

ESTIMATION OF THE EFFICIENCY OF POLLINATION BY BEES OF SUNFLOWER CULTURE FOR HYBRID SEED PRODUCTION

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Abstract

The purpose of the research was to estimate the efficiency of pollination by bees of some parental sunflower varieties, depending on the distance between the selected sectors with inflorescences and hives with bees, placed for pollination, was carried out. The experiments were performed on a field of sunflowers, with an area of 36 ha, where maternal variety "Express" and paternal variety "NS-X 6006" (both from Republic of Serbia), destined for crossing to obtain hybrid seeds, were sown alternatively. Around chain have been located 144 bee families, so that there were 4 families per ha. For verifying the self-pollination capacity of sunflower, 4 experimental sectors were selected, at different distances from the beehives - 10, 100, 300 and 500 m. As a control 8 inflorescences were selected in each sector, which before flowering, were covered with gauze. In the phase of full ripening of seeds, from each experimental sector the seeds were collected manually - 8 control-inflorescences and 9 experimental inflorescences (naturally pollinated). For each inflorescence in part were examined: the total number of seeds, number of fertile and sterile seeds, total weight of seeds, weight of fertile and sterile seed (weighed on electronic scales accurate to 0.1 g) and degree of seed's fertility. A result of researches was found that sunflower crops of varieties "Express" and "NS-X 6006" researched by us, are typically entomophilous, because in our experience, self-pollination (isolated) did not occur. The degree of seed's fertility of pollinated by bees inflorescences, varied depending on the distance between experimental inflorescences to the beehives, from 85.7% to 90.3%. The average total mass of the seeds from free pollinated inflorescence was higher compared to that of the self-pollinated inflorescences with 36.6 to 54.0 g or 260-740% ($t_d = 7.5$ to 16.3; $P < 0.001$), hence, pollinating by bees of parental varieties of sunflower "Express" and "NS-X 6006" is quite effective and increases the harvest of seeds from 3.6 to 8.4 times.

Key words: efficiency, pollination, bees, sunflower.

INTRODUCTION

One of the most important benefits brought to human by bees is additional product obtained from increased productivity of cultivated and spontaneous entomophile flora, as a result of their pollination, thus ensuring the perpetuation of nature biodiversity. Especially, the increasing of productivity occurs at crops. In the Republic of Moldova approximately 350 thousand ha of lands with agricultural plants are pollinated by bees, which allow increasing the harvest by 20-30%, the annual value consisting over 700 mil. lei. Unfortunately, agricultural producers (farmers, agronomists), mostly ignores the fact that the bees are the main pollinators of entomophilous crops and can serves as key factor in increasing of their harvest. Both farmers and beekeepers until the present didn't realized the fact that only by increasing

the yield of harvest per unit of land and quality of agricultural products by using honeybees for directed pollination of entomophilous crops and producing of ecological agricultural and beekeeping products, can ensure economic efficiency and sustainable development of the respective branches in the country. Traditionally, the sunflower (*Helianthus annuus*) crop is considered typical entomophilous, whose pollination is performed exclusively by means of insects (Alexandru et al., 2007). Numerous researches carried out in this field (Falaleev et al., 1973; Frediani, 1973; Furgala, 1973; Hociota, 1973; Ion, 2012; Ion et al., 2008; Ion et al., 2007; Ion et al., 2006; Yadav et al., 2003; Фаркаш, 1987) shows that sunflower pollination by bees increases considerably the production (harvest) of seeds with 35-70% compared to the free pollination, without bees. Moreover, some researchers (Frediani,

1973) states that "*after cross-fertilization there is a considerable increases not only of seed's weight, but also oil concentrate in sunflower*".

Also there is information that in some modern hybrid varieties of sunflower, the phenomenon of self-pollination occurs in 18-98% of cases (Ion, 2012). Based on this information in recent years, the traders of sunflower seeds had spread among farmers and seed producers of this crop, hypothesis that most modern hybrid varieties are self-pollinating and does not require pollination by insects.

