THE ROLE OF BEEKEEPING IN PRODUCTION OF OIL CROPS

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Abstract: Production of sunflower oil are expected to serve larger and larger extent – over the demand of food industry and chemical industry – biofuel production. This could be especially true for that areas where climate is not allowed to grow winter rape safely and economically. Ecological role of honey-bees can be considered undoubtful in preservation of biodiversity of flora and fauna. I analyse the following problems in our study:

- What is the significance of oil plants in European and Hungarian energy production?
- How influence pollination the yields and the safety of production of oil plants?
- What is the role of oil plants in the development of production structure of beekeeping?
- What are the economical advantages of the above-mentioned effects?

Keywords: oil plants, biodiesel, bio-energy, bee, pollination

1. Introduction

While everybody knows the ecological importance of bees, yet the economic significance of bees and beekeeping sector can be difficult to accurately access. The economic statistical surveys usually measure only the contribution of beekeeping to GDP through sale and export. However bees play key role in cultivation techniques of crops requiring insect pollination, thus in production of oil crops as well. Nevertheless oil crops play important role not only in food supply, but also in production of bio-propellants. The importance of pollination is hard or impossible to express in money, since its role is essential, but it is plentifully available in Hungary, thus it is worth nothing and everything at the same time.

Increasing population and improving living standard are accompanied by growing demand for food and energy as well. Currently the population of the world annually consumes 500 EJ energy (IEA, 2013) (approximately 8 MJ/hour/capita on an average!) and it will probably increase by 25% until 2030 despite of the energy-saving measures (Ortwein, 2011). Decrease of fossil reserves, rising costs of exploitation lead to the increase of energy prices – in addition to the growth of environmental damages. Their partial replacement is a key issue of all kinds of economic policy; nevertheless arable energy production could improve the income position of agriculture as well as the safety of sale (Bai, 2008). On the other hand – from food safety, environmental protection, land utilisation, energy efficiency point of view – production obviously has limits in this case as well.

2.The importance of oil crops and biodiesel

As demand for oil crops – through this, particularly the domestic sowing area of rape – is considerably influenced by the use for propellant, thus I deem it advisable to briefly introduce this segment of use as well.

At present biodiesel substitutes only 1% of global gasoline use, however fourfold of this value is utilised in the EU. Between 2007 and 2012 global production is almost doubled, it increased from 9 239 thousand tonnes to 18 510 thousand tonnes (21 billion litres) (Jobbágy 2013). In 2012 the biodiesel production of the EU (Jobbágy 2013) gave about 43% of global production. As a new tendency, next-generation biofuels like TBK-biodiesel and algae-oil-methylester have already been appeared in biodiesel production, but they should not be cause appreciable effect on oil plant production (Bai, 2011). *Figure 1.* demonstrates the continually increasing utilisation of diesel in contradiction to petrol, which slightly decreases. It can be mainly explained by the fact that from environmental protection and economic aspects the utilisation of diesel is more favourable than the use of petrol.

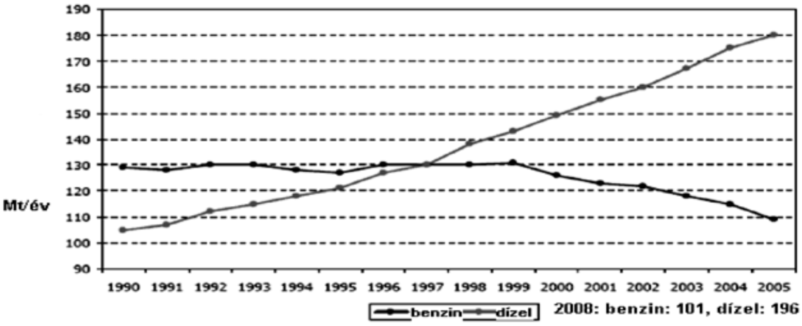

Figure 1.: **The evolution of petrol and diesel consumption in the EU**
Source: Eurostat (2010)

In 2010 the capacity of biodiesel plants was 21.9 million tonnes/year in the EU (Popp et al, 2010), the utilisation of it was 41%; in 2011 this proportion was only 33% (Jobbágy 2013), thus biodiesel is produced in a more costly way, their competitiveness can be improved very simply by continuous operation. It entails the further increase of the sowing area of rape, which can not be accessed easily in view of rotation period and food safety aspects. *Table 1.* illustrates the domestic, EU and global basic data of the most important oil crops being allowed to produce in the EU.

