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VARIABILITY IN NECTAR AND POLLEN PRODUCTION IN FLOWERS OF DOUBLE-LOW LINES OF WHITE MUSTARD (*Sinapis alba* L.) AND THEIR ATTRACTIVENESS TO HONEY BEES

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Abstract. The studies concerned the variability in nectar and pollen production in flowers of 75 double-low lines of white mustard (*Sinapis alba* L.) and a reference cultivar 'Nakielska'. Also, rates of insect visitation to flowers in 19 lines were investigated. Significant genotypic differences were found in nectar amount, sugar concentration in nectar and total nectar sugar amount. The average nectar amount/10 flowers varied from 2.3 to 24.4 mg, with a mean 14.7 mg for 'Nakielska'. Nectar concentration for most lines exceeded 20%. The majority (52%) of the lines tested produced more than 2 mg of sugars/10 flowers in nectar. The average amounts of pollen varied from 1.2 to 12.0 mg/10 flowers, with the mean 8.5 mg for 'Nakielska'. No clear genotypic effect on the amount of pollen/10 flowers was demonstrated. The lines did not differed significantly in their attractiveness to flower visitors. The main foragers were honey bees (93% of all visiting insects). It is concluded that the double-low lines of *S. alba* are comparable to conventional cultivars in their potential for nectar flow but perform poorer as pollen producers.

Key words: *Sinapis alba* L., nectar, pollen, double-low lines, insect visitation rates

INTRODUCTION

White mustard *Sinapis alba* L. (Brassicaceae), is a crop species with a great economic value. Seeds of this plant are used primarily as condiments and a source of oil. They can also be a possible source of protein in the human and animal diet. White mustard seeds usually contain about 35% of erucic acid in the oil and high levels of glucosinolates, mainly sinalbin, (about 170 µmol·g seeds) in the meal [Katepa-Mupondwa et al. 2005]. Recently, breeding efforts have focused on improving seed yield to make

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white mustard production competitive with canola [Katepa-Mupondwa et al. 2006, Gupta and Pratap 2009]. Hence, the breeding lines of white mustard have been developed with low concentrations of erucic acid and glucosinolates in the seeds [Krzymański et al. 1991, Piętka and Krzymański 2007], resulting in plants which are devoid of sinalbin [Piętka et al. 2010].

On the basis of its floral traits, white mustard is adapted to pollination by short-tongued bees and flies but the key pollinators are honey bees and solitary bees from the families Andrenidae, Halictidae and Megachilidae [Corbet 1978, Jabłoński and Skowronek 1983, Dukas and Shmida 1989, Free 1993, Masierowska 2012]. Previous studies on pollination in *S. alba* have shown that both the fruit set and seed yield substantially increased when pollinating insects were provided [McGregor 1976, Free 1993, Jabłoński et al. 1999, Masierowska 2012]. As insect pollination ensures that mustard plants produce optimum yield, it is important to breed cultivars with features attractive to bees. Traditional cultivars of *S. alba* are known to be very attractive to insect pollinators, supplying them with substantial amounts of both nectar and pollen [Jabłoński et al. 1999, Masierowska 2003]. Although new cultivars are commonly screen for agronomic qualities such as increased yield, oil and protein content or their phytosanitary properties, no attention has been given to any potential change in nectar and pollen production. As regards double-low cultivars or lines of *S. alba*, devoid of sinalbin, no data on nectar and pollen rewards are currently available. The aim of the present study was to (a) investigate variability in nectar and pollen production in flowers of these lines and to (b) estimate their potential attractiveness to pollinators in terms of rates of insect visitation.

MATERIALS AND METHODS

Plant and site characteristic. In the years 2005–2007 and 2009, double-low lines of *S. alba* (tab. 1) and a reference cultivar 'Nakielska' were studied. All improved lines have been bred at the Department of Genetics and Breeding of Oilseed Crops in Poznań, Poland. The number of these lines differed in the consecutive years of studies and was 35, 29, 6 and 18, respectively. Thus, finally, a total of 76 different genotypes were tested for nectar production but 2-year investigation was carried out on 12 genotypes. The total number of genotypes tasted for pollen production was 72 and 2-year study was performed on 9 genotypes. All genotypes were grown at the experimental field of the Plant Breeding and Acclimatization Institute – National Research Institute (IHAR – PIB) Research Division in Poznań, western Poland (52°17"–52°30"N, 16°44"–17°28"E). Seeds were sown directly in the field on plots of 1.6 m^2 area each. Just before the beginning of blooming, plots were covered with cage isolators to protect flowers against visiting insects. Isolators were made from white, fine synthetic fabric.

Determination of nectar ad pollen production in flowers. For each genotype, nectar was gathered from 4 to 7 flowers, in 3–8 replications. The sampling was made after 24 hours of nectar secretion. Nectar was extracted using micropipettes drawn out from 37 µl glass capillaries (Polamed Poznań, Poland). They were weighted before and after nectar collection and from the mass difference a nectar amount (in mg) was determined. Sugar concentration of nectar (% wt / total wt) was measured with the Abbe refractometer type RL-4 (PZO Warsaw, Poland). Then, nectar amount and sugar concentration of nectar were used to calculate the total sugar amount (in mg) secreted in nectar per 10 flowers. During nectar sampling, the presence as well as the size of nectar droplets on a nectary surface was noted, and the arrangement of floral elements, influencing nectar accessibility was observed.

Table 1. Variability of qualitative traits in double-low lines of *Sinapis alba* in the years of study

Year of the study	Erucic acid (%)	Glucosinolates in total ($\mu mol \cdot g^{-1}$)	Alkenyl glucosinolates ($\mu mol \cdot g^{-1}$)	Sinalbin ($\mu mol \cdot g^{-1}$)
2005	0.0–6.5	13.9–33.1	7.0–22.1	0.0–1.7
2006	0.0–0.7	11.6–35.0	6.2–23.6	0.0
2007	0.0–3.0	16.8–25.6	12.7–19.2	0.0
2009	0.0–1.4	15.0–27.4	1.6–21.2	0.0

The pollen mass available to insects was determined using modified Warakomska method [1972]. For each genotype, 3 samples of 120 mature anthers were collected from 20 flowers and placed in previously-weighted Eppendorf tubes of 1.5 ml capacity. Samples were dried at 35°C to dehisce, and pollen was washed out from the anthers using 70% ethanol. The empty anthers were removed from Eppendorf tubes. Then the weight of tubes with pollen was determined, allowing the calculation of the mass of air-dried pollen. Pollen production was expressed in mg per 10 flowers.

Attractiveness to insects. In 2007 insect foraging activity was monitored on 19 double-low lines representing the following groups: A – best nectar producers in 2005 or 2006 (n = 6), B – lines with sepals strongly bent down a pedicel (n = 6), C – lines with sepals partially fused (n = 4) and D – lines with partially fused stamens (n = 3), as well as on 'Nakielska'. Visiting insects: Hymenoptera (honey bees, bumblebees and solitary bees), Diptera and Lepidoptera, were counted on open plots, each of the size 1 m × 2 m, on 3 days (5^{th}–7^{th} June) at the full bloom. Counting was performed three times for 1 minute at 7:00, 10:00 and 13:00 h (GMT + 2 h). Before each census open flowers on plots were counted so that results could be converted to a visiting rate (visits per $flower \cdot h^{-1}$) according to Mayfield et al. [2001].

Statistical analysis. The obtained data were analyzed applying ANOVA procedures. Data on sugar concentration of nectar were transformed according to arcsin($x^{0.05}$) to improve normality. Differences between genotypes were tested by one-way ANOVA, separately for the following years of study because of a different set of lines in each year. The nectar and pollen data for genotypes studied in two years were tasted using two-way ANOVA with GENOTYPE and YEAR as main factors. When significant differences were stated, the ANOVAs were followed by the HSD Tukey test at $\alpha = 0.05$ [Sokal and Rohlf 1995]. Data analyses were performed with STATISTICA (v.7.1) (StatSoft, Poland).

