THE EFFECT OF POLLINATING INSECTS ON THE YIELD OF WINTER RAPESEED (*Brassica napus* L. var. *napus f. biennis*) CULTIVARS

Zbigniew Kołtowski

Research Institute of Pomology and Floriculture, Apiculture Division,
ul. Kazimierska 2, 24-100 Puławy, Poland; e-mail: zbigniew.koltowski@man.pulawy.pl

Received 8 September 2005; accepted 28 October 2005

Summary

In the years 1999-2001, at the Apiculture Division of the Research Institute of Pomology and Floriculture in Puławy, experiments were carried out to investigate the response of 7 cultivars of winter rapeseed (Kana, Lirajet, Liropa, Marita, Polo, Silvia, and Skrzeszowicki) to a lack of pollinating insects. Analyses were conducted on plant samples from plots freely available to the pollinating insects and from plots kept in the blooming period under a gauze cover made of plastic mesh with a mesh size of 2 x 2 mm.

The cultivars examined did not demonstrate any specific reactions to the lack of pollination by insects and their responses were found to be similar. Under very similar conditions of growth and development of plants in both experimental variants, (with a similar number of plants per area size unit, with similar heights and comparable numbers of branches and blooming yield) it was found that the plants freely visited by the pollinating insects, compared to those kept under gauze cover, were setting a similar number of fruits from 100 flowers and a higher number of seeds per pod (by 22% on average), which at a similar, yet slightly lower weight of 1000 seeds, resulted in an average yield increase of 10%.

Keywords: winter rapeseed, blooming, pollination, yielding.

INTRODUCTION

Winter rapeseed (*Brassica napus* L. var. *napus f. biennis*) is commonly known as a fine honey flow plant. In areas where it is cultivated, it is the plant which beekeepers collect one of the first spring commercial honeys from. In respect of pollination requirements, this species is acknowledged as a facultative plant yielding both at self-pollination and allogamy. Nevertheless, self-pollination outweighs allogamy and the plants are capable of high seed yield even with a lack of pollinating insects. A number of authors have demonstrated the beneficial impact of these insects on rapeseed yield, which has been reported by Williams (1985), Free (1993) and Westcott and Nelson (2001). The published results referred to a specific group of cultivars grown over twenty years ago. Continuous breeding advance, resulting in an ever-increasing number of new cultivars successively implemented in cultivation practices, necessitates cyclic measurements of pollination requirements for currently grown cultivars.

The goal of this study was to recognize the pollination requirements of another group of new rapeseed cultivars grown in Poland, namely, to determine whether, and to what extent, they require pollinating insects to produce higher yields.

METHODS

Investigations were carried out in the years 1999-2001, at a research field of the Apiculture Division, Research Institute of Pomology and Floriculture in Puławy, in class IV light podsolic soil. Six new (at that time) double-zero cultivars of winter rapeseed (Kana, Lirajet, Liropa, Marita, Polo, and Silvia) were selected for the study and compared with Skrzeszowicki cultivar characterized by a high content of erucic acid. Each year, experimental plots were established with the method of randomized blocks in 4 replications. The area size of each plot was 8 m2. Typical agricultural procedures recommended in the production of winter rapeseed (Wałkowski et al. 1996) were applied. Sowing was carried out with a drill with a row spacing of 40 cm. At the stage of the first proper leaf, thinning was carried out to achieve a similar plant density on each plot. Crop cultivation was limited to manual weeding once in the autumn and once in the spring.

During the vegetative season of rapeseed, the times and lengths of the cultivars' blooming periods were observed. In addition, measurements were made for the foraging intensity of their flowers by pollinating insects, expressed by the number of simultaneously working insects per 1 m^2 of a plot during favorable weather. In sunny days, the number of foraging insects in the specified 3.2 m^2 observation plots was recorded at least three times in 1 h-intervals. The distance between the experimental plots from the closest apiary with several colonies did not exceed 40 m.

To eliminate pollination by insects and to determine the degree of pod and seed setting under self-pollination conditions, during the blooming period of a part of each experimental plot was covered with a plastic mesh permeable to air. At the stage of technical maturity of rapeseed, the number of pods set and peduncles was counted in a sample of 10-15 plants from both parts of each field (isolated and non-isolated from insects) to determine the exact number of all flowers produced by plants of individual cultivars. The number of flowers in a plant sample and the number of plants per 1 m^2 enabled a calculation of the number of flowers in the specified sowing area.

In further biometric analyses each sample was examined for the height of plants, the number of branches per plant, and the numbers of pods and seeds per plant. Each sample was weighed and the weight of 1000 seeds was calculated.

The obtained results were statistically elaborated using an ANOVA. The significance of differences was determined with Duncan's test at α=0.05.

WEATHER DURING THE TRIALS

Effective development of a winter rapeseed plantation is affected, to a significant extent, by climatic conditions in the autumn-winter season that determine uniform sprouting and good winter survival of the plantation, as well as by weather in the spring season (April – May) which affects the term and abundance of blooming of plants and nectar production of flowers. Nevertheless, the efficiency of flower pollination depends primarily on the weather in the blooming period of the plantation.

During the experimental period, weather conditions favored the development and blooming of rapeseed, yet in long-term study carried out on this species, there were seasons of complete winter killing of plantations. In the period preceding sowing, as well as immediately after sowing, no longer periods of draught were observed that could have resulted in attenuated sprouting. The earliest minus temperatures were recorded in the 1998/99 season, still in the second half of November, due to which plants had enough time to prepare themselves for winter. Winter was quite frosty with low

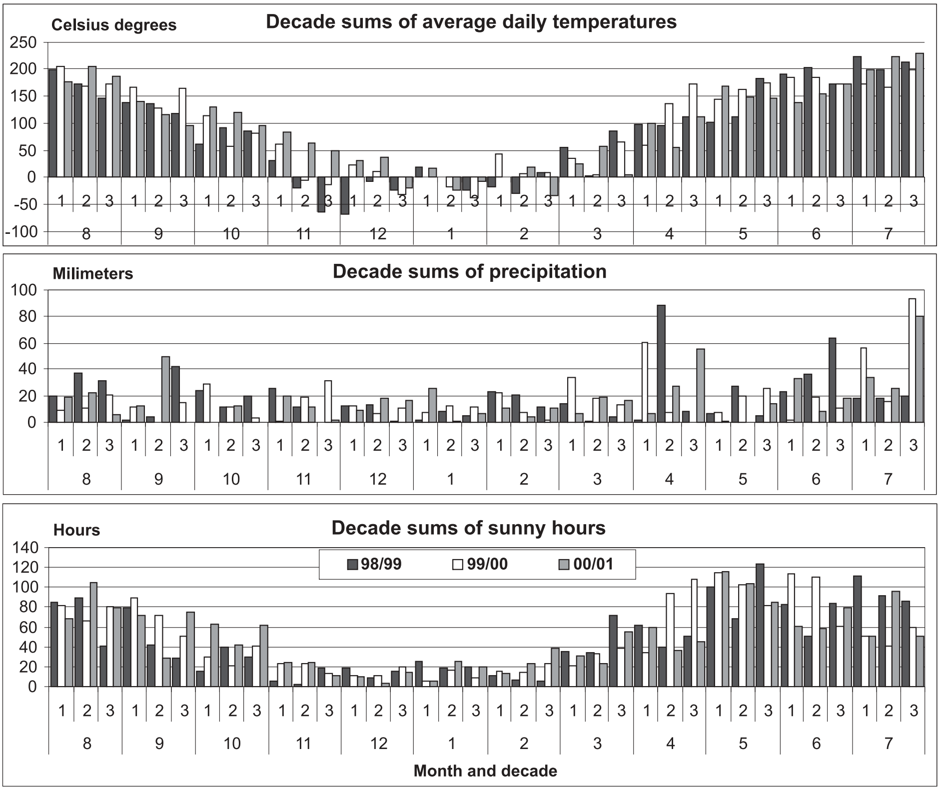

Fig.1. Selected weather factors during winter rapeseed cultivation seasons.

precipitation, but the plants survived it well. In the 1999/2000 season, the cooling proceeded gradually and very slowly, and the winter was mild, which facilitated good winter survival of rapeseed. In the season 2000/01, the autumn appeared to be warm and sunny, and the first minus temperatures were recorded in the third decade of December. Temperature drops in the winter season were negligible, due to which the plants survived well, even with a lack of snow cover.

Climatic conditions in the spring season had a decisive impact on the time as well as length of blooming. The earliest arrival of spring was noted in 2000, with the highest temperatures in April, which accelerated the blooming time of rapeseed. The coldest and most abundant with rainfalls spring occurred in 2001. In 1999, the spring season was moderately warm with very low precipitation. More rainfalls were recorded in the second decade of April, which strongly stimulated the growth and development of plants.

In the blooming period of rapeseed, namely in the first and second decade of May on average, the year 1999 appeared to be remarkably cooler than the two consecutives years of the study. The average daily temperature of this period reached 10.5°C, whereas that of the other years was ca. 15°C. The year 1999 was also characterized by the greatest cloud cover and the highest rainfalls. The subsequent years (2000 and 2001) were very similar to one another, with one noticeable difference in precipitation. The blooming period of 2001 was very dry, and the sum of precipitation in the 1st and 2nd decade of May was as low as 1 mm (fig.1).

RESULTS

Growth and development of plants

Due to the application of thinning and the relatively good winter survival of the plantation, no considerable differences were observed between cultivars in the number of plants per area size unit in a given year. More remarkable differences were, however, reported between the experimental years. In the second year of the study, plant density per 1 m^2 was the highest (ca. 47 plants per 1 m^2 vs. ca. 35 plants in the other years), and only these differences appeared to be statistically significant (tab. 1). All plots were quite equal and no significant differences were noted in the number of plants per area size unit between their parts which were freely-accessible by insects and the parts under gauze cover.

The height of plants is determined by the genetic properties of a cultivar and environmental conditions they grow in. Each year, the lowest values of that trait

Table 1.

Number of plants per 1 m^2.

Cultivar	Open pollination				Gauze			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	36.0	48.4	38.9	41.1 ab	37.7	49.9	34.2	40.6 ab
Lirajet	28.0	47.9	31.3	35.7 a	36.7	55.0	33.2	41.6 ab
Liropa	35.8	49.8	35.9	40.5 ab	36.0	49.1	38.6	41.2 ab
Marita	31.9	50.3	31.7	38.0 ab	40.3	48.8	39.8	43.0 b
Polo	36.5	44.1	35.6	38.7 ab	38.9	41.7	30.6	37.1 ab
Silvia	36.1	41.9	37.8	38.6 ab	32.7	41.8	32.1	35.5 a
Skrzesz.	35.5	43.2	32.3	37.0 ab	39.8	43.8	31.9	38.5 ab
Average	34.2 a	46.5 b	34.8 a	38.5 a	37.4 a	47.1 b	34.3 a	39.6 a

Table 2.

Height of plants in cm.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	171	153	154	159.3 a	173	148	159	160.1 a
Lirajet	185	159	164	169.2 bc	184	159	171	171.1 bc
Liropa	183	162	162	169.0 bc	185	157	167	169.5 bc
Marita	190	167	173	176.9 d	191	163	175	176.4 d
Polo	181	156	165	167.5 bc	181	152	168	167.3 b
Silvia	184	161	171	172.0 c	184	158	171	171.1 bc
Skrzesz.	190	170	176	178.5 d	188	171	179	179.3 d
Average	183.5e	161.0b	166.5c	170.3a	183.6e	158.3a	170.1d	170.7a

Table 3.

Number of branches per plant.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	8.3	7.3	7.7	7.73 a-d	8.0	6.6	7.8	7.47 a-c
Lirajet	9.1	6.6	8.6	8.08 cd	8.5	6.8	8.5	7.93 b-d
Liropa	7.9	6.5	7.4	7.24 ab	7.7	6.8	8.4	7.62 a-d
Marita	7.7	5.9	7.5	7.03 a	7.7	5.9	7.8	7.12 a
Polo	8.6	7.4	7.9	7.93 b-d	8.4	7.4	8.6	8.11 cd
Silvia	8.4	7.2	8.4	7.99 cd	9.0	7.0	8.7	8.23 d
Skrzesz.	8.7	6.4	7.9	7.67 a-d	7.9	7.6	8.4	7.97 cd
Average	8.38 c	6.74 a	7.88 b	7.67 a	8.15 bc	6.86 a	8.31 c	7.78 a

were reported for plants of Kana cv., whereas the highest ones were for those of Skrzeszowicki cv. and occasionally, for those of Marita cv. (tab. 2). The other four cultivars were intermediate between the above-mentioned ones and did not demonstrate any significant differences between one another.

In addition, both experimental variants (open pollination and gauze cover) did not result in any considerable differences in the values of that trait, although negligible differences in years 2000 and 2001 appeared statistically significant. On the contrary, diverse weather conditions in the experimental years were found to have a significant impact on the height of plants. Definitely, the least favorable conditions were recorded in the year 2000 when plants of winter rapeseed reached a height of ca. 160 cm on average. In the years 2001 and 1999 their heights reached nearly 170 cm and over 183 cm, respectively.

The number of branches per plant, apart from being genetically-determined, is affected to the greatest extent by the number of plants per area size unit. Due to the similar plant density, differences in respect of that trait between the cultivars examined were not remarkable, yet were statistically significant (tab. 3).

The least branched appeared to be Marita cv. (ca. 7 branches per plant on average) which was statistically different from cultivars reaching ca. 8 branches, i.e. Lirajet, Polo and Silvia. No significant differences were observed between experimental variants either, the plants had 7-8 branches on average. Only in the year 2000 were the plants significantly less branched. In that year, the number of branches did not reach seven, whereas in the other experimental years it was over 8. This was likely to be affected by a significantly higher number of plants per 1 m^2 in 2000, compared to the other years of the study (tab. 1).

Time and yield of blooming.

The most advanced blooming of rapeseed was observed in the year 2000 (as soon as on the 27th of April), when the spring was early and warm. In the two other years, all the examined cultivars started their blooming period around the 3rd of May. It should be added that only in 2001 were negligible differences noted in the blooming time of particular cultivars; Kana cv. was first to blossom (1st of May), whereas Marita and Silvia were the last (4th of May) (fig. 2).

Journal of Apicultural Science

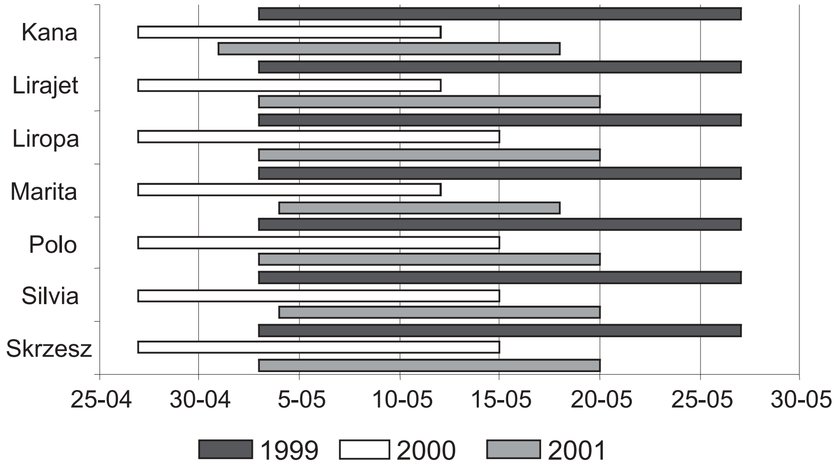

Fig. 2. Time and length of blooming of the examined winter rapeseed cultivars.

No remarkable differences were observed between the cultivars analyzed in the length of blooming. In the year 1999, the blooming period appeared to be the longest for all the cultivars, i.e. as long as 24 days. The blooming ended on the 27th of May. In 2000, the blooming period spanned from 15 days (Kana, Lirajet and Marita) to 18 days (the other cultivars). In 2001, only Marita cv. bloomed for as short as 14 days, whereas the blooming period of the other cultivars spanned for 16-17 days and ended around the 20th of May.

In the experiment reported, one plant of winter rapeseed produced ca. 290 flowers on average, both on plots with open pollination and those under gauze cover (tab. 4). In contrast, values of this trait were highly differentiated both within cultivars and experimental years. The lowest number of flowers was produced by plants of Marita cv., with 240 flowers per plant on average. Each year, this cultivar was observed to reach the lowest values of that trait and the differences in the average values compared with the other cultivars

Table 4.

Number of flowers per plant.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	368	202	297	289.0 cd	331	189	322	280.6 b-d
Lirajet	427	197	297	306.8 cd	366	193	343	300.5 cd
Liropa	357	194	274	274.7 bc	323	210	285	273.1 bc
Marita	297	175	268	246.6 ab	262	182	254	232.5 a
Polo	388	231	311	309.7 cd	355	232	342	309.7 cd
Silvia	378	220	311	303.0 cd	397	229	345	323.5 d
Skrzesz.	370	206	292	289.4 cd	355	264	335	318.0 cd
Average	369.1 d	203.5 a	292.8 b	288.5 a	341.2 c	214.3 a	317.8c	291.1 a

Table 5.

Number of flowers per 1 m^2 in 10^3

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	13.11	9.80	12.95	11.96 c	12.43	9.31	11.91	11.22 bc
Lirajet	11.94	9.40	10.33	10.56 a-c	13.38	10.47	12.51	12.12 c
Liropa	12.53	9.63	10.96	11.04 bc	11.45	10.33	12.15	11.31 bc
Marita	9.43	8.53	9.49	9.15 a	10.56	8.69	11.54	10.26 ab
Polo	14.16	10.15	12.24	12.18 c	13.38	9.49	11.29	11.39 bc
Silvia	13.66	9.11	13.09	11.95 c	12.75	9.58	12.13	11.49 bc
Skrzesz.	12.42	8.80	10.45	10.56 a-c	13.39	11.20	11.56	12.05 c
Average	12.46 c	9.35 a	11.36 b	11.06 a	12.48 c	9.87 a	11.87 bc	11.41 a

appeared to be significant. In second place was Liropa cv. which produced 274 flowers per plant on average. The numbers of flowers per plant for that cultivar were, however, not significantly different from those of the other cultivars whose plants produced 285-313 flowers on average.

In the year 1999, the blooming period was the longest and particular plants produced the highest numbers of flowers in both experimental variants, i.e. 369.1 flowers in open pollination and 341.2 flowers under gauze cover, on average. In the consecutive year, due to the higher plant density per plot, the plants produced fewer flowers per plant, on average 203.5 and 214.3, respectively. In 2001, plant density was similar to that of 1999, however, favorable weather shortened the blooming period and the plants produced 292.8 and 317.8 flowers on average. The differences in the values of this trait between all experimental years were found to be significant.

The most reliable measure of abundance of blooming a particular crop is the number of flowers initiated by plants per area size unit (plot) over the entire blooming period. Data present in Table 5 demonstrate that both at open pollination and under gauze cover, the number of flowers initiated was very similar. Statistically significant differences were, however, confirmed between the experimental years. In 1999, all the cultivars produced the highest numbers of flowers per 1 m^2 (ca. 12.5 x 103 on average), whereas in 2000 it was significantly less (slightly over 9.5 x 103 on average).

Significant differences in this trait were also observed between the cultivars examined. Over the 3 years of the study, taking into account both experimental variants (open pollination and gauze cover), Marita cv. produced significantly less flowers per 1 m^2 on average (as little as 9.7 x 103), whereas values of this trait for the other cultivars ranged from 11.2 to 11.8 x 103.

Intensity of foraging of flowers by pollinating insects

Blooming rapeseed plots were very attractive to different groups of insects for nectar and pollen. Honeybees were always dominant and constituted over 89% of all pollinating insects observed on flowers. They were followed by solitary bees that constituted almost 9% of all pollinators on average. In addition, nectar flow of

Table 6.

Density of honeybees per 1 m^2 of the blooming plot of winter rapeseed cultivars.

Cultivar	Year of study			Average
	1999	2000	2001	
Kana	7.0	6.3	3.9	5.74 bc
Lirajet	7.8	5.8	4.3	5.98 c
Liropa	7.1	6.3	3.8	5.71 bc
Marita	6.6	5.5	4.0	5.36 b
Polo	6.8	6.1	4.2	5.70 bc
Silvia	7.5	6.8	4.2	6.17 c
Skrzesz.	4.3	5.9	4.0	4.73 a
Average	6.72 c	6.11 b	4.05 a	5.63

rapeseed was sporadically attractive to bumblebees (0.17%) and diptera mainly of the Syrphidae family (1.81%).

In 1999, the density of honeybee foragers per 1 m^2 of plot in the full blooming of rapeseed, during peak flight hours, reached nearly 7 bees on average (tab. 6). It was significantly lower in 2000 (slightly over 6 workers per 1 m^2) and substantially lower in 2001 (4 bees per 1 m^2 on average).

In consecutive years, the flight intensity of particular cultivars was little diversified, except for the remarkably weaker forage of Skrzeszowicki cv. in the first year. However, it had a decisive effect on confirming the significance of differences between the average values of experimental years for the cultivars examined. It was demonstrated that Skrzeszowicki cv. was foraged with the lowest intensity compared to all other cultivars (on average 4.73 of foragers per 1 m^2). Significantly fewer bees, on average, were also observed on Marita cv. compared to Lirajet and Silvia cultivars, which was most likely a result of a lower number of flowers produced per size area unit.

Setting fruits and yielding

Under conditions of free access of pollinating insects, the plants were observed to set 146 pods each on average, whereas under gauze cover and without the insects they set nearly 150 pods each (tab. 7). This slight difference appeared to be statistically insignificant. Likewise, the significance of differences could not be confirmed for particular cultivars between experimental variants: open pollination vs. gauze cover. In the first two years of the study, plants with free access for pollinating insects set more pods, yet the significance of differences was not confirmed statistically. On the contrary, in 2001 a significantly higher number of pods was set by plants kept under gauze cover during the blooming period compared to those with free access by pollinating insects.

Plants of all cultivars were observed to set the lowest number of pods in 2000 (ca. 100 on average), whereas in the other years the average number of pods set oscillated around 160-180. Of the cultivars examined, the least pods were set by Marita cv. (ca. 120), whereas in the other cultivars the average value of this trait for

Table 7.

Number of pods per plant.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	175	108	160	147.7 c-f	173	91	180	147.9 c-f
Lirajet	201	99	164	154.7 c-f	199	89	189	159.1 c-f
Liropa	165	99	146	136.5 a-c	163	99	167	142.8 b-d
Marita	147	84	142	124.1 ab	128	76	146	116.6 a
Polo	181	102	158	147.2 c-f	164	94	177	144.7 b-e
Silvia	188	119	173	159.9 d-f	208	109	190	169.1 f
Skrzesz.	173	117	165	151.8 c-f	176	131	199	168.6 f
Average	175.7 c	104.0 a	158.3 b	146.0 a	173.0 c	98.3 a	178.1 c	149.8 a

years and pollination variant ranged from 140 (Liropa) to 165 (Silvia).

A comparison of the degree of fruit setting and the number of flowers, enabled an analysis of the impact of pollinating insects on yielding. The data in Table 8 indicate that, irrespective of pollination variant, cultivar or vegetation conditions, it may be assumed that every second (on average) a flower sets a fully developed pod. Considering the differences in respect to pollination variant, their significance could not be confirmed statistically for any of the cultivars examined. On the contrary, when experimental years were taken into account, significantly higher numbers of pods were set either under gauze cover (1999) or in open pollination (2000), or the differences were insignificant (2001). It cannot be proven, thus, that the pollinating insects exert an influence on pod setting in rapeseed. The function of those insects in rapeseed yielding is elucidated by further analysis of the experimental material collected.

Table 8.

Number of pods per 100 flowers for winter rapeseed cultivars.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	47.5	53.3	54.1	51.65 cd	52.5	48.0	56.1	52.20 cd
Lirajet	47.3	50.2	55.5	50.98 cd	54.4	46.2	55.3	51.98 cd
Liropa	45.9	51.0	53.8	50.22 b-d	50.4	47.1	58.4	51.94 cd
Marita	49.5	48.2	52.5	50.06 bd	49.3	42.2	56.7	49.41 ac
Polo	46.5	44.3	51.1	47.30 ab	46.3	40.6	51.7	46.19 a
Silvia	49.9	54.1	55.5	53.17d	52.8	47.6	55.4	51.96 cd
Skrzesz.	46.9	57.2	56.4	53.52 d	49.7	49.5	59.7	52.97 cd
Average	47.64 a	51.18 b	54.14 c	50.99 a	50.77 b	45.90 a	56.18 c	50.95 a

Journal of Apicultural Science

Table 9.

.Number of seeds per pod.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	21.72	18.56	19.89	20.05 b	16.78	17.67	16.35	16.93 a
Lirajet	22.38	18.08	19.92	20.13 b	17.25	15.20	16.31	16.25 a
Liropa	23.22	18.58	18.51	20.10 b	18.68	14.82	16.23	16.58 a
Marita	27.28	24.31	24.60	25.40 c	21.89	18.79	20.51	20.40 b
Polo	21.77	18.79	19.45	20.00 b	18.59	14.75	17.00	16.78 a
Silvia	21.54	16.69	19.22	19.15 b	17.40	14.15	15.87	15.81a
Skrzesz.	22.69	19.77	19.07	20.51 b	16.89	15.29	15.62	15.93 a
Average	22.94 e	19.26 d	20.09 d	20.76 b	18.21 c	15.81 a	16.84 b	16.95 a

The number of seeds per pod in plants freely available to the pollinating insects reached 20.76 on average, whereas in plants kept under gauze cover over the blooming period, it accounted for as little as 17 on average (tab. 9). Significant differences were observed both between cultivars and experimental years. Definitely the highest number of seeds per pod was produced by Marita cv. (on average 25.4 at open pollination and 20.4 under gauze cover), compared to the other cultivars which reached values of ca. 20.0 and 16.5 under respective conditions.

In 2000, the average number of seeds per pod was the lowest, whereas in 1999 it was the highest. It should be emphasized that all the cultivars examined demonstrated the same strong response to the lack of the pollinating insects, i.e. a reduction in a seed number per pod by 15-22%.

The average weight of 1000 seeds in plants growing on non-isolated plots, as

Table 10.

.Weight of 1000 seeds (g) of winter rapeseed cultivars.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	3.544	3.449	3.390	3.461 cd	3.855	3.742	2.992	3.530 d
Lirajet	3.210	3.289	3.138	3.212 a-c	3.545	3.851	2.635	3.343 b-d
Liropa	3.172	3.404	3.004	3.193 a-c	3.305	3.517	2.793	3.205 a-c
Marita	3.215	3.413	2.850	3.160 a-c	3.177	3.407	2.554	3.046 ab
Polo	2.827	3.253	2.998	3.026 ab	3.236	3.391	2.241	2.956 a
Silvia	3.158	3.436	3.028	3.207 a-c	3.308	3.632	2.481	3.140 a-c
Skrzesz.	3.277	3.265	3.299	3.281b-d	3.546	3.539	2.869	3.318 b-d
Average	3.200bc	3.359cd	3.10b	3.220a	3.425de	3.582e	2.652a	3.220a

Table 11.

.Seed yields of winter rapeseed cultivars in q/ha.

Cultivar	Open pollination				Gauze cover			
	1999	2000	2001	Average	1999	2000	2001	Average
Kana	36.83	32.88	41.74	37.15 c	41.80	28.67	29.76	33.41 bc
Lirajet	32.28	27.57	32.21	30.69 ab	44.10	27.98	27.31	33.13 bc
Liropa	34.05	30.75	28.55	31.12 ab	34.98	24.79	27.88	29.21 bc
Marita	32.58	33.81	32.05	32.81 bc	35.73	23.27	29.78	29.59 ab
Polo	33.66	27.18	32.79	31.21 ab	37.32	19.41	20.59	25.77 a
Silvia	38.85	27.73	37.37	34.65 bc	39.15	23.22	24.09	28.82 ab
Skrzesz.	34.28	32.25	33.31	33.28 bc	39.89	30.11	28.46	32.82 bc
Average	34.65 c	30.31 b	34.00 c	32.99 b	39.00 d	25.35 a	26.84 a	30.39 a

well as in those kept under gauze cover was identical and reached 3.22 g (tab. 10). The differences between cultivars were negligible, but statistically significant. The largest seeds were observed for Kana cv. The weight of its 1000 seeds reached almost 3.5 g and was significantly different compared to the other cultivars. The smallest seeds were reported for Polo cv. (only 3 g on average) which differed significantly from the cultivars Kana, Lirajet and Skrzeszowicki.

The first two years of the study were characterized by similar average values noted for all the cultivars examined as well as by the statistically confirmed correctness of setting larger seeds under gauze cover than under conditions of open pollination by insects. The last experimental year was, however, completely different; the seeds set appeared to be the smallest, and significantly smaller under gauze cover than at open pollination.

In the experiments analyzed, seed yield at open pollination reached nearly 33 q per 1 ha on average. In spite of the fact that it was significantly more than under gauze cover, no significant differences were confirmed for any of the cultivars between seed yields as affected by the pollination variant (tab. 11). In the year 1999, seed yields were definitely the highest and accounted for 35 q at open pollination, on average, and as much as 39 q under gauze cover. This was an exceptional situation, as never again were the yields higher under gauze cover than in open pollination. In the subsequent years of the study, the seed yield was observed to reach 30-34 q at open pollination and 25-27 q under gauze cover, on average.

Comparing the cultivars examined in terms of the seed yield, it can be concluded that under conditions of normal flight intensity of flowers by the insects in the years 1999-2001 the highest yield of seeds was obtained from Kana cv. (over 37 q on average), and the lowest was from the cultivars Lirajet, Liropa and Polo (ca. 31 q on average).

DISCUSSION AND CONCLUSIONS

The results of the reported study into the effect of pollinating insects on setting fruits and seed yields of the examined winter rapeseed cultivars can be compared with findings of other authors. Most of them confirmed an increased seed yield in plants freely available to the pollinating insects compared to those under cover, e.g. by 16% in Australian studies (Manning and Boland 2000), by 20-24% in Polish experiments (Woźnica 1982, Jabłoński et al. 1985), by 37% in Sweden (Fries and Stark 1983), and by over 50% in Czech Republic (Kubišova et al. 1980, Kamler 1983). A key role of the pollinating insects has also been postulated in the pollination of male-sterile lines and hybrid cultivars, where without the insects functioning as vectors carrying pollen, the seed yield appeared to be 3-4-fold lower than under conditions of free flight of flowers by the insects (Mesquida and Renard 1981, Kołtowski 2001).

In the light of investigations of the above-mentioned authors, the data obtained in this study on seed yield confirm the positive role of pollinating insects. However, despite the statistically confirmed, significantly better average yielding of all cultivars in open pollination, the significance of such differences could not be proven for particular cultivars. This has also been observed by a group of French researchers who were not always able to statistically confirm the significance of numerical differences that indicates a beneficial impact of the pollinating insects on particular factors of seed yield (Mesquida et al. 1988).

In present study, this was undoubtedly affected by the results obtained in the first experimental year, i.e. when the seed yield under gauze cover was higher than that at open pollination. This abnormal situation resulted from unfavorable atmospheric conditions during the blooming period that determined very weak seed setting, especially in the variant of open pollination. In the first two decades of May, the decade sums of average daily temperatures as well as the sum of sunny hours were the lowest of all the experimental years. In addition, very frequent and heavy rainfalls did not facilitate the flights of the pollinating insects. Although during occasional days of favorable weather, the number of honeybees per area size unit was very high (the bees were observed to fly out on nectar flows on a mass scale), yet sporadic periods of good flight did not result in a sufficient degree of fruit setting.

In conclusion, it may be stated that in the presence of the pollinating insects, the new winter rapeseed cultivars assayed in this study are capable of setting a similar number of fruits per 100 flowers as those under gauze cover, however they set 22% more seeds per pod which, at a similar, but lower, weight of 1000 seeds, results in a considerable increase in seed yield, i.e. by 10% on average.

REFERENCES

Free J.B. (1993) - Insect pollination of crops. 2nd edition, Acad. Press, London-New York, :172-180.

Fries I., Stark J. (1983) - Measuring the importance of honeybees in rape seed production. *J. Apic. Res*. 22(4):272-276.

Jabłoński B., Skowronek J., Szklanowska K. (1985) - Wartość pszczelarska, zapylanie i plonowanie niskoerukowych odmian rzepaku ozimego [Beekeeping value, pollination and yields of low erucic acid winter rapeseed cultivars]. *Pszczeln. Zesz. Nauk*. 39:339-358.

Kamler F. (1983) - Reakce wybranych odrud repky ozime na opyleni vcelou medonosnou [The response of selected winter rape cultivars to the pollination by honeybees]. *Rostlinna vyroba*, 29(56):225--234.

Kołtowski Z. (2001) - Beekeeping value and pollination requirements of double--improved cultivars of spring rapeseed (*Brassica napus* L. var. *oleifera* Metzger *f. annua* Thell.). *Journal of Apicultural Science*, 45:69-84.

Kubišova S., Nedbalova V., Plesnik R. (1980) - Činnost včely medonosne (*Apis mellifera* L.) na repce (*Brassica napus* L. var. napus) [The activity of honey bee (*Apis mellifera* L.) on rape (*Brassica napus* L. var. *napus*)]. *Polnohospodarstvo* 26(8):744-754.

Manning R., Boland J. (2000) - A preliminary investigation into honey bee (*Apis mellifera*) pollination of canola (*Brassica napus* cv. Karoo in Western Australia. *Australian Journal of Experimental Agriculture*, 40:439-442.

Mesquida J., Renard M. (1981) - Pollination of male-fertile and male-sterile winter rape-seed (*Brassica napus* L. var. *oleifera* Metzger) by the honeybee (*Apis mellifica* L.) Effects on phenology and yield. *Apidologie*, