking various aspects into consideration, because there was no opportunity for the analysis of every hybrid in every year and at every production site.

Results of nectar studies 1. (Kerekharaszt-Hatvan, 2002-2003)

Among the studied sunflower hybrids significant differences were observed both in nectar production and in the sugar content of the nectar. In the average of two years, 5 out of the examined 12 hybrids produced below the average (0.180 mg/disc floret) nectar quantity, but with a sugar concentration well above the average, exceeding 50%. In contrast, hybrids such as Arena PR, Cledor, Coriste, Florix, LG5645, Louidor and Magóg produced above the average quantities of nectar, but with sugar concentrations below 50%.

The significantly highest sugar value (0.134 mg/disc floret) was reached by the Coriste hybrid, which produced the highest volumes of nectar with the lowest sugar concentration values (Table 1).

Table 1 Nectar production and sugar content of sunflower hybrids (average±SD) (Kerekharaszt-Hatvan, 2002-2003)

Hybrid	Nectar production (mg/disc floret)	Sugar concentration (%)	Sugar value (mg/disc floret)
Alexandra PR	0.138±0.073 bc	53.0±7.7 a	0.068±0.027 b
Arena PR	0.196±0.077 b	47.4±7.0 ab	0.093±0.041 b
Cledor	0.183±0.148 bc	46.7±8.2 ab	0.076±0.053 b
Coriste	0.337±0.074 a	40.2±3.6 c	0.134±0.022 a
Florix	0.210±0.146 bc	49.3±9.0 ab	0.093±0.052 b
Hysun 321 PR	0.126±0.057 c	51.9±7.1 ab	0.064±0.025 b
LG5645	0.195±0.104 bc	50.4±5.6 ab	0.096±0.050 b
Louidor	0.207±0.132 bc	45.4±9.3 c	0.084±0.041 b
Magóg	0.183±0.066 b	49.3±7.6 ab	0.089±0.030 b
Opera PR	0.163±0.082 bc	54.4±8.9 a	0.083±0.031 b
Pixel PR	0.167±0.078 bc	55.0±7.6 a	0.089±0.038 b
Rigasol PR	0.143±0.065 bc	52.4±6.7 ab	0.073±0.029 b
Average	**0.180**±0.107	**50.0**±8.4	**0.084**±0.041
Min.	0.036	27.3	0.018
Max.	0.484	65.0	0.228

Different letters (a,b,c) indicate significant differences among the hybrids (P<0.05) for the examined parameter.

The nectar produced by the LG5645 hybrid was the second most attractive for bees, with its well above the average nectar production and high sugar concentration. The lowest sugar values were found in Alexandra PR and Hysun 321 PR hybrids, which produced the lowest amounts of nectar, but with high sugar concentrations in the average of the two years.

Results of nectar studies 2. (Verseg, 2004-2006)

There were significant differences among the sunflower hybrids concerning both the quantity and the sugar concentration of nectar. During the three years of study nectar production ranged from 0.070 to 0.428 mg, with nectar sugar concentrations varying between 20.5 and 66.1%. The nectar yield was good in the majority of the examined hybrids, there were no weak nectar producers among them. The hybrids NK Brio, Pixel PR and Arena PR proved to be excellent nectar producers with nectar amounts exceeding 0.2 mg in the average of the three years. For honey bees the least attractive hybrid was NK Armoni PR, which produced little (0.129 mg/disc floret) nectar with lower than average sugar concentration (45.1%), and thus the lowest sugar value (0.058 mg/disc floret) in the average of the three years.

Results of nectar studies 3. (Kerekharaszt, Hatvan, Verseg, 2002-2006)

The results have shown significant differences for all examined nectar parameters of the hybrids. It can be stated that not only the hybrids producing large volumes of concentrated nectar can be appreciated by beekeepers, since an average sugar value can be reached by a hybrid secreting lower than average quantity of nectar with high sugar concentration values (Opera PR), and also by a hybrid producing larger quantities of nectar with lower sugar content (NK Brio, Arena PR). Well below the average nectar production, with average or above the average sugar content can result in below the average sugar values, as in the case of the hybrids Alexandra PR, Hysun 321 PR, Pedro PR and Rigasol PR.

Results of nectar studies 4. (2nd investigation district, Mezőhegyes, 2002-2004)

There were significant differences in the nectar production of the examined hybrids, but the differences in sugar concentration could not be verified statistically (Table 2).