RESULTS

Nectar secretion and accessibility. In all genotypes, nectar was produced by the median and lateral pair of nectaries, situated in the region of filament bases. Droplets of nectar secreted by lateral glands were usually bigger than those produced by median nectaries. Only in 19 lines the secretory activity of both pairs of glands was almost equal.

Table 2. Significance (P-values) of main effects for nectar and pollen production for 2-years (12 genotypes) and 1-year (64 genotypes) evaluation of *Sinapis alba* genotypes

	Effect	Nectar amount per 10 flowers (mg)	Nectar sugar concentration (% wt/wt)	Total sugar amount in nectar per 10 flowers (mg)	Pollen amount per 10 flowers (mg)
Genotypes studied in two years[1]	genotype	0.0000	0.0004	0.0000	0.01132
	year	0.0000	0.0038	0.0000	0.37667
Genotypes studied in a single year[2]	genotype	0.0000[3]	0.0000[3]	0.0000[3]	0.19226[3]
		0.0000	0.0000	0.0000	0.00000
		0.0000	0.0000	0.0000	0.87819

[1] depending on genotype: 2005 and 2007, 2006 and 2007 or 2006 and 2009
[2] 2005, 2006, 2009
[3] in each column: P-values for genotypic effect in year 2005, 2006 and 2009, respectively

In both 2-year and single year studies, a strong genotypic effect was detected in the amount of nectar as well as in the sugar concentration of nectar and total nectar sugar content in nectar (tab. 2). The average values of nectar amount secreted per 10 flowers varied from 2.3 to 24.4 mg, with a mean 14.7 mg for 'Nakielska'. Flowers in half of the lines produced less than 70% of the amount secreted by 'Nakielska' flowers (fig. 1a). In one line nectar amount exceeded 20 mg·10 flowers. Genotypic differences in sugar concentration of nectar were also high and the average values ranged from 7.8 to 39.9%. The mean for 'Nakielska' was 19.5%. Most of the double-low lines (41) produced nectar with 20% or more sugar content. In 9 lines the mean concentration exceeded 30% (fig. 1b). Comparison of the total sugar amount in nectar/10 flowers (fig. 1c) showed that most lines (52%) produced more than 2 mg of sugars in nectar but only 12% – more than 3 mg. Overall, the mean values ranged from 0.3 to 4.3 mg of nectar sugars/10 flowers. Five out of eleven lines under 2-year test secreted the average amounts of total sugar in nectar/10 flowers similar to that of the reference cultivar (tab. 3). Two-year study showed a significant year effect in nectar amount produced by 10 flowers as well as in sugar nectar concentration and total sugar amount in nectar/10 flowers (tabs 2 and 3). The highest mean values of all these features were found in 2005. The worst year for nectar production was 2007.