Table 1: Sowing area of sunflower and rape as well as their expected yield (2010/2011)

	World		EU		Hungary	
MU	Mill ha	Mill t	Mill ha	Mt	Thsd ha	Thsd t
Sunflower	23	31,8	3,8	6,7	501	973
Rape	31,7	59,8	6,8	21,2	261	555

Source: www.akii.hu, www.fapri.org

While the role of Hungary can be considered significant in sunflower production within the EU, owing to the domestic weather conditions rape can be produced by much smaller yields, higher average cost and greater risk in comparison with western-European countries (*Figure 2.*). This two oil crops represented about 16% (732 thousand tonnes) in crop structure in 2010, which approached the theoretical limit from the crop rotation point of view. *Figure 2.* also well presents that the sowing area of the most important oil crops was doubled in the past years, which was primarily owing to the production of rape of biodiesel purpose. In compliance with Pepó (2011) in Hungary the sowing area of sunflower can be enlarged to maximum 600–650 thousand ha without any negative consequences, while in case of rape the same sustainable limit can be maximum 390–420 thousand ha. The limitedness of sowing area is typical in other countries of the EU and the world as well, although there have been still reserves in that respect in the agriculture of the world, it can be generally stated that this reserves show a downward tendency everywhere and they are limited.

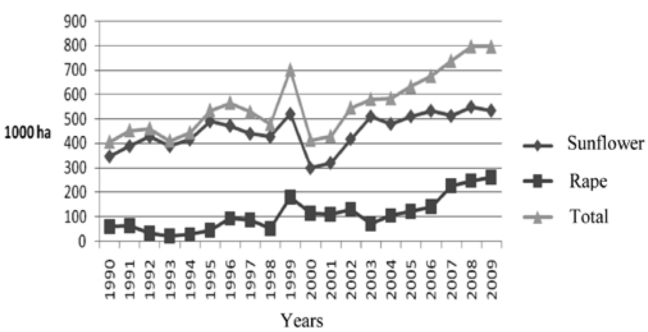

Figure 2: The alternation of the sowing area of sunflower and rape in Hungary (1990–2009)
Source: www.ksh.hu (2010)

The current domestic and EU market tendencies show increasing demand for sunflower products, to which the decline of the EU stores and soy bean import contribute. The quality of rape is clearly worse as regards feeding aspects, though from the motor point of view it is better than sunflower (Molnár et al (AKI), 2011).

3. The role of beekeeping in oil crop production

The ecological importance of bees and other pollinating insects in preservation of the biodiversity of the flora and fauna is undoubted (Daily, 1997). While sunflower- and rape sector are bee pastures for the bees, on the other hand bees – mainly the pollinating activity of them – are elements of the cultivation practices for the oil crops' sector. According to Lampeitl (2009) the honey-bee (Apis melifera) carries the 80% of insect pollination, while McGregor (1976) considers pollination as the most important economic factor primarily in monoculture cultivation. In case of certain orchards the 90% of yield depend on the activity of pollinating bees (Southwick és Southwick, 1992). Allsopp et al. (2008) make the value of pollination equal with the costs of that. In order that the effect made by beekeeping sector to crop production can be valued, we have to be acquainted with the aspects on the score of which the bees choose bee pasture and with the factors influence their activity.

Bees collect pollen as nutriment owing to its high protein content, mainly for feeding larvae (grubs). Nectar and honey-drew[1] of blooms are also important nutriments for bee, particularly owing to their high energy content. Ruff (2007) describes in detail that self-inductor process, in the course of which the hive selects the most suitable pasture for it, which expresses in so-called bloom loyalty. The economic importance of bloom loyalty mainly appears in the fact that bees pollinate the same kind of crops in large numbers insuring the fertilization, while wild insects, pollinating organs visit different species, thus fertilization is doubtful. During the selection of bee pasture the most important aspect for the bees

[1]In consequence of the inadequate plant protection of sunflower aphides can proliferate, which pass high sugar content moisture to the plant during their secretion.

is the quality, quantity of the harvestable nutriment and the distance of it from the hive.