The pollination of the flowers, in general, consists in transporting of the pollen from anthers of the stamens on the flower's stigmas. Sunflower is considered as allogamous but entomophilous flower, because the process of self-pollination of flowers in nature is very difficult. This is explained by the fact that "*there is a difference of maturity between male organs (stamens) and female organs (stigma), the stamens grow and mature before the stigma, which means that the pollen is set free long before the stigma is receptive*" (Ion, 2012). For these reasons, the necessity of entomophilous pollination of the sunflower crop is not researched enough (Лайко и др., 1987).

Unlike developed countries, in the Republic of Moldova honeybees are underutilized for directed crop pollination, in particular for sunflower. This is explained by the fact that it was extremely widespread in agronomy information that most contemporary varieties of sunflower are self-fertilized and do not requires entomophilous cross pollination.

In this context, our research was aimed to check the phenomenon of self-pollination and the necessity of pollination by bees of some varieties of sunflower, grown in our country.

MATERIALS AND METHODS

To solve the purpose, an experiment to estimate the efficiency of pollination by bees of some parental sunflower varieties, depending on the distance between the selected sectors with inflorescences and hives with bees, placed for pollination, was carried out. The experiments were performed on a

field of sunflowers, with an area of 36 ha, where maternal variety "Express" and paternal variety "NS-X 6006" (both from Republic of Serbia), destined for crossing to obtain hybrid seeds, were sown alternatively. Around chain have been located 144 bee families, so that there were 4 families per ha. For verifying the self-pollination capacity of sunflower, 4 experimental sectors were selected, at different distances from the beehives - 10, 100, 300 and 500 m. As a control 8 inflorescences were selected in each sector, which before flowering, were covered with gauze, thus, isolation of flowers from pollinating insects was ensured. In the phase of full ripening of seeds, from each experimental sector the seeds were collected manually - from 8 control-inflorescences and 9 experimental inflorescences (naturally pollinated). For each inflorescence in part were examined: the total number of seeds, number of fertile and sterile seeds, total weight of seeds, weight of fertile and sterile seed (weighed on electronic scales accurate to 0.1 g) and degree of seed's fertility. Obtained data were statistically analyzed using computer software "STATISTICA-12" and appreciated their significance, according to biometric variational statistics after the methods of Плохинский Н. (1969).

RESULTS AND DISCUSSIONS

Given that to the natural pollination of meliferous plant participate several species of insects, and *A. mellifera* prevail in its activity, covering about 80% of all pollination, in our experience, the notion of "pollination by bees" means directed pollination, by placing bee families next to sunflower crop with free participation of various species of entomophilous insects, existing in respective area. The experimental results showed that the varieties of sunflowers "Express" and "NS-X 6006" are typical entomophilous because self-pollination (isolated), in our experience, has not been determined (Table 1). The degree of fertility of seeds at the pollinated inflorescences had varied depending on the distance between the experimental sectors and beehives. Thus, seed's fertility in the sector no. 4, located at 500 m from the beehives, was 85.7% in the sector no. 1, located at a

distance of 10 m of the beehives - up to 90.3%, and at the inflorescences pollinated

isolate (self-pollinated) seed fertility varies from 0 to 0.8%.

Table 1. The results of pollination by bees sunflower varieties "Express" and "NS-X 6006", grown for hybrid seed production

Or. No.	Studied indices	Pollination by bees, M ± m	Self-pollination M ± m	Bees pollination <i>versus</i> self-pollination		
				d	%	t _d
Sector no. 1 (10 m)						
1	Number of investigated inflorescences	10	8	x	x	x
2	Total number of seeds per 1 inflorescence	1217 ± 75	1041 ± 51	+176	+16,9	1.9
3	Total mass of seeds per 1 inflorescence, g	68.7 ± 5.7	14.7 ± 1.5	+54.0	+4.7 time	9.2
4	Total number of fertile seeds per 1 inflorescence	1104 ± 78	9.6 ± 9.0	+1094	+115 time	13.9
5	Fertile seeds, %	90.3 ± 1.9	0.8 ± 0.7	+89.5	+112.9 time	44.3
6	Mass of fertile seeds (harvest), g	68.0 ± 5.7	0.7 ± 0.7	+67.3	97.1 time	11.7
Sector no. 2 (100 m)						
1	Number of investigated inflorescences (N)	9	8	x	x	x
2	Total number of seeds per 1 inflorescence	1010 ± 73	1224 ± 147	-214	0.83	9.1
3	Total mass of seeds per 1 inflorescence, g	61.9 ± 5.1	13.6 ± 1.4	+48.3	+4.6 time	9.1
4	Total number of fertile seeds per 1 inflorescence	879 ± 70	0.0 ± 0.0	+879	100	100
5	Fertile seeds, %	87.1 ± 2.6	0.0 ± 0.0	+87.1	100	100
6	Mass of fertile seeds (harvest), g	61.0 ± 4.9	0.0 ± 0.0	+61.0	100	100
Sector no. 3 (300 m)						
1	Number of investigated inflorescences (N)	9	8	x	x	x
2	Total number of seeds per 1 inflorescence	947 ± 79	1081 ± 108	-134	0,88	1,0
3	Total mass of seeds per 1 inflorescence, g	50.4 ± 4.8	13.8 ± 1.1	+36.6	+3.6 time	7.5
4	Total number of fertile seeds per 1 inflorescence	858 ± 88	0.0 ± 0.0	+858	100	100
5	Fertile seeds, %	89.9 ± 2.2	0.0 ± 0.0	+89.9	100	100
6	Mass of fertile seeds (harvest), g	49.6 ± 4.9	0.0 ± 0.0	+49.6	100	100
Sector no. 4 (500 m)						
1	Number of investigated inflorescences (N)	9	8	x	x	x
2	Total number of seeds per 1 inflorescence	1041 ± 41	754 ± 60	+287	+38,1	3,9
3	Total mass of seeds per 1 inflorescence, g	56.6 ± 3.0	6.7 ± 0.6	+49.9	+8.4 time	16.3
4	Total number of fertile seeds per 1 inflorescence	890 ± 35	0.0 ± 0.0	+890	100	100
5	Fertile seeds, %	85.7 ± 1.8	0.0 ± 0.0	+85.7	100	100
6	Mass of fertile seeds (harvest), g	54.8 ± 3.1	0.0 ± 0.0	+54.8	100	100

For comparison, in our previous research (Cebotari et al., 2015), the degree of fertility of seeds of sunflower hybrid variety EL PASSO-199, pollinated by bees, was depending on the distance between the experimental sectors and beehives from 88.6 to 92.1%.

Based on these results we can say that self-pollination of researched by us varieties, completely is lacking, because the seeds from isolated inflorescences remained practically sterile (empty).

In various sectors, the total weight of seeds in a inflorescence was different, depending on the distance between the sector and beehives. The highest total seeds weight per inflorescence was registered at inflorescences from the sector no.1, which is at a distance of

10 m from beehives, and constituted 68.7 ± 5.7 g. The lowest total weight of seeds per inflorescences, was registered in the sector no. 3, 300 m distant from the beehives, and it was 50.4 ± 4.8 g. The weight of seeds from sector no.1 is higher compared to the sector no. 3 with 18.3 g or 36.3%, (td = 2.5; P < 0.05) and compared to sector no. 4, with 12.1 g or 21.4% (td = 1.9; P < 0.1).

Seeds of inflorescences pollinated by bees were voluminous and hard to the touch because they were filled with core. At the same time, the seeds of isolated from insects inflorescences were small and empty to touch, because they had no core.

The average weight of one seed from pollinated by bees inflorescences has constituted 53-61 mg, but seeds from the

isolated inflorescences - only 9-14 mg. So, the average weight of a seed from bee-pollinated inflorescences was 4.1 to 6.0 times higher compared to that from self-pollinated inflorescences. On average, total weight of the seeds of one inflorescence (harvest) pollinated

by the bees exceeded the average weight of the seeds of an self-pollinated inflorescence by 3.6-8.4 times.