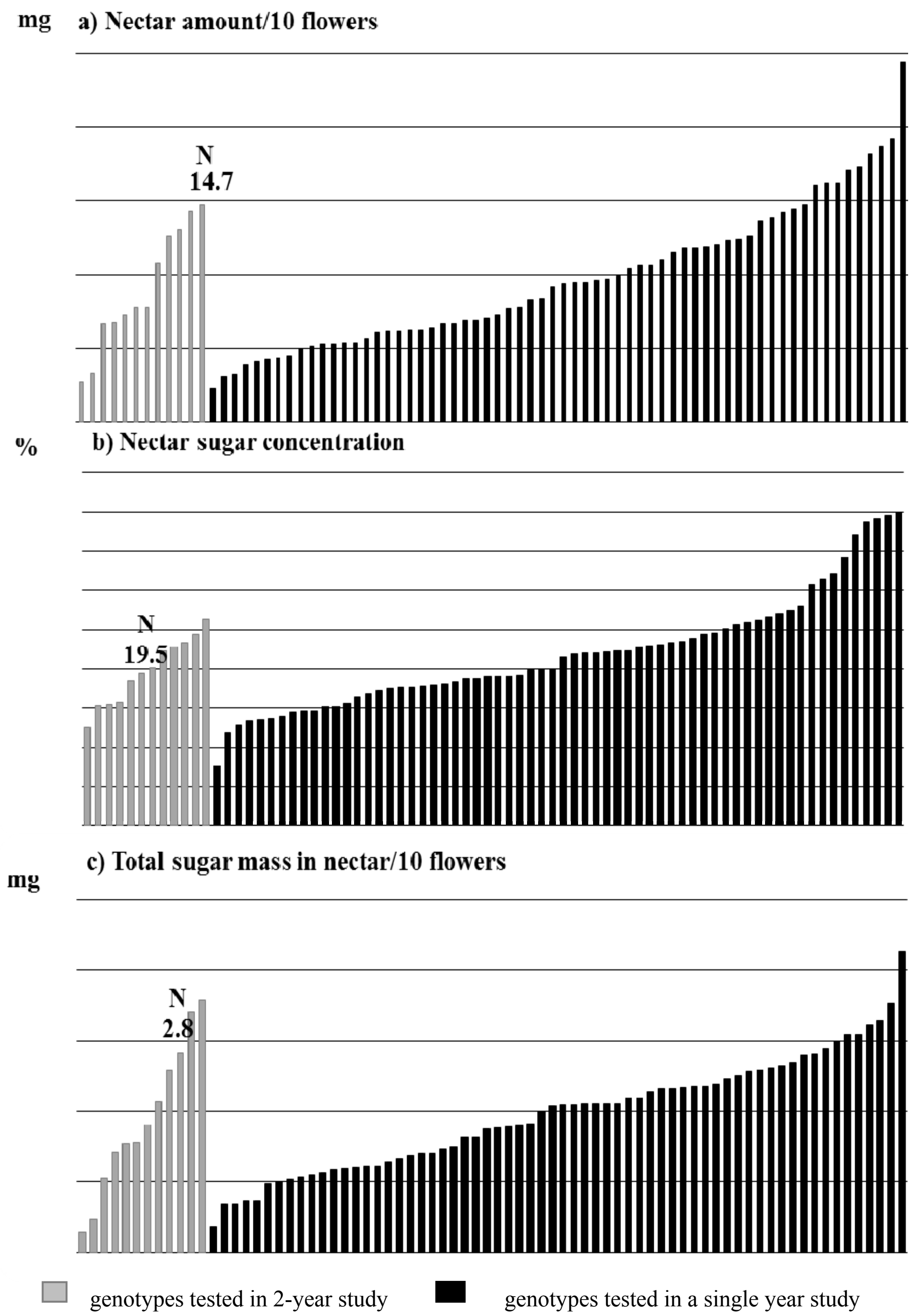

Fig. 1. Characteristics of nectar secretion in flowers of *S. alba* double-low lines and 'Nakielska' (N) in the years of study. Means are given

Table 3. Comparison of nectar and pollen production in flowers of *S. alba* double-low lines with reference cultivar 'Nakielska' in 2-years study. Mean values are given ± SD

Genotype	Year of study	Nectar amount per 10 flowers (mg)	Nectar sugar concentration (% wt/wt)	Total sugar mass in nectar per 10 flowers (mg)	Pollen amount per 10 flowers (mg)
'Nakielska'	2006, 2009	14.7 ±5.9 a n = 11	19.5 ±4.8 a–e n = 11	2.8 ±1.1 ab n = 11	8. 5±2.1 a n = 6
86	2006, 2007	– –	– –	– –	5.7 ±0.3 cd n = 6
97	2006, 2009	6.8 ±3.9 cd n = 9	20.2 ±5.8 a–e n = 9	1.4 ±2.8 b–e n = 9	– –
102	2006, 2007	3.3 ±1.4 d n = 12	15.5 ±8.4 de n = 12	0.5 ±0.2 de n = 12	6.6 ±1.5 abc n = 6
122	2006, 2007	7.8 ±3.2 bcd n = 17	23.4 ±6.8 abc n = 17	1.8 ±0.8 bcd n = 17	6.1 ±0.5 bc n=6
133	2006, 2009	2.7 ±1.47 d n = 13	12.6 ±2.79 e n = 13	0.3 ±0.1 e n = 13	– –
135	2006, 2009	7.8 ±4.8 bcd n = 10	22.3 ±7.7 a–d n = 10	1.6 ±0.7 b–e n = 10	– –
143	2006, 2009	13.0 ±5.9 abc n = 11	15.8 ±2.5 c–e n = 11	2.1 ±1.2 a–c n = 11	– –
144	2006, 2009	14.3 ±4.1 ab n = 12	24.4 ±5.3 ab n = 12	3.6 ±1.5 a n = 12	7.9 ±0.8 ab n = 6
531	2005, 2007	6.7 ±6.5 cd n = 15	18.5 ±6.7 b–e n = 15	1.5 ±1.7 b–e n = 15	3.8 ±1.2 d n = 6
550	2005, 2007	7.3 ±4.8 bcd n = 9	15.4 ±1.9 de n = 9	1.1 ±0.6 cde n = 9	5.1 ±0.7 cd n = 6
555	2005, 2007	12.6 ±5.0 abc n = 11	26.3 ±3.2 a n = 11	3.4 ±1.6 a n = 11	3.7 ±0.8 d n = 6
557	2005, 2007	10.8 ±8.5 abc n = 11	22.9 ±1.8 a–d n = 11	2.6 ±2.1 abc n = 11	5.8 ±0.3 cd n = 6
Mean for double–low lines		8.3 ±6.6 n = 130	19.8 ±6.8 n = 130	1.8 ±1.7 n = 130	5.6 ±1.6 n = 48
Mean for year	2005	15.1 ±4.1 a n = 23	23.0 ±5.6 a n = 23	3.6 ±1.5 a n = 23	5.1 ±0.9 n = 12
	2006	9.9 ±6.5 b n = 44	18.9 ±7.1 b n = 44	1.9 ±1.3 b n = 44	6.3 ±1.5 n = 12
	2007	4.3 ±3.3 c n = 40	18.6 ±4.6 b n = 40	0.8 ±0.6 c n = 40	5.8 ±1.1 n = 18
	2009	8.4 ±7.7 b n = 34	20.1 ±8.2 ab n = 34	1.9 ±2.13 b n = 34	6.8 ±2.0 n = 6

Means followed by the same letter within columns (a–e for genotypes, a–c for years) are not significantly different at α = 0.05.

Some differences in flower morphology between investigated lines were found. In flowers of 3 lines the stamens were fused, making access to nectar difficult. In 4 lines the fusion of sepals was observed. Contrary, in 8 lines sepals were strongly bent down towards a pedicel, so nectar could be easily collected by insects.

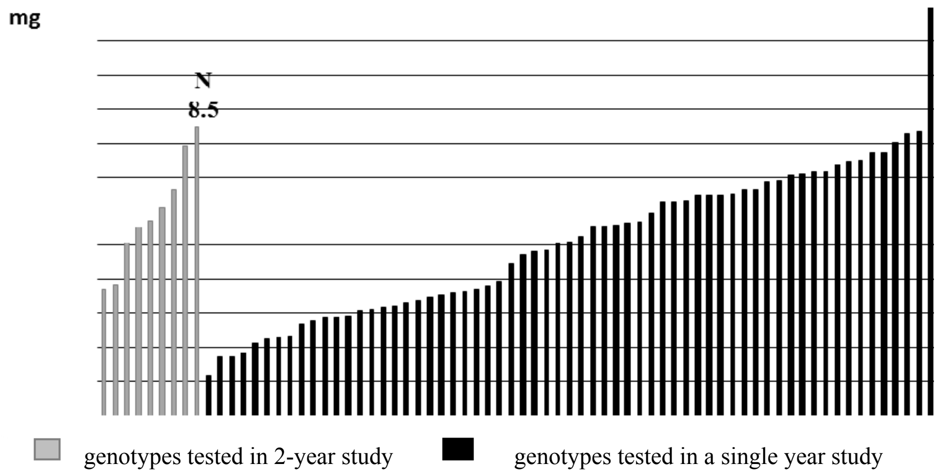

Fig. 2. Mean pollen mass produced in 10 flowers of *S. alba* double-low lines and 'Nakielska' (N) in the years of study