All that generate that bees visit certain blooming cultures with higher intensity – owing to the above-mentioned aspects –, in spite of the fact that more different blooming cultures bloom at the same time. Simultaneously with the blooming of economically important oil crops other wild relatives bloom very rarely, thus competition mostly emerges between certain species and hybrids. As a consequence of the above-mentioned, from two sunflower- or rape fields bees will visit more often that providing more and better nectar and pollen. So it can be seen that pollination is more certain on field proving to be better bee pasture, thus yield safety is larger, which finally improves the efficiency of cultivation practice and reduces the specific costs of that. The situation of Hungary can be considered very favourable as regards pollination; its bee density is almost 10 bee hives/km^2 on an average of the total area of the country. In Hungary 70% of the 16 000 beekeeping farms are wandering beekeepers, thus the above-mentioned bee density concentrates further during the blooming of oil crops securing pollination.

Results of the questionnaire survey made by Kovács in 2010 present that beekeepers in Eastern-Hungary, within that in Békés County mostly have three wandering destinations. In chronological order the first one is rape, the second one is acacia and the third one is sunflower. In Békés County 87% of beekeepers are wandering beekeepers. The high ratio of wandering beekeepers is favourable as regards the pollination of oil crops, since the mobility of bee hives is a key issue in order to develop the bee density referring to the sowing area of oil crops that can be considered ideal as regards fertilization. The aforementioned tendency is also typical in the other member states of the European Union, which practically excludes for the beekeeping industry the opportunity that the beekeepers in the EU countries obtain income as a compensation for pollination. Kevan et al. (2008) explains that the pollinating activity of bees is rather underestimated. Countries possessing large bee density take pollination for granted. In contradiction for example to the USA and to those countries where crop production can be characterised by extensive monocultures and lower bee density is typical in beekeeping industry. There farmers not only accept, but also give material support for beekeepers in order that they settle down their cultivated crops. The fact was contributed to this that between September 2007 and March 2008 36% of the hives of that place became depopulated, but in certain beekeeping farms damage reached 90%. The absence of beneficent "activity" of bees in pollination resulted in serious damages.

It can be expected in the future that sunflower-seed oil production will increasingly serve the utilisation of energetic purpose beside the demand of food- and chemical industry. It can be particularly true in those areas where climate does not open the door to safe and economical production of rape, such as in the eastern part of Hungary or in the drier, warmer area of South-European countries.

4. The role of oil crops in production structure of beekeeping sector

On the basis of literature data (Lampeitl, 2009, Ruff, 2007) 1 ha oil crop gives an average quantity, but not a negligible amount of honey, which expected volume is the following:

- Sunflower: 80–100 kg/ha;
- Coleseed: 50–60 kg/ha.

Table 2. demonstrates that rape and sunflower give minimum 25% of the produced honey in Hungary. It has to be realized that there is significant fluctuation in produced quantity of certain honeys. In those years when conditions was less favourable to acacia-honey production, the amount of honey being collected from oil crops attained 40% of the whole commodity supply as well. It can be clearly stated that oil crops are defining bee pastures beside acacia for beekeeping sector.

Table 2: **The structure of honey production and distribution**

Year	1999-2003	2004	2005	2006	2007	2008	2009
Production (t)	17 780	19 500	19 700	22 500	24 700	26 700	22 500
Ratio of honey types	%	%	%	%	%	%	%
Rape	11	19	19	9	18	12	5
Sunflower	14	11	18	30	12	30	20
Acacia, mixed blossom honey	75	70	63	61	70	58	75

Source: OMME (2007)

5. Introduction of the experiment

The main objective of the experiment is to explore the relations between beekeeping sector, within that bee density and sunflower sector. Considering that bee density in Hungary can be regarded high on a world scale (10 bee hives/ km^2), I tried to model low bee density by increasing distance between bee pasture and hive. This modelling method is made possible by the above-mentioned bloom loyalty and the preference order of bees. During the experiment I tried to find the answer for the following question: What an effect has bee density on sunflower sector?

