THE IMPACT OF FOLIAR FERTILIZATION ON THE NECTAR PRODUCTION AND APICULTURAL VALUE OF SUNFLOWER (*HELIANTHUS ANNUUS L.*)

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Abstract

Beside black locust (*Robinia pseudoacacia*) the sunflower is the second most important bee pasture in Hungary. New species and hybrids are generally considered as the sources for different honey flow of the nectariferous plant. However, the quantity and quality of the nutrition supply of the growing area can more effectively influence the honey flow of sunflower than the genetic potential of the crop. From the agro-technical point of view the nectar production of sunflower cannot be increased through the enlargement of the growing area but by increasing the nectar production in our dissertation.
We analysed the correlation between the nectar production and the nutrition supply of the crop in near Mocsa (47°40’37,9’’N 18°10’52,0’’E). We observed that the essential micro- (Zn and Cu), and macro-elements (Mg and Ca) applied as foliar fertilizers increased the quantity of nectar production. Foliar fertilizers of applied compounds ($Zn(OH)_2$+$ZnCO_3$, $Cu(NH_3)_4$, $MgCO_3$, $CaCO_3$) were produced from industrial by-products of high purity. We used ICP-AES analytical measuring method to measure the exact active substance. Compared to the control foliar fertilizer agents induced positive quantitative change in one floret in the dosage range of 0.086-0.341 mg/flower and in the average of three sample taking days (n=864). We examined the data with non-parametric significance method. Compared to the control ($p<0.05$) every sunflower hybrid showed higher nectar production due to tetramine-copper application.

Key words: sunflower, micro-, and macro-elements, foliar fertilization, nectar, bee-pasture

Összefoglalás

Magyarországon a napraforgó méhészeti szempontból a második legfontosabb méhlegelő az akác után. A növény eltérő mézeléséért az új fajtákat, hibrideket okolják. A napraforgó mézelését azonban sokkal inkább befolyásolhatja a termesztési terület tápanyag ellátottságának mennyisége és minősége, mint a vetett növény genetikai potenciálja. A napraforgó nektártermelésének növelése agrotechnikai szempontból nem a vetésterület növelésével, hanem a növény nektártermelésének fokozásával érhető el. Munkánkban a napraforgó nektártermelése, és a tápanyag ellátottság közötti kapcsolatot vizsgáltuk Mocsa település közelében (47°40'37,9''N 18°10'52,0''E). Az esszenciális mikro- (Zn, Cu), és makró elemek (Mg, Ca) lombtrágyaként való alkalmazásának, a termelt nektár mennyiségére gyakorolt hatását figyeltük meg. A lombtrágyázáshoz használt vegyületeket ($Zn(OH)_2+ZnCO_3$, $Cu(NH_3)_4$, $MgCO_3$, $CaCO_3$) nagy tisztaságú ipari melléktermékekből állítottuk elő, amelyek pontos hatóanyagtartalmát ICP-AES műszeres analitikai módszerrel határoztuk meg.Az alkalmazott lombtrágyák a napraforgó hibridnél a három mintavételezési nap (n=864) átlagában a kontrollhoz képest pozitív mennyiségi változást mutattak egy csöves virágra vetítve 0,086-0,341 mg · virág^{-1} tartományban. Az adatokat nem parametrikus szignifikancia vizsgálatnak vetettük alá. Minden napraforgó hibridnél a réz-tetramin kezelés mutatott szignifikáns nektár mennyiségbeli növekedést a kontrollhoz képest ($p<0,05$).

Introduction

In Hungary, we cannot expect an enlargement of the sunflower growing area of about 600.000 hectares, or 593 600 hectares (FAO, 2013) because of crop rotation requirements. Sunflower is allogeneic and entomophilous plant. This crop species has no specialized pollinating wild bees in Europe (Benedek and Manninger, 1972). Only honey bees (A*pis mellifera*) can provide effective pollination. Sunflower is grown in all counties of Hungary, however, its distribution is not even, therefore beekeepers have to migrate in order to reach better honey yields (Ruff, 1999; Frank, 1989). Beekeepers blame exclusively the new hybrids for differing honey flow and do not pay enough attention to the nutrient supply of the plants (Zajác et al., 2006; Lajkó, 2001; Nikovitz and Szalainé, 1984).