Table 2. Nectar production and sugar content of sunflower hybrids in the average of three years (average±SD) (Mezőhegyes, 2002-2004)

Hybrid	Nectar production (mg/disc floret)	Sugar concentration (%)	Sugar value (mg/disc floret)
Alexandra PR	0.126±0.035 a	46.5±8.7 a	0.059±0.020 a
Arena PR	0.152±0.035 bc	49.1±9.5 a	0.073±0.018 bc
Cledor	0.155±0.043 bc	51.4±11.6 a	0.078±0.023 bc
Coriste	0.167±0.043 b	49.4±10.7 a	0.082±0.026 b
Hysun 321 PR	0.145±0.043 ac	48.7±9.2 a	0.071±0.030 ac
Louidor	0.136±0.041 ac	49.5±10.1 a	0.067±0.023 ac
Average	**0.147**±0.042	**49.1**±10.0	**0.072**±0.024
Min.	0.060	27.0	0.024
Max.	0.365	69.0	0.201

Different letters (a,b,c) indicate significant differences among the hybrids ($P<0.05$) for the examined parameter.

Although a remarkable fluctuation could be observed in the nectar production of the Coriste hybrid in various years, it produced the most abundant nectar in the average of the three examined years, with an above average sugar content, thus it was ranked first in the apicultural attractiveness ranking. The flowers of the Cledor and Arena PR hybrids produced high amounts of nectar with high sugar content values, thus they became the second and third best nectar producing hybrids in Mezőhegyes. The Hysun 321 PR and Alexandra PR hybrids produced low volumes of nectar with lower than average sugar concentration in the average of the three years.

3.1.2. The effect of the year on nectar production, nectar sugar content and sugar value

The quantity, sugar content and sugar value of the nectar were significantly affected by the year in both examination districts. The examined hybrids reacted sensitively to the seasonal effects.

1st investigation district

The least advantageous weather conditions affecting nectar production were experienced in 2002, when temperatures were well above the average, with abundant precipitation during the year, but very little rain directly before bloom. Under such weather conditions sunflower hybrids produced significantly the lowest amounts (0.102 mg/disc floret) of nectar, at the same time reaching the highest sugar concentration values (54.1%) and the lowest sugar values (0.055 mg/disc floret). On the basis of the mean nectar production values, 2003 proved to be significantly the best year, when the sunflower hybrids produced an average of 0.265 mg nectar in a disc floret, which was 2.6 times higher compared to 2002, the year with the

weakest nectar yield. The weather of 2004, with temperatures below the average of the study years and near the average precipitation, affected favourably the amount of nectar, the sugar content and the sugar value. In 2005 and 2006 the hybrids produced lower amounts of nectar with less sugar content compared to the average of all study years (0.177 mg/disc floret).

2nd investigation district

The year of 2002 was the most advantageous for the nectar production of the examined sunflower hybrids in Mezőhegyes. In this year the hybrids produced the most nectar (0.158 mg/disc floret), at the same time with significantly the lowest sugar concentration values (39.8%) compared to the years of 2003 and 2004, thus resulting in the lowest sugar value among the years.

3.1.3. The effect of the production sites on nectar production, sugar content and sugar value

The production sites had a strong significant effect on all the examined parameters. Nectar yields were significantly the best at the production site near Hatvan (0.265 mg/disc floret) on meadow chernozem soil, where the hybrids secreted a nectar amount exceeding the average of production sites with 58%. Compared to the production site near Hatvan, the hybrids produced 61.5%, 34.0% and 44.5% less nectar in Kerekharaszt, Verseg and Mezőhegyes, respectively, which differences were statistically reliable. The hybrids reached the lowest average sugar values at the production site of Kerekharaszt (0.055 mg/disc floret).

3.1.4. The effect of weather conditions on nectar production, sugar content and sugar value

Abundant precipitation had a diluting effect on sunflower nectar, 15 mm precipitation resulting in sugar concentrations lower by 7% in the disc florets. Nectar yield was favourably affected by the more than 18 mm precipitation which fell during the study period. The most concentrated nectar (53.3%) was produced on the sunniest days (12.1-16.0 sunny hours/day). Disc florets produced the significantly highest amounts of nectar with the lowest sugar concentrations in the highest range of humidity (64.0-85.0%). There was a medium negative ($r= -0.509$; $P<0.01$) correlation between relative humidity and the sugar content of nectar, while there was a medium positive ($r=0.437$; $P<0.01$) correlation between temperature and sugar content of nectar. The sunflower hybrids produced the highest volumes of nectar with the lowest sugar concentration values in the temperature range of 20.0-24.9 °C.

3.1.5. The effect of flower age on nectar production and sugar content

The male-phase florets of sunflower hybrids secreted significantly more nectar, but with lower sugar content, compared to the female-phase florets, based on the average of the examined hybrids and years.