The increase of the sunflower harvest after pollination by bees is presented in histogram.

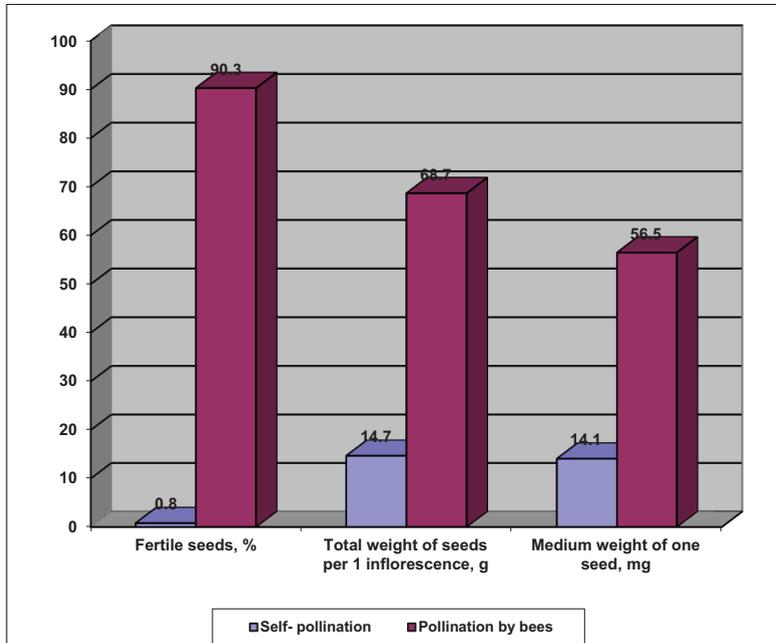


Figure 1. The results of pollination by bees of sunflower crop

The results have shown that total weight of the seeds is related to the degree of fertility of the seeds, since the weight of fertile seeds represents 96.8 to 99.0% of the total weight of the seeds.

Accordingly, the seeds collected from sector No.1, having the highest fertility also have had the highest total weight, compared to other sectors. The lowest total mass of seeds and, respectively, the lowest degree of fertility was recorded at the seeds collected from the sector no. 4. It was observed that with increasing of the fertility of seeds from 85.7%, in the sector no. 4, up to 90.3%, in the sector no. 1, there are an increasing of their total mass, from 96.8% to 99.0% respectively. Given the fact that fertile seeds in proper represent the harvest, we can say that it (the harvest) is entirely due to the entomophilous pollination, especially pollination by bees.

Also, we found that the harvest of sunflower seeds pollinated by bees is depending on the

distance between inflorescences and beehives. The closer the inflorescences of sunflower are to the beehives, the higher is the harvest of seeds.

Therefore, pollination with bees of the parental varieties of sunflowers "Express" and "NS-X 6006" is effective both from practical and economic viewpoint, since it increases the harvest of the seeds from 3.6 to 8.4 times.

CONCLUSIONS

Sunflower crops of varieties "Express" and "NS-X 6006" researched by us, are typically entomophilous, because in our experience, self-pollination (isolated) did not occur.

The degree of seed's fertility of pollinated by bees inflorescences, varied depending on the distance between experimental inflorescences to the beehives, from 85.7% to 90.3%.

The average total mass of the seeds from free pollinated inflorescence was higher compared

to that of the self-pollinated inflorescences with 36.6 to 54.0 g or 260-740% (td = 7.5 to 16.3; $P < 0.001$), hence, pollinating by bees of parental varieties of sunflower "Express" and "NS-X 6006" is quite effective and increases the harvest of seeds from 3.6 to 8.4 times.

ACKNOWLEDGEMENTS

Scientific studies have been carried out within the fundamental institutional project 15.817.02.12F "Diversity, structure and functioning of natural and anthropogenic faunistic complexes in the context of strengthening of the national security strategy of the Republic of Moldova" from the state budget.