In Hungary, the quantity of applied fertilizers grew rapidly between 1940 and 1985 (Láng and Csete, 1992), although it decreased by 80% in the 1990s (Csathó and Radimszky, 2007). The utilization of various fertilizers containing nitrogen, phosphor and potassium has been slightly increased in the last decade in Hungary (KSH, 2014). Most soils in Hungary show microelement deficiency (Várallyay et al., 2009). Fresh manure may contain high enough quantity of microelements although the microelement content of the organic fertilizer will not be fully available for the plants in the first year (Zorn et al., 2007). During the past 10 years the utilization of organic fertilizers reduced by 2.3 t/ha in Hungary (KSH, 2014). Foliar fertilization can be applied economically to complete the crop's requirement on microelements (Szakál et al., 1988).

Since the beginning of 20th century we have known that zinc and copper (Sommer and Lipman, 1926; Sommer, 1931) have an essential function in plant physiological processes, and since the middle of 9th century we have known the same about magnesium and calcium (Benton, 2014). Copper has a biochemical role, as enzyme activator it works as a catalyser in redox reactions. It acts like magnesium and zinc in cytochrome c oxidase enzyme as enzyme building substance (Carr and Winge, 2003). Zinc being a component of tryptophan (a precursor of indole acetic acid (IAA)) influences the growth of plants. Interacting with indole acetic acid Ca^{2+} ions play a role in cell elongation and differentiation as well as in stabilizing the middle lamella of primary cells walls (Wehr et al., 2004; Carpita and McCann, 2000). Mg^{2+} ion has an essential function in the structure of the chlorophyll porphine skeleton in the photosynthesis. It has a function as a bridging element for the aggregation of ribosomal subunits *(*Cammarano et al*.*, 1972*).* Clearing the role of microelements in nectar production of sunflower could tangibly benefit to the beekeepers.

Our hypothesis was that the nutrition has larger role in the nectar production of the sunflower than that of the hybrid effect. The purpose of this experiment was to define the efficacy of the compounds used as foliar fertilizer on the quantity the nectar of sunflower.

Material and Method

Foliar fertilizers of five different concentrations and quality were applied on four sunflower hybrids. $ZnCO_3$+$MgCO_3$ and $Cu(NH_3)_4$+$CaCO_3$ foliar fertilizers were applied in quantities of 10 l h-1 in each case, further on 20 l ha-1 of $Zn(OH)_2$+$ZnCO_3$ and 3 l ha-1 of $Cu(NH_3)_4$ plant conditioner were applied on the crop. 10 m^2 large plots of the four Dow Seed hybrids (8N 358 CLDM, 8H 288 CLDM, MG 305 CP, 8M 449 CLDM) was. Hybrids of the Dow AgroSciences are classified either as conventional or high oleic (with oleic contents of greater than 84%). In many cases, the sunflower oil has a high proportion of heart-healthy mono-unsaturated fat, which confers health benefits and improved cooking characteristics. There splots were treated with the above mentioned doses of foliar fertilizers. Beside every hybrid we included one control plot (untreated one). It was 8 plots by hybrids. An isolation distance of 1.4 m was left between the plots.

The substances applied were produced from industrial by-products of high purity (Szakál et al., 1988). The micro- and macro-element agents of the foliar fertilizers were analysed with the method of inductively coupled plasma atomic emission spectroscopy (ICP-AES) and according to the Hungarian Standards (MSZ 21470-50:1998). Using three different measures 1-2.5-5ml samples of foliar fertilizers were sent to digestion according to the above described standard. Three different dilutions of every digested sample (1x, 10x, 100x) were analysed with the method of ICP-AES.