Table 4. Rates of insect visitation to flowers of 4 groups of double-low lines of *S. alba* (A – best nectar producers in 2005 or 2006, B – lines with sepals bent down a pedicel, C – lines with sepals partially fused, D – lines with partially fused stamens) and cultivar 'Nakielska' during 5th–7th June 2007. Differences between means are not significant at $\alpha = 0.05$

Group	No. of lines	Mean visits per flower·h^{-1} ±SD
A	6	6.82 ±1.91 n = 162
B	6	5.58 ±2.21 n = 162
C	4	5.32 ±2.15 n = 108
D	3	3.57 ±1.09 n = 81
'Nakielska'	1	5.38 ±2.12 n = 27

Pollen amount in flowers. Considering the genotypic effect, no clear effect on the amount of pollen produced by 10 flowers could be demonstrated (tab. 2). The differences in an average amount of pollen/10 flowers were statistically significant only for the lines tested in 2006 as well as for lines in 2-year study (tab. 2). However, the average amounts of pollen varied substantially from 1.2 to 12.0 mg·10 flowers, with the mean 8.5 mg for 'Nakielska'. In a single year study, most of the lines (64%) produced less than 6 mg of pollen/10 flowers that is 70% of pollen amount yielded by flowers of 'Nakielska' (fig. 2). Among the lines in 2-year study, the values were less contrasted though only two of them produced amounts of pollen/10 flowers similar to that of the reference cultivar. There were not significant year-to-year differences (tab. 2).

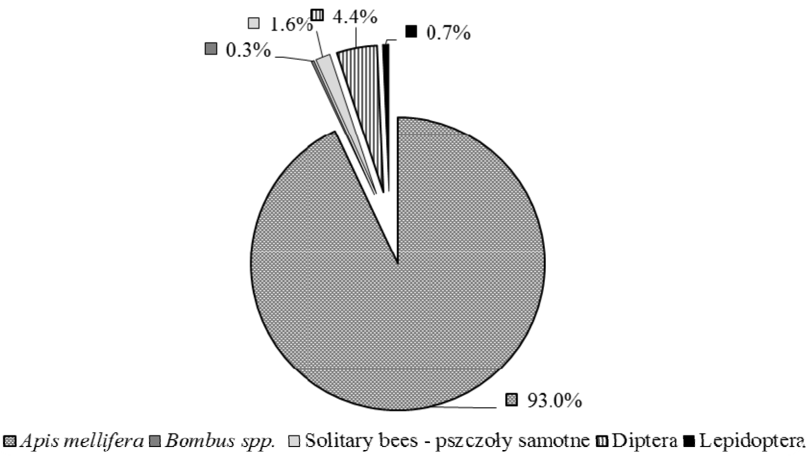

Fig. 3. Relative abundance of insects visiting flowers of *S. alba* double-low lines and 'Nakielska' on 5th–7th June 2007. Mean values are given

Insect visitation. The average visiting rates for chosen lines are shown in Table 4. Statistical analysis of data showed no significant differences between observed lines in their attractiveness to flower visitors ($F_{4, 20} = 1.8442$, $P = 0.18249$). However, the highest visiting rates were found in the group of best nectar producers, the lowest – in the lines with fused stamens. The principal visitors were honey bees comprising 93% of all insects working on mustard flowers. The second common group of visitors were dipterans (4.4%). The role of solitary bees, bumblebees and butterflies as flower visitors was marginal (fig. 3). Insects gathered mainly nectar, though workers collecting pollen comprised up to 20% of all honey bees observed on mustard flowers at 7 a.m.