3.1.6. The effect of the time of the day on nectar production, sugar content and sugar value

The hybrids produced significantly higher amounts of nectar with lower sugar concentrations between 9-11 a.m. than in the afternoon between 1-3 p.m. Conversely, the difference in the sugar values of the nectar produced in the morning and in the afternoon was not significant. There was a strong positive ($r=0.808$; $P<0.01$) correlation between relative humidity and the amount of nectar, while no correlation was found between temperature and the amount of nectar ($P>0.05$). The relation between the daily mean temperature and the sugar content of nectar was strong positive ($r=0.708$, $P<0.01$), while the relation between the daily average humidity and the sugar content of nectar was strong negative ($r= -0.771$, $P<0.01$).

3.1.7. The sugar composition of sunflower nectar

Glucose and fructose constituted the highest portion of the nectar sugars in sunflower, while turanose, maltose and sucrose were present in significantly lower amounts in the nectar. The year had a significant effect on the presence of all sugar components. According to PERCIVAL's (1961) classification, the nectar of all three examined hybrids could be classified into the fructose-glucose dominant group. According to the sucrose/glucose+fructose (S/G+F) value, the nectar of the hybrids Alexandra PR and Hysun 321 PR was hexose-dominant, while that of Arena PR hybrid belonged to the hexose-rich category. On the hottest days with the lowest humidity significantly the most sucrose was produced in the nectar.

3.2. Flower- and inflorescence morphology examinations

3.2.1. Investigation of the corolla tube length

The corolla tube length of the six investigated sunflower hybrids changed between 5.35 and 6.73 mm in the years of study. The year did not significantly influence the length of the corolla tube. However, there was a significant difference among the hybrids, thus in the

average of two years the Arena PR and Pixel PR hybrids had significantly the shortest corolla tube length (5.84 mm), while the hybrid with the longest corolla tube was Louidor (6.30 mm).

3.2.2. Investigation of sunflower head diameter

In the average of three years the largest sunflower head diameter was measured in the Coriste hybrid (16.4 cm), while the smallest values were observed in the hybrids Hysun 321 PR (12.7 cm) and Louidor (10.8 cm). The year had a significant influence on the head diameter of the sunflower hybrids.

3.3. The pollen production of the sunflower hybrids

There were significant differences between the sunflower hybrids concerning pollen production, both within a year and among the years. The hybrids produced significantly less pollen in the cooler and wetter year of 2005, with temperatures well below the average, than in the somewhat hotter year of 2006, with still below the average temperatures and precipitation. In the average of two years, the best pollen producer was the NK Brio hybrid (45,279 pollen grains/disc floret), followed by Arena PR, Alexandra PR and finally NK Jazzy (31,286 pollen grains/disc floret).

3.4. New scientific results

1. The nectar production of sunflower hybrids can be characterized by variable quantity and quality, the hybrids producing higher volumes of less concentrated nectar between 9-11 a.m. than between 1-3 p.m. There are hybrids with constantly outstanding or constantly low sugar values. For apiculture the most valuable hybrids are the ones that produce high amounts of nectar with high sugar concentration values (LG5645, Pixel PR), but the hybrids with large nectar yield, but low sugar content (NK Brio, Arena PR, Coriste) can also be highly attractive for bees. Aging of the florets was found to reduce the quantity and increase the refraction of the nectar.

2. Sunflower hybrids react sensitively to the effects of the year and the production sites; these factors have a significant effect on the quantity and quality of the nectar. The difference in sugar values can be as high as 36-38% between a hot, dry year and another year with average temperatures but more precipitation. Some nectar yield can be expected even in a hot and droughty year, if the sunflower field receives sufficient quantity of precipitation before blooming.

3. Weather conditions significantly influence the nectar production and nectar sugar content of sunflower hybrids. More than 18 mm precipitation was found to have a significantly favourable effect on the nectar yield of sunflower, and higher sugar levels were detected in the nectar produced on sunny days. The 20-25 °C average daily medium temperature range is the optimum for the nectar production of sunflower hybrids.

4. The ratio of sugar components in sunflower nectar was determined, furthermore the presence of turanose and maltose was demonstrated, as well. The year was found to have a significant effect on the ratio of nectar sugars. An increase in temperature reduces the quantity of glucose and increases the amount of sucrose in the nectar, while higher humidity values are connected to reduced quantities of sucrose.

5. According to the results of the flower- and inflorescence morphology investigations, the year was found to significantly affect the flower head diameter of sunflower hybrids, and the corolla tube length of the investigated sunflower hybrids (5.35-6.73 mm) makes nectar available for the domestic honey bees (*Apis mellifera carnica*).