Table 1. Contents of active substances of the foliar fertilizers applied in our study based on analytical measurements

foliar fertilizer compound	quantity of active substances
$Cu(NH_3)_4$ + $CaCO_3$	5.57% Cu; 2.41% Ca
$ZnCO_3$ + $MgCO_3$	1.2% Mg; 1.18% Zn
$Cu(NH_3)_4$	5.65% Cu
$Zn(OH)_2$ + ZnCO3	10.71% Zn

Foliar fertilizers shall be applied at phenological stages of 53-57-59 on BBCH scale (Free, 1993). We applied them on 64th day from sowing (13th June 2014). We applied top dressing on the crop with 150 kg/ha NPK in dosages of 10:20:20. There were 50 000 sown germs per hectare in all the four different hybrid crops.

During the sampling period of three days the temperatures varied between 30-34C°. There was no rainfall in this period. The air humidity measured between 40-72%.

Nectar samples were taken from disc florets isolated with tulle netting and spacing 24 hours before (Free, 1993). Three discs being in identical flowering period were isolated per plot. Samples were taken twice a day at 7-11 AM and at 13-17 PM. Sampling was repeated on 3-5th July 2014 with 24 hour-differences. Pre-fabricated glass capillary tubes were used to take samples. We applied pipettes of narrowed inner diameter of 1mm at the end of the glass capillaries of 2.2 mm diameter. Samples were taken from 5 tubiferous florets with one pipette. Samples were taken from the female and male flowers at the same growth stage with the help of the glass pipettes and capillary effects.

We used bees wax balls to close the glass capillaries after sampling. Because the glass capillaries and the bee wax balls have different masses we weighed and numbered them on a four decimal precision analytical balance type Ohaus Adventure Pro AV264. After taking the samples we weighed the numbered capillaries on the same analytical balance in a laboratory. The fifth of the difference of net respectively gross capillary masses provided the nectar yield of one tubiferous floret in 24 hours. We compared the nectar yields of the four hybrids received as a result of the treatments.

We processed the received data in a chart data base using the programme Microsoft Office Excel 2007. Statistical evaluation was prepared with the programme IBM SPSS Statistics 20. We used Kolmogorov-Smirnov test to analyse the values of nectar samples and the distribution of the sample masses. We analysed the three-day nectar yields of hybrids treated with foliar fertilizers with Kruskal-Wallis test. Null-hypothesis was accepted if the mean values were the same in every group, i.e. the p-value exceeded 0.05 at a confidence interval of 95 %. Alternative hypothesis was accepted if the mean values of each group differed, i.e. p-value was lower than 0.05 at a confidence interval of 95 %. If the Kruska-Wallis test resulted in an alternative hypothesis we analysed the difference between the control and the treatments with Mann-Whitney test. If there is a null hypothesis the varying values belong to identical mean values based on the data of the three days and we can accept the null-hypothesis if the p-value exceeds 0.5 at a confidence interval of 95%. If there is an alternative hypothesis the mean values of the varying values received on the three days considerably differ. We can accept the alternative hypothesis if the p-value is lower than 0.05

at 95% confidence interval. Samples from the control plots were analysed with Levene-test and One-Way ANOVA because of the normal distribution of sample masses.

Results

Results of nectar yields of the four hybrids show the effect of foliar fertilizer treatment. The Kolmogorov-Smirnov test showed that the different quantities of the nectar samples taken from treated plots have not shown normal distribution. The Mann-Whitney test showed the following values for the differences in nectar production of the treated hybrids:

The average nectar yields of the hybrid 8N 358 CLDM treated with foliar fertilizers $Cu(NH_3)_4$ (0.49±0.24 mg · one flower^{-1}), $Cu(NH_3)_4+CaCO_3$ (0.37±0.19 mg · one flower^{-1}), $ZnCO_3+MgCO_3$ (0.46±0.31 mg · one flower^{-1}), $Zn(OH)_2+ZnCO_3$ (0.42±0.27 mg · one flower^{-1}) show significant increases compared to the control plots (0.29±0.13 mg · one flower^{-1}) ($p<0.05$) (Table 2.).