DISCUSSION

The existence of considerable intraspecific variability in nectar production is well established for many species. Studies concerning differences in parameters of floral nectar production between selections, cultivars or breeding lines were carried on e.g., *Medicago sativa* [Walker et al. 1974, Barnes and Furgala 1978, Teuber et al. 1980, 1990], *Vicia faba* [Pierre et al. 1996], *Allium cepa* [Silva and Dean 2000, Soto et al. 2013], *Brassica napus* and *B. campestris* [e.g., Szabo 1982, Mesquida et al. 1991, Davis et al. 1994, 1996, Pernal and Currie 1998, Pierre et al. 1999, Kołtowski 2001, 2003]. The present study demonstrates the genotypic variability in both nectar and pollen production in flowers of double-low lines of *S. alba*, bred to improve seed yield.

In flowers of all investigated lines, a nectarium consists of two pairs of nectaries − lateral and median − as was previously described for *Sinapis* species [Davis et al. 1998, Masierowska 2003]. In a majority, a secretory activity of lateral nectaries was apparently bigger than that of median nectaries. These results corroborate those found in another cultivar of *S. alba* – 'Borowska' [Masierowska 2003] and confirm the knowledge that median nectaries in the Brassicaceae usually yield little nectar. According to Davis et al. [1998], in six brassicacean species that secreted nectar from both lateral and median glands, 95% of the flower's total nectar carbohydrates were gathered from the lateral ones.

A variability in the nectar amount and sugar concentration in nectar secreted in *S. alba* flowers exists in the scientific literature. The average amounts of nectar produced by 10 flowers of double-low lines ranged from 2.3 to 24.4 mg. Although for most of lines these values were lower than the mean for 'Nakielska', they are still comparable with results previously reported for other traditional cultivars. According to Jabłoński et al. [1999] and Masierowska [2003], under conditions in Poland, 10 flowers of white mustard secreted 2.2 to 13.4 mg of nectar, on average, with mean sugar content between 15–45%. Moreover, observations made by Ermakova [1959 cit. in Takahata 2009] and Haragassimova-Neprasova [1960 cit. in Takahata 2009], showed that the *S. alba* flower produced between 0.2 and 0.6 mg nectar, the sugar concentration of which reached 60%. According to Corbet [1978], in *S. alba* sugar nectar concentration was in a range of 20–90%. In the improved lines recently studied, the average sugar concentration of nectar rarely exceeded 30% but results of 2-year study are comparable with those reported for *S. alba* by Jabłoński et al. [1999]. Comparison of nectar amount as well as sugar concentration in nectar in lines tested during two vegetation seasons showed not only differences between genotypes but also between years of study. The influence of number of environmental factors such as air humidity, light and temperature has been demonstrated for nectar secretion in *S. alba* previously [Corbet 1978].

Owing to their relative constancy, comparison of total sugar amount secreted in nectar per 10 flowers seems to be the best parameter to contrast studied lines [Shuel 1989]. Half of the double-low lines produced more than 2 mg of sugars/10 flowers, amount similar both to that of 'Nakielska' and to other cultivars grown in Poland [Jabłoński et al. 1999, Masierowska 2003]. So in terms of total sugar in nectar, those lines seem to be equally attractive to pollinators and may have the same capacity for honey production as traditional cultivars.

Sinapis alba is classified as a valuable polleniferous crop [Roman 2008, Lipiński 2010]. Our study demonstrates a high variability in pollen amount offered to pollinators by flowers of 71 double-low lines. However, a genotypic effect was not consistent as well as pollen production did not show as much dependence on environment conditions as did nectar production. Therefore, our results suggest that, despite variability, the pollen production in white mustard flowers may be a relatively stable trait. Young et al. [1994] found that pollen production in another crucifer *Raphanus sativus* showed significant heritability under all growth environments. Overall, the vast majority of lines (80%) tested in this study was poorer pollen producers than 'Nakielska'. Only in 20% of double-low lines, pollen yield (7.1–12.0 mg·10 flowers) was comparable to values found in cultivars of *S. alba* by Jabłoński et al. [1999] and Masierowska [2012]. Pollen yield in flowers is a characteristic of each particular species and depends on anther size, productivity of archesporial tissue, pollen viability, and on environmental conditions [e.g., Warakomska 1972, Denisow 2011]. Pollen production per flower is known to affect pollinator visitation. Although honey bees appear insensitive to small differences in pollen production, they avoid flowers from which pollen was removed [Young and Stanton 1990]. So, poor pollen production in double-low lines of white mustard may negatively affect total pollen export from their flowers.