6. The years have a profound influence on the pollen production of sunflower hybrids, which were found to produce significantly more pollen in hotter years with lower than average precipitation, compared to cooler years with more precipitation.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions based on the results of nectar studies

4.1.1. The effect of the hybrid on the quantity, sugar content and sugar value of the nectar

Significant differences were demonstrated among the 17 investigated sunflower hybrids concerning nectar production, nectar sugar concentration and sugar value. 64% of the examined sunflower hybrids proved to be good nectar producers, 23% of the hybrids were found to be excellent nectar producers, while 13% of the hybrids could be characterized with low nectar production. In 6% of the results the hybrids produced dilute nectar, in 52% sugar concentration was of good quality, and in 40% the nectar was concentrated. In the hottest and dry years 2% of the examined hybrids produced highly concentrated nectar. On the basis of my results, the majority of sunflower hybrids can be considered as attractive for bees, based on the quantity and quality of their nectar. The highest apicultural value can be attributed to LG5645 and Pixel PR hybrids, which produced much and concentrated nectar with the best sugar values. The NK Dolbi and NK Armoni PR hybrids, producing the least nectar with lower than average sugar concentration and consequently low sugar values, are less attractive for bees.

4.1.2. The effect of the year and production sites on nectar production, nectar sugar content and sugar value

Both the year and the production sites were demonstrated to have highly significant effect on every investigated nectar production feature. It was confirmed that sunflower hybrids do not produce sufficient and good quality nectar in every habitat and under all circumstances, their nectar production is variable.

4.1.3. The effect of weather conditions on nectar production, nectar sugar content and sugar value

Major weather conditions, such as temperature, relative humidity, precipitation and sunshine were found to significantly influence the quantity and quality of nectar in sunflower hybrids. In reaction to certain weather factors, the nectar production of sunflower hybrids shows a notable fluctuation.

4.1.4. The effect of the flower age on nectar production and sugar content

The flower age was found to significantly influence the amount and sugar concentration of the nectar. With the aging of the flower lower volumes of nectar are secreted by the disc florets of sunflower, but with higher concentration values.

4.1.5. The effect of the time of the day on nectar production, nectar sugar content and sugar value

The outcomes of my research justify the results of PESTI (1980), HADISOESILO and FURGALA (1986), according to which higher nectar yields in the morning are accompanied with less concentrated nectar, while in the afternoon sunflower hybrids produce lower amounts of nectar, but with higher concentration. From weather factors mainly the relative humidity was demonstrated to influence nectar production.

4.1.6. Investigation of nectar sugar composition

Concerning the nectar sugar composition of sunflower, the amount of simple and compound sugars was shown to differ significantly. The ratio of simple sugars is much higher compared to compound sugars. From monosaccharides, the amount of glucose exceeded that of fructose, which was followed by the disaccharides maltose and turanose, and finally sucrose was detected in the lowest quantity. The year was found to have a significant effect on the ratio of nectar sugars, thus in hot and dry years less glucose, and at the same time more sucrose was detected in sunflower nectar.

4.2. Conclusions drawn from the results of the flower- and inflorescence morphology investigations

The corolla tube length of the investigated sunflower hybrids (5.35-6.73 mm) allows the exploitation of nectar by domestic honey bees (*Apis mellifera carnica*). The year did not significantly influence the corolla tube length, in contrast with the flower head diameter of the hybrids. In drier and hotter years head diameters can be expected to reach higher values in the hybrids, compared to wetter and cooler years. This suggests that in a more favourable year a larger number of florets can serve as nectar and pollen source for the pollinating insects, which in turn facilitates higher total nectar and pollen production, attracting larger number of insects.

4.3. Conclusions drawn from the results of the pollen production investigations

My results demonstrated that sunflower hybrids can be expected to produce significantly higher amounts of pollen in hotter years with lower than average precipitation, compared to wetter and cooler years, which might even double the pollen production in some hybrids in a more favourable season.

4.4. Summary of practical considerations

The floral attractiveness of sunflower hybrids is largely determined by the verified significant differences in the quantity, quality and sugar composition of the nectar. Differences in the ability of sunflower hybrids to attract bees with their nectar can directly influence oil and achene yield, which in turn affects the income of people involved in sunflower production. Although sunflower hybrids are self-fertile, higher pollen production can make a hybrid more attractive for pollinating insects, which can play a substantial role in more successful allogamy. If good pollen production is accompanied by excellent or good nectar yield, thus increasing the apicultural value of a hybrid, chances are even bigger to reach a higher fruit yield. The honey production of sunflower is significantly influenced by the hybrid, the year and the habitat, which should be taken into account by beekeepers when selecting a hybrid.

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