The average nectar yields of the 8H 288 CLDM hybrid treated with $Cu(NH_3)_4$ (0.55±0.29 mg · one flower^{-1}), $Cu(NH_3)_4+CaCO_3$ (0.40±0.19 mg · one flower^{-1}), $ZnCO_3+MgCO_3$ (0.61±0.31 mg · one flower^{-1}), $Zn(OH)_2+ZnCO_3$ (0.63±0.44 mg · one flower^{-1}) foliar fertilizers show significant increases compared to the control plots (0.29±0.14 mg · one flower^{-1}) ($p>0.05$) (Table 2.).

The average nectar yields of the MG 305 CP hybrid treated with $Cu(NH_3)_4$ (0.51±0.35 mg · one flower^{-1}), $Zn(OH)_2+ZnCO_3$ (0.42±0.27 mg · one flower^{-1}) foliar fertilizers show significant increases compared to the control (0.28±0.16 mg · one flower^{-1}) ($p<0.05$) (Table 3.).

The average nectar yields of 8M 449 CLDM hybrid treated with $Cu(NH_3)_4$ (0.62±0.33 mg · one flower^{-1}), $ZnCO_3+MgCO_3$ (0.46±0.31 mg · one flower^{-1}) foliar fertilizer showed significant increases compared to the control plots (0.30±0.13 mg · one flower^{-1}) ($p<0.05$) (Table 3.).

In contrast the plots treated the Kolmogorov-Smirnov test produced normal distribution for the control plots. According to the One-Way ANOVA analysis the following sunflower hybrids of 8N 358 CLDM (0.29±0.13 mg · one flower^{-1}), 8H 288 CLDM (0.29±0.14 mg · one flower^{-1}), MG 305 CP (0.28±0.16 mg · one flower^{-1}), and 8M 449 CLDM (0.30±0.13 mg · one flower^{-1}) produced no significant differences in the nectar production ($p>0.05$).

Compared to the control three out of four hybrids of 8N 358 CLDM, 8M 449 CLDM and MG 305 CP produced the highest nectar yields as the result of $Cu(NH_3)_4$ foliar treatment, as follows: increases in nectar yield of 73.47%, 89.57%, 92.66%. Compared to the control 8H 288 CLDM hybrid produced 117.70% in increase, the highest nectar yield, as a result of $Zn(OH)_2$+$ZnCO_3$ foliar treatment.

The hybrids 8N 358 CLDM, 8M 449 CLDM, and MG 305 CP had samples of normal distribution (0.54±0.31 mg · one flower^{-1}) as a result of $Cu(NH_3)_4$ foliar treatments as shown with the Kolmogorov-Smirnov test. Based on One-Way ANOVA analysis the nectar mass production of the three hybrids showed no significant differences (p>0,05).

Table 2. The role of fertilization in the nectar productions of the 8N 358 CLDM and 8H 288 CLDM sunflower hybrids, in milligrams (mg · one flower^{-1})