REFERENCES

- Alexandru V. et al., 2007. Manualul apicultorului. Asociația Crescătorilor de Albine din România. Ed. „LVS Crepuscul”, Ploiești, 320 p.
- Cebotari V., Buzu I., 2015. The bee families use at sun flower pollination. University of Agricultural Sciences and Veterinary Medicine of Iasi, Romania. Scientific Papers – Animal Science Series. Ed. „Ion”. Ionescu de la Brad”, Iași, vol. 63, 173-181.
- Falaleev N.A. et al., 1973. Sporirea producției de floarea-soarelui în Kazahstanul de Est cu ajutorul deplasărilor în pastoral ale stupinelor în vederea culesului și a polenizării. Polenizarea cu albine. Ed. „Apimondia”, București, 230-233.
- Frediani D., 1973. Rolul albinelor în polenizarea florii-soarelui (*helianthus annuus*) în Italia Centrală. Polenizarea cu albine. Ed. „Apimondia”, București, 228-230.
- Furgala B., 1973. Polenizarea foliei-soarelui - un domeniu de cercetare neglijat. Polenizarea cu albine. Ed. „Apimondia”, București, 233-237.
- Hociota E., 1973. Probleme actuale și de perspectivă în cultura florii-soarelui ca plantă tehnică și meliferă în R.S. România. Polenizarea cu albine. Ed. „Apimondia”, București, 321-328.
- Ion N., 2012. Resursele melifere ale României. Apicultura – manualul cursantului. ACAR, ICDA, România. Ed. „LVS Crepuscul”, Ploiești, 12 - 48.
- Ion N., Ion V., Fota G., Coman R., Ștefan V., 2008. Scientific data regarding the honey phasing in sunflower crops. International Apiculture Symposium Durable Management of Beekeeping Activity According to EU Demands, Romania, Tulcea, Ed. CITDD- TULCEA, 27 – 30.
- Ion N., Fota G., Coman R., Ștefan V., Ion V., 2007. Rezultate privind caracteristicile melifere ale hibridilor străini de floarea-soarelui cultivați în România. Lucrări Științifice Zootehnie și Biotehnologii, România, Timișoara, vol. 40(2):80–90.
- Ion V., Ștefan V., Ion N., Roman G., Dumbravă M., 2006. Date privind înflorirea la un sortiment de hibridi străini de floarea-soarelui admiși pentru cultivare în România. Simpozionul Internațional de Apicultură „Managementul durabil al exploatațiilor apicole în concordanță cu cerințele UE. România, Tulcea, 9.
- Katarov G., 1973. Eficiența economică a polenizării florii-soarelui de către albine în Dobrogea. Polenizarea cu albine. Ed. „Apimondia”, București, 225-227.
- Ponomareva E.G., 1973. Dirijarea activității polenizatoare a albinelor. Polenizarea cu albine. Ed. „Apimondia”, București, 220-224.
- Yadav R.N., Sinha S.N., Singhal N.C., 2003. Polenizarea de către albinele melifere (*Apis sp.*) și producția de semințe hibrid de floarea-soarelui: efectul tipului de plantare asupra mișcărilor albinelor melifere și aria lor de acțiune. Lucrările științifice ale XXXVI-lea Congres Internațional al Apicultorilor din APIMONDIA. Lyubljana, Slovenia, 24-29 august, 248–233.
- Лайко Л., Никовиц А., Салаи Е. и др., 1987. Изучение медоносных качеств подсолнечника и вопросов его опыления. XXXI-й международный конгресс по пчеловодству. Апиомндия, Варшава, с. 152.
- Фаркаш Е., 1987. Экономическое значение пчелоопыления подсолнечника. XXXI-й международный конгресс по пчеловодству. Апиомндия, Варшава, с.155.
- Плохинский Н.А., 1969. Руководство по биометрии для зоотехников. Изд. «Колос», Москва, 256 с.