The adequate nectar and/or pollen rewards are critical in obtaining stable and frequent insect visitation on flowers. Bees can discriminate among cultivars or lines that produce more or less rewards [Waddington 1980, Teuber et al. 1983, Pierre et al. 1996]. Since nectar of the double-low lines was not high concentrated it might negatively affected the forage activity of insects, especially honey bees. However, nectar production per flower affect insect visit mainly indirectly by way of total nectar production, taking into account the number of flowers displayed at the same time to insects [Klinkhamer and de Jong 1990, Leiss and Klinkhamer 2005]. In our study, flowers of selected lines were visited by insects with a comparable intensity. Nevertheless, the tendency to increased insect visitation on flowers of the best nectar producers was noted. The lowest visiting rates were observed on flowers with fused stamens, which obviously limited exposition of nectar droplets. Why these differences were not statistically significant may be due to a fact that specimens of particular groups were grown on plots located in the vicinity of each other. According to Leiss and Klinkhamer [2005], plants in patches of high nectar production could enhance pollinator service on plants occurring close even if the letter are poorer nectar producers. Available literature consistently reports that *S. alba* flowers are dominated by honey bees. Also in the present study, the main foragers on tasted lines were honey bees collecting both nectar and pollen, accounting more than 90% of all visiting insects.

CONCLUSIONS

1. At the flower level, nectar secretion in the majority of the investigated double-low lines of white mustard is comparable to conventional cultivars, with a high potential for commercial nectar flow.

2. Considering pollen amount offered to pollinating insects, the double-low lines performed worse than traditional cultivars. To explain their poor pollen production more studies on development and viability of pollen grains are needed.

3. Although visiting insect did not significantly discriminated flowers of a particular group of investigated lines, they most eagerly foraged on flowers with abundant and easy accessible nectar.

4. Nectar and pollen production in flowers should be an important consideration for plant breeding programs, especially in honey bee mediated crops, in which pollination is highly dependent on adequate nectar and/or pollen rewards.

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ZMIENNOŚĆ PRODUKCJI NEKTARU I PYŁKU W KWIATACH PODWÓJNIE ULEPSZONYCH LINII GORCZYCY BIAŁEJ ORAZ ICH ATRAKCYJNOŚĆ DLA PSZCZOŁY MIODNEJ

Streszczenie. Badania dotyczyły zmienności produkcji nektaru i pyłku w kwiatach 75 podwójnie ulepszonych linii gorczycy białej oraz odmiany wzorcowej 'Nakielska'. Ponadto monitorowano intensywność odwiedzin owadów na kwiatach 19 linii. Stwierdzono, że masa i koncentracja produkowanego nektaru oraz całkowita masa cukrów wydzielonych w nektarze różniły się istotnie pomiędzy genotypami. Średnia masa nektaru z 10 kwiatów badanych linii wahała się od 2,3 do 24,4 mg, w porównaniu z 14,7 mg u 'Nakielskiej'. Koncentracja nektaru dla większości linii przekroczyła 20%. U 52% badanych linii, dziesięć kwiatów wydzielało średnio powyżej 2 mg cukrów w nektarze. Średnia masa pyłku z 10 kwiatów wyniosła 1,2–12,0 mg, przy średniej dla 'Nakielskiej' 8,5 mg. Nie stwierdzono jednoznacznego wpływu genotypu na masę produkowanego pyłku. Badane linie nie różniły się istotnie atrakcyjnością dla odwiedzających je owadów. Wśród entomofauny dominowały pszczoły miodne (93% wszystkich owadów pracujących na kwiatach). Sekrecja nektaru w kwiatach linii podwójnie ulepszonych gorczycy białej jest porównywalna z odmianami konwencjonalnymi, które produkują jednak istotnie mniej pyłku.

Słowa kluczowe: *Sinapis alba* L., nektar, pyłek, linie podwójnie ulepszone, intensywność oblotu kwiatów

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