Dates of samplings	sunflower hybrids									
	8N 358 CLDM					8H 288 CLDM				
	foliar treatmnets									
	$Cu(NH_2)_4$	$Cu(NH_2)_4$+ $CaCO_3$	$ZnCO_3$+ $MgCO_3$	$Zn(OH)_2$+ $ZnCO_3$	control	$Cu(NH_2)_4$	$Cu(NH_2)_4$+ $CaCO_3$	$ZnCO_3$+ $MgCO_3$	$Zn(OH)_2$+ $ZnCO_3$	control
	mean±SD									
03.07.2014	0.50±0.25	0.29±0.17	0.32±0.26	0.32±0.14	0.26±0.11	0.43±0.24	0.39±0.20	0.42±0.12	0.37±0.20	0.29±0.15
04.07.2014	0.32±0.18	0.32±0.12	0.56±0.40	0.45±0.30	0.30±0.15	0.59±0.24	0.40±0.18	0.67±0.24	0.72±0.53	0.30±0.14
05.07.2014	0.61±0.24	0.49±0.21	0.49±0,20	0.48±0.32	0.32±0.15	0.64±0.36	0.42±0.20	0.73±0.42	0.81±0.41	0.29±0.14
	sum mean±SD									
	0.49±0.24	0.37±0.19	0.46±0.31	0.42±0.27	0.29±0.13	0.55±0.29	0.40±0.19	0.61±0.31	0.63±0.44	0.29±0.14

Table 3. The role of fertilization in the nectar productions of the MG 350 CP and 8M 449 CLDM sunflower hybrids, in milligrams (mg · one flower^{-1})

Dates of samplings	sunflower hybrids									
	MG 305 CP					8M 449 CLDM				
	foliar treatmnets									
	$Cu(NH_2)_4$	$Cu(NH_2)_4$+ $CaCO_3$	$ZnCO_3$+ $MgCO_3$	$Zn(OH)_2$+ $ZnCO_3$	control	$Cu(NH_2)_4$	$Cu(NH_2)_4$+ $CaCO_3$	$ZnCO_3$+ $MgCO_3$	$Zn(OH)_2$+ $ZnCO_3$	control
	mean±SD									
03.07.2014	0.31±0.25	0.33±0.11	0.14±0.11	0.30±0.14	0.27±0.17	0.62±0.29	0.34±0.13	0.14±0.11	0.47±0.23	0.26±0.18
04.07.2014	0.54±0.43	0.49±0.30	0.28±0.17	0.40±0.28	0.30±0.16	0.51±0.23	0.40±0.40	0.54±0.24	0.67±0.26	0.31±0.14
05.07.2014	0.70±0.25	0.53±0.42	0.42±0.20	0.56±0.31	0.26±0.18	0.74±0.41	0.51±0.25	0.68±0.28	0.79±0.32	0.29±0.15
	sum mean±SD									
	0.51±0.35	0.45±0.31	0.28±0.20	0.42±0.27	0.28±0.16	0.62±0.33	0.42±0.28	0.46±0.31	0.64±0.30	0.30±0.13

Discussion

All of the hybrids 8N 358 CLDM, 8H 288 CLDM, MG 305 CP and 8M 449 CLDM gave different reaction for the foliar fertilization regarding the nectar production. Foliar fertilizer can be brought out together with other agro-technical treatments, for example, plant protection agents.

Our results point that the nutrition is an important factor in the nectar production of sunflower hybrids. After using foliar fertilizer more nectar are available on the same bee pasture at the same time. It means that within a unit of time more nectar can be brought into the hives and it may increase the profitability of bee keeping.

Among the applied foliar fertilizers $Cu(NH_3)_4$ (copper-tetramine treatment) proved to be the most effective on three out of four hybrids. The physiological function of copper seems justified. Comparing the untreated controls we observed that there were no significant differences among the nectar yields of hybrids. Beekeepers mean consider that differences in hybrids account for uneven nectar production (Zajácz et al., 2006). Our investigations revealed that nutrient supply is a similarly important factor as the hybrid effect is.

Conclusion

Control hybrids on the same plot did not show any significant differences in nectar yield. Increasing nutrient supply with higher micro-and macro-elements applied as foliar fertilizers significantly increased the nectar quantity of every hybrid used in this trial.

We can conclude that the nutrient supply have more significant role in nectar production than the effect of hybrids. Applying micro- and macro-elements in foliar fertilizers readily available for plants can contribute to the apicultural value of different sunflower genotypes/hybrids.

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