EFFECT OF POLLINATION OF ONION SEEDS UNDER ISOLATION BY THE RED MASON BEE (*Osmia rufa* L.) (*Apoidea*, *Megachilidae*) ON THE SETTING AND QUALITY OF OBTAINED SEEDS

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Summary

The aim of the experiment was to assess the results of the pollination of seed onion by the red mason bee *Osmia rufa* L. in isolated conditions in comparison with self-pollination and free pollination. The results allowed the authors to conclude that *Osmia rufa* is an effective onion pollinator. Even though the mean number of fruits in the inflorescence set as a result of onion flower pollination by *Osmia rufa*, was lower than that resulting from free pollination, the percentage of pollinated flowers, which set seeds in the total number of flowers in the inflorescence was very similar in both systems of pollination. In addition, the total seed yield as well as the weight of 1,000 seed did not differ in the case of the pollination by the solitary bee and free pollination. Seeds set as a result of the pollination by the solitary bee and free pollination were characterized by the best germination capacity and energy. Self-pollinated onion inflorescences produced the lowest seed yields, which were, in addition, characterized by low germination capacity and energy.

Keywords: *Osmia rufa*, pollination, onion, seeds.

INTRODUCTION

Single umbel flowers of the onion inflorescence are not capable of self-pollinating. In order for its pollination to occur, the pollen must come from another flower of the same or different plant. Although, the onion belongs to this type of self-pollinating plants, cross-pollination between plants is very common, which is a requirement for setting well-developed seeds. The absence of natural pollinators on onion seed plantations poses a serious problem for breeders all over the world. Widespread use of the honeybee as the pollinator does not always bring about the expected results because the onion nectar is not particularly attractive for it and the appearance of different sources of nourishment can easily pull away this bee from plantations of flowering onion. Furthermore, in the case of male sterile varieties whose flowers produce less nectar, the number of bee families should be almost doubled (Voss et al. 1999). Apart from honeybees, onion flowers are visited by bumblebees, dipterans and butterflies (Jabłoński et al. 1982, Wojtowski et al. 1980). In various regions of India, *Apis dorsata*, followed by *A. cerana*, *A. florea* and *A. mellifera* are the most effective onion pollinators. Also dipterans from the syrphid (*Syrphidae*) family take part in the process of pollination (Chandel et al. 2004). On the other hand, the attempts to employ the alfalfa leafcutter bee (*Megachile rotundata*) to pollinate onion flowers failed to produce satisfactory results (Mayer et al. 1993). Acute deficit of natural pollinators is one

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of the main reasons of low onion seed yields (Witter and Blochtein 2003) and explains why attempts to increase the number of pollinating insects on plantations of this plant are still continuing (Mayer and Lunden 2001). Onion purebred seed production carried out in closed, isolated spaces, where insects flying from outside have no access is a different problem. In these conditions, the use of pollinators derived from controlled breeding becomes essential and the red mason bee (*Osmia rufa* L.) appears to be just the right species. In nature, females of *Osmia rufa* collect also pollen of the *Allium genus* (Wilkaniec et al. 2002). Furthermore, unlike the honeybee, the solitary bee tolerates well closed spaces and, what is even more important; it is easy to adjust its flying period to the period of onion flowering by delaying the emergence of mature insects from cocoons (Wilkaniec 1991).

The objective of the experiment was to ascertain to what extent, the presence of the solitary bee *Osmia rufa* L. in isolated conditions could influence the level and quality of onion seed yield.

MATERIAL AND METHODS

The investigations were carried out at the field station of the Chair of Useful Insects' Breeding in Swadzim near Poznań during the 2003 vegetative season. The experimental material comprised onion (*Allium cepa*) seedlings of Grabowska cultivar.

Seedlings of 16 onion plants were planted out in the middle of April on three experimental plots of 0.2 m^2 each. The plots were treated as experimental groups differing in the method of pollination, while plants were replications in individual groups. One of the plots was left uncovered (free pollination), whereas the other two were covered with a polyamide net spread over a metal framework in the shape of a cylinder. When 30% of flowers developed in the onion inflorescences, females of the solitary bee *Osmia rufa* (one female per two inflorescences) were let into one of the isolation cages and nests made of the common reed stalks was also placed inside this cage. The uncovered plot as well as the other covered plot without insects in it were treated as control. Only females weighing 110-120 mg (mean for the population) were selected for the experiment. The insects were weighed in their cocoons, prior to their activation at the temperature of 26°C and when they emerged out of their cocoons, their gender was determined on the basis of their morphological traits. The setting of seeds in the other isolation cage with no access of free flying insects was achieved by self-pollination.

Once the seeds were set, which was in the middle of August, five inflorescences with stalks were cut from each experimental plot, placed in gauze bags and left for drying. Then, non-pollinated and pollinated flowers that set fruits (seeds) were counted in each inflorescence.

The pollination effectiveness in experimental groups was determined on the basis of: the number of fruits, the percent of fruits in relation to the number of flowers developed in an inflorescence and the weight of seeds obtained from five selected inflorescences. The value of the obtained seed materials was evaluated on the basis of: the weight of 1,000 seed and the germination energy and capacity. In order to perform germination tests, seeds were placed in Petri dishes on moist gauze at the temperature of 21°C. Sprouted seeds were counted, first after six days to determine their germination energy and next after twelve days to assess their germination capacity. The obtained means were compared with the assistance of the one-factorial analysis of variance and the Tukey's test. Statistical analyses were

carried out at the significance level of α=0.05 and the critical level of significance *p* was also determined. The performed analyses of germination energy and capacity were carried out by selecting randomly, from each experimental treatment, 25 seeds and the obtained means were compared statistically and then transformed into percentage values. When comparing the percentage proportion of fruits in inflorescences, the analyses were performed on data transformed in accordance with Bliss degrees.

RESULTS

Depending on the method of pollination, the obtained mean numbers of fruits in the inflorescence differed significantly from one another ($p<0.001$) (Table 1). Flowers pollinated by way of free pollination were found to have set the highest number of fruits followed by those pollinated by the solitary bee. The smallest number of fruits developed in the result of self-pollination. On the other hand, the number of flowers, which remained non-pollinated, was significantly higher in the group of plants exposed to self-pollination in comparison with the remaining experimental groups ($p<0.001$). The number of flowers, which were not pollinated by the solitary bee and by free-flying insects, did not differ significantly. In addition, also the weight of 1,000 seed obtained from five inflorescences was very similar in the case of these two ways of pollination. However, the number of seeds developed by way of self-pollination was almost ten times lower.

The mean proportion of pollinated flowers, which set seeds, in relation to the total number of flowers in inflorescences pollinated by mason bees in the isolation cage and as a result of free pollination did not differ between each other and amounted to 69.5% and 73.5%, respectively (Fig. 1).

Table 1

Results from the application of different methods to pollinate onion cv. *Grabowska*

Pollination method	Mean number per inflorescence			Seed yield per 5 inflorescences (g)
	flowers	fruits	non-pollinated flowers	
Osmia rufa	398.4	273.4 b	125.0 b	13.84
Free pollination	560.8	411.8 a	149.0 b	13.99
Self-pollination	496.4	44.8 c	451.6 a	1.52

Means followed by different characters are significantly different (Tukeya's test α=0.05)

Table 2

Properties of onion seeds cv. *Grabowska* depending on pollination method

Pollination method	weight of 1,000 seed (g)	Germination capacity (%)	Germination energy (%)
Osmia rufa	3.14	92 a	90 a
Free pollination	3.05	86 a	85 a
Self-pollination	2.74	66 b	62 b

Means followed by different characters are significantly different (Tukeya's test α=0.05)

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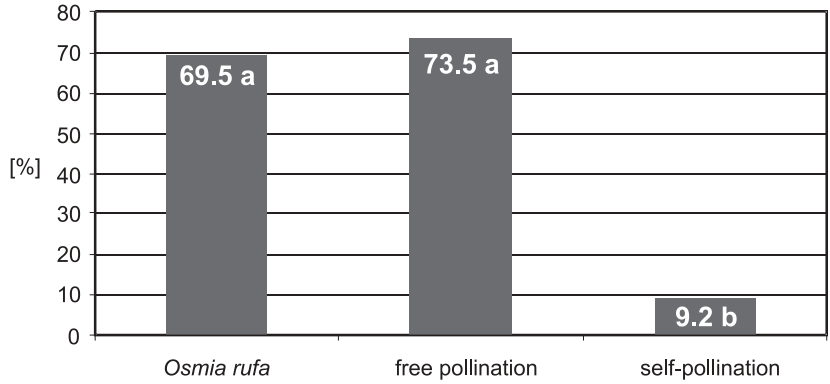

Fig. 1 Percent of pollinated flowers that set seeds in the total number of flowers in an inflorescence of onion cv. *Grabowska*

A significant difference was only recorded in the case of self-pollination during which only 9.2% of flowers developed fruits and set seeds.

The seeds set in the result of the pollination of flowers by insects revealed a significantly higher germination capacity and energy in comparison with the seeds set in the result of self-pollination ($p<0.001$) (Table 2). Moreover, also the weight of 1,000 seed was higher in the treatments with the solitary bee and free-flying insects. The pollination by the solitary bee and free-flying insects failed to exert any significant influence on the seed quality, although it was slightly higher in the treatment with the *Osmia rufa* L.

DISCUSSION

The effectiveness results of flower pollination as well as the seed yields and quality confirm the importance of insects in onion pollination.

In the case of onion inflorescence of *Wolska* cultivar, the proportion of the developed fruits averaged 64%, when the pollinating insects, among which the honeybee was the dominant one, had free access to plants (Jabłoński et al. 1982). In another experiment carried out in isolation cages with the honeybee as the pollinator, approximately 60% flowers developed fruit. This result was worse in comparison with the experiment where the *Lucilia casear* fly was used, but it was still better than free pollination (HaeJun et al. 1998).

In our experiment, the percentage of set fruits per inflorescence from the plot with the solitary bee and the unsheltered one (free pollination) was higher then results obtained by mentioned researchers.

On the other hand, Tolon and Duman (2003) reported much higher yields of onion seeds on uncovered plots than in isolation cages with the honeybee and their better seed germination energy and capacity. Different results of free pollination announced by mentioned authors could probably be attributed mainly to the number of natural pollinators present on onion plantations. In cases when there is lack or inadequate wild bees, the honeybee becomes the indispensable insect in the onion commercial seed production (Witter and Blochtein 2003). However, closed spaces are not well tolerated by the honeybee and that is why the authors decided to use the red mason bee. Schittenhelm et al. (1997) maintain that despite the fact that the solitary bee was not very enthusiastic to visit onion flowers, it pollinates them effectively in isolation cages.

In the discussed experiment, during analysing about 70 nest tubes, in same of them were found from 1 to 2 cells with pollen provision. It can, therefore, be said that individual females had to undertake the job of pollen collectors and did not utilise onion flowers only to provide them nectar. Hence, the probability of cross-pollination occurred much more frequently than only during nectar collection. However, in the discussed experiment, the plots were too small to supply the females with sufficient quantities of pollen to develop their progeny.

According to Tolon and Duman (2003) the weight of 1,000 seed, germination capacity and energy are higher when onion flowers are pollinated by honey bees. The difference in the onion seed germination capacity derived from plantations where pollinating insects were introduced in relation to plantation where they were absent reached over 20% (Chandel et al. 2001). In our experiment, the germination capacity was the highest when onion flowers were pollinated by the solitary bee and this value reached 92%. Doruchowski (2000) claims that the minimum required germination capacity of seeds derived from the direct regeneration of maternal material should be at least 75%.

Seed yields and the weight of 1,000 seed obtained in the result of free pollination and of the pollination by the solitary bee were similar, although the solitary bee pollinated considerably fewer flowers in the inflorescence. This appears to suggest that there were more seeds in the capsule than in the result of free pollination in which also bumble bees, honeybee and the solitary bee were observed to take part.

CONCLUSIONS

The solitary bee *Osmia rufa* L. can be successfully used to pollinate onion seed plantations in closed spaces.

In the case of onion pollination, *Osmia rufa* can replace successfully other insect species, which take part in the process of free pollination.

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WPŁYW ZAPYLANIA CEBULI W IZOLATORACH PRZEZ PSZCZOŁĘ MURARKĘ OGRODOWĄ (*Osmia rufa* L.) (*Apoidea*, *Megachilidae*) NA ZAWIĄZYWANIE I JAKOŚĆ UZYSKANYCH NASION

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S t r e s z c z e n i e

Cebula należy do roślin samopylnych, u której powszechnie dochodzi także do zapylenia krzyżowego. Nie wydaje ona dobrze wykształconych nasion bez udziału owadów zapylających, a deficyt naturalnych zapylaczy jest jednym z głównych powodów uzyskiwania niskich plonów nasion cebuli. Powszechne stosowanie pszczoły miodnej celem zwiększenia zagęszczenia zapylaczy na plantacjach, z uwagi na małą atrakcyjności nektaru cebuli, nie zawsze przynosi oczekiwane rezultaty. Prócz pszczoły miodnej kwiaty cebuli odwiedzają pszczoły samotnie żyjące, trzmiele, muchówki i motyle. Zastąpienie owadów swobodnie latających zapylaczami, które pochodzą z kontrolowanego chowu staje się koniecznością w przypadku prowadzenia produkcji nasiennej czystoodmianowej w przestrzeni zamkniętej.

Celem przeprowadzonego doświadczenia było stwierdzenie, w jakim stopniu obecność pszczoły samotniczej *Osmia rufa* L. pochodzącej z chowu może wpłynąć, w warunkach izolowanych, na wielkość i jakość plonu nasion cebuli.

Eksperyment przeprowadzono na poletkach doświadczalnych w warunkach polowych na materiale wysadzeniowym cebuli (*Allium cepa*) odmiany Grabowska.

Zależnie od sposobu zapylania uzyskane średnie liczby owoców w kwiatostanie różniły się od siebie istotnie. Przeciętnie najwięcej owoców w jednym kwiatostanie zawiązały kwiaty na drodze wolnego zapylania (411,8), następnie zapylane przez murarkę ogrodową (273,4), a najmniej powstało w wyniku samozapylenia (44,8). Natomiast liczba kwiatów niezapylonych przez murarkę ogrodową oraz owady wolno latające nie różniła się istotnie. Także zbliżona była masa nasion uzyskanych z pięciu kwiatostanów, która w obydwóch przypadkach wyniosła prawie 14 g. Na drodze samoczynnego samozapylenia pozostało najwięcej niezapylonych kwiatów w kwiatostanie i powstało prawie dziesięciokrotnie mniej nasion.

Średni udział kwiatów zapylonych, które zawiązały nasiona w ogólnej liczbie kwiatów w kwiatostanach zapylanych przez owady w izolatorze i w wyniku wolnego zapylania nie różnił się między sobą i wynosił odpowiednio 69,5%, i 73,5%. W przypadku samozapylenia jedynie 9,2% kwiatów zawiązało owoce i wykształciło nasiona.

Nasiona powstałe w wyniku zapylenia kwiatów przez owady odznaczały się wysoką zdolnością kiełkowania na poziomie 90-92% i energią kiełkowania wynoszącą 85-86%. Nasiona zawiązane na drodze samoczynnego samozapylenia skiełkowały tylko w 66%, a

w próbie na energię kiełkowania w 62%. Także masa 1000 nasion była wyższa w kombinacjach: murarka ogrodowa (3,14 g) i wolne zapylanie (3,05 g), niż w samozapyleniu (2,74 g).

Przeprowadzone doświadczenie wykazało, że pszczoła murarka ogrodowa (*Osmia rufa* L.) może być z powodzeniem wykorzystywana do zapylania upraw nasiennych cebuli w przestrzeni zamkniętej. Ilość oraz jakość uzyskanego plonu nasion cebuli wyraźnie pokazuje, że *Osmia rufa* dorównuje efektywnością pracy różnym gatunkom owadów biorącym udział w zapyleniu wolnym.

Słowa kluczowe: *Osmia rufa*, zapylanie, cebula, nasiona.