5.1. Experimental conditions

The location of the experiment can be found in Southeast-Hungary, in the northern part of Békés County, in the southern boundary of Vésztő. The sunflower field initiated in the experiment is 60 ha large and its farthest point from the hives is 1.6 km far. The name of sunflower hybrid is LG 5658CL. On the north-western corner of the field 30 bee hives were introduced. In this way 2 bee hives/ha bee density was modelled in the field. Locally, close by hives, where sampling also happened, the bee density is 10 bee hives/ha. Bee hives were located in hives of NB24 type, the name of bee breed is apis melifera carpatica. The next beekeeping farm around the table was 3.5 km far from the location of the experiment directly on the edge of an other sunflower field. The neighbouring beekeeping farm had altogether 90 bee hives, which also covered a sunflower field being in the same level of development as the initiated field and it was situated in 100 ha large area. It is important to emphasize that the total area of the experimental sunflower had smooth stand showing same level of development. In my view it was due to that weather conditions and the quality of the see-bed were optimal during the sowing-time.

5.2. Measurement methods

In the course of sampling I selected 20–20 sunflower plants in those third of the field which was the nearest (where the distance of the flowers from the hives was only 12–15 m) and in those which was the farthest (about 1590 m distance) from the hives leaving out the rotating area. These plants were labelled by ribbons strengthened to the lower part of their stems. The labelled plants had the same parameters, their height was between 115 and 125 cm, their blooming started on the same day, on 21 July in the calendar year. The reason why I counted the numbers of bees on the blooms in the next 15 days between 9 and 10 a.m. and 3 and 4 p.m., was that flowering of sunflower tipically about a forthight-long. Based on Pesti (1976), secretion of nectar from sunflower reach its maximum in every 4 hour, between 9–10 a.m. and at about 1 p.m. For the sake of avoiding the distortion of my tests during the above-mentioned two day-periods I averaged the results of the two numbering in the case of every bloom and sample.

On the ninth day it was rainy in the afternoon, thus data of this day showed negative outliers. On the basis of data provided by the instruments of the harvesting combine I found that yields were smooth on the whole area of the field. The average yield was 2.8 t/ha on the field. According to the instruments of the combine the lowest yield was 2.65 t/ha, while the highest value was 2.9 t/ha, this suggests that pollination completely happened on the whole area of the field. Data collected by sampling presented normal distribution, which opened the door to examine the two sampling numbers by two-sample T-test (*Table 3.*). Line chart was used for explaining results (*Figure 3.*), since I judge it can present my consequences in the most expressive way.

5.3. Results and discussions

Two-sample T-test (*Table 3.*) presents significance of 0.84 value by 5% error band, which indicates very close connection between the two sample numbers. It confirms the fact that pollination happened in the whole area of the field and it can be explained by the fact that there was higher bee density in the whole area of the parcel in comparison with the country average that can be considered high on a world scale as well (Zajácz 2011.)

As the result of statistical test does not describe the importance of relations between bee density and pollination for crop cultivation in itself, analyses of trends presented by two sample numbers is also necessary (*Figure 3.*) Graphs on *Figure 3.* include similar values, which is equal to the result of two-sample T-test. However from a practical point of view a significant difference can be investigated, the graph indicating the number of bees being counted on far blooms takes the value of the graph indicating the number of bees being observed on near blooms with a fed day difference. It is practical to write the trend function of the two graphs and compare their zero points in order to determine the degree of differences.

The equation of trend function in the case of near blooms:

$$Y' = -0{,}0403x^2 + 0{,}6362x - 0{,}4613$$

zero points: $\mathbf{x'_1=0{,}76}$ and $\mathbf{x'_2=15{,}02}$

Table 3.: **Two-sample T-test**

Group Statistics					
	Distance	N	Mean	Std. Deviation	Std. Error Mean
Bee density	Near	15	1.293	0.7755	0.2002
	Far	15	1.243	0.6100	0.1575

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. 2-	Mean Diffe-rence	Std. Error Diffe-rence	Lower	Upper
bee density	Equal variances assumed	1,198	0,283	0,196	28	0,846	0,05	0,2548	-0,4719	0,5719
	Equal variances not assumed			0,196	26,527	0,846	0,05	0,2548	-0,4732	0,5732

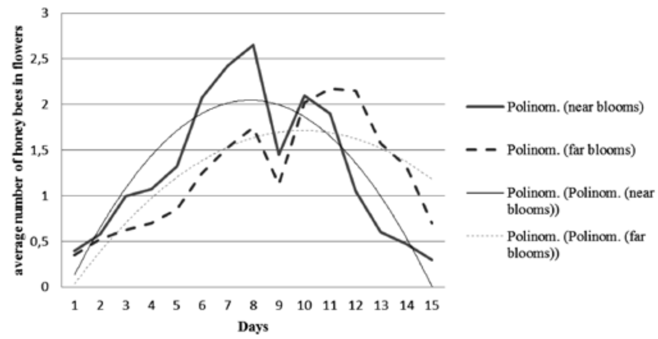

Figure 3: Pollinating activity of bees

The equation of trend function in the case of far blooms:

$$Y'' = -0{,}021x^2 + 0{,}4174x - 0{,}3623$$

zero points: x''_1=0,91 and x''_2=18,97

$\mathbf{x_1}$ zero points indicate the start of pollination on the x-axis, and $\mathbf{x_2}$ zero points indicate the finish of pollination. It shows that pollination happened about 4 days earlier on near blooms than on far blooms having relatively lower bee density. From crop cultivation point of view it means that higher bee density increase pollination. Increase of yield safety is primarily attained by decreasing risks of pollinating activity. It can be supposed that pollination can even more pass beside lower bee density and by increasing distance between bee pastures and hives exposing sunflower production to any more risks. Pollination lasted 19 days on the sunflower field being under experiment. It is a feature of sunflower that it is blooming through 10–15 days under ideal conditions, but it can even wait for pollination until 2 weeks (Frank 2012). By increase of waiting period the harvesting time is also postponed. The prospect of fertilization is minimal on the expiration of 3 weeks. During the experiment period conditions were favourable for the examined sunflower stand, thus pollination happened within 15 days on near blooms, where 10 bee hives/ha bee density was modelled. It follows from the foregoing that favourable effect of fast pollination emerges not only in assuring yield, but it also increases the safety of harvesting. The reason for this is that harvest of sunflower can be started potentially a week earlier on those areas where the level of bee density reaches 10 bee hives/ha in contradiction to areas where bee density is lower than 2 beehives/ha. The economic advantage of it is that the chance of the quality and quantity damage of different fungus infections decreases and more time remains for completing cultivation and sowing. Consequently earlier harvesting has favourable effect on the quality of sunflower achene and it assures more possibility to evolve an optimal sowing structure.

1 ha sunflower supplies 80–100 kg honey on an average (Lampeitl, 2009, Ruff, 2007). In compliance with the questionnaire survey of KOVACS carried out in 2010 the beekeeping farms in North-Békés annually produce almost 50 kg sunflower honey per bee hive on an average. Consequently in beekeeping sector there is no honey yield loss from the competition among bee hives beside 2 bee hives/ha bee density. According to the experimental experience at the same level pollination is also carried out in 19 days. Considering the above-mentioned facts it can be stated that in the case of sunflower the evolution of 2 bee hives/ha bee density can be considered optimal in terms of beekeeping and crop cultivation. In case of higher bee density specific honey yield can decrease, on the other hand in case of lower bee density yield loss can emerge in sunflower sector.

6. Summary

Nowadays the demand for energy and food of the growing world population has been rather increasing. Owing to the bees we can produce not only an energy source but also honey – a very significant food – on the same area. Considering that the energy sources are limited we have to pay increasing attention to the rational and efficient use of our existing sources. In crop cultivation external environmental conditions have a great influence on the efficiency of different agro-technological elements. Bees can play important role in decreasing these environmental risks and ensuring the efficiency of the applied technological elements. As regards pollination the weather risk expresses in the stop of pollination, since in cold and rainy weather bees do not leave their hives. From crop cultivation point of view it means that the chance increases for getting unproductive blooms. By 10 bee hives/ha bee density the generative life cycle of sunflower is shorter by around 30% than in case of lower bee density than 2 bee hives/ha. Hereby harvesting can also happen earlier, which has a favourable effect on the quantity and quality parameters of sunflower achene, that can help with evolving optimal sowing structure in that way it makes easier the work organization of cultivation and sowing. During my research I found that as regards beekeeping and sunflower sector the evolution of 2 bee hives/ha bee density can be considered optimal in Hungary.

On the basis of the experiment I suggest that during the purification of sunflower the quantity and quality feature of nectar producing capacity should be an additional standpoint beside the primary measure of value properties. The more nectar a crop is able to produce, the more bee hives can be applied on the sowing area of sunflower, thus it leads to faster pollination and more safety sunflower production. In the course of experiment I managed to establish that the evolution of 2 bee hives/ha bee density does not induce any problem for the member of domestic beekeeping sector due to the high level of mobility and the large number of wandering beekeepers. This explains the fact why pollination can not be sold as a service in Hungary and in area being characterised by similar bee density. The direct economic advantage of pollination is the value of harvested honey, but it can be resulted - indirectly – significant reduction in the quality of oil seed in case of insufficient number of bees. The determination of the lowest bee density beside that yield loss emerges owing to the lack of pollination requires further examinations.

References

Allsopp, M.H. - Lange, W. J. de -Veldtman, R. (2008): Valuing insect pollination services with cost of replacement. PLoS ONE. 2008; 3(9): e 3128. Publushed online 2008 September 10. doi: 10.1371/journal.pone0003128.

Bai A. (2011): Újabb generációs bio-üzemanyagok perspektívái. Magyar Tudomány. Az MTA folyóirata. HU ISSN 0025 0325. Kiadó: Akaprint Kft, Budapest. 171. évf, 7. szám, 2011 július, pp. 861-871.

Bai A. (2008): Liquid biofuels in Hungary: Effects and contradictions. Apstract.Official periodical of the International MBA Network. Agroinform Kiadó, HU ISSN 1789 221X, Vol 2, No. 1-2, Budapest 2008 pp.89-94

Daily, G. C. (1997): Nature's services. Societal dependence on natural ecosystems. Island Press, Washington, DC. 392 pp. ISBN 1-55963-478-8 (hbk), 1 55963 476 6 (soft cover)

Frank J. (2012): Versenyképes napraforgó-termesztés, Mezőgazda Kiadó, Budapest, pp.46.

Jobbágy P. (2013): A hazai biodízel-ágazat komplex elemzése, PhD értekezés, pp. 15-16.**Kevan, P. G. – Clark, E. A. – Thomas, V. G.** (2008): Insect Pollinators and sustainable agriculture. American Journal of Alternative Agriculture. 5. 13-22. Cambridge University Press.

Lampeitl, F. (2009) : Méhészek könyve, Mezőgazda Kiadó, Budapest, pp. ???

McGregor, S. E. (1976): Inseckt pollination of cultivated crop plants. Agricultural Handbook. No. 496. A. R. S., U.S.D.A, Washington D.C., p. 411.

OMME: Magyar Méhészeti Nemzeti Program (2007–2010), *Melléklet a 152/2007. (XII. 22.) FVM rendelethez www.omme.hu/portal/download/.../MMNP_2007-2010.rtf*

Pepó P. (2011): Az olajnövények termesztése és meghatározó agrotechnikai elemeik Agrofórum, p. 10

Pesti J. (1980): A struktúra és a produkció vizsgálata a Compositae florális nektáriumaiban. Doktori disszertáció, Budapest:MTA könyvtára, 150 p.

Ruff J. (2007): Korszerű méhészet, Szaktudás Kiadó Ház, Budapest,

Southwick, E. E. – Southwick, JR. L. (1992): Estimating the economic value of honey bees (Hymenoptera: Apidae) as agricultural pollinatiors int he United States. Journal of Economic Entomology. Volume 85. Number 3. June 1992., pp. 621-633. Entomological Society of America.

Ortwein, S. (2011): Technology Leader`s Keynote Address World Future Energy Summit (WFES) 2011 Technology Forum in Abu Dhabi. http://www.renewableenergyfocus.com/view/15342/wfes-2011-global-energy-demand-to-rise-25-by-2030/

Molnár Zs-Pájtli P.-Keresztessyné M.Zs: Agrárpiaci jelentések. Gabona- és ipari növények. AKI Kiadványok. XIV. évf., 5 sz., 2011 március 25, pp. 17-23, www.aki.gov.hu

Popp J-Somogyi A.-Bíró T. (2010): Újabb feszültség a láthatáron az élelmiszer- és bioüzemanyag-ipar között? Gazdálkodás, 54. évf., 6. sz., pp. 592-603.

www.ksh.hu, www.fapri.org, www.aki.gov.hu

Zajácz E. (2011): Napraforgó hibridek nektártermelési és egyes területi elhelyezési kérdései eltérő agroökológiai adottságok esetén, Doktori értekezés, 34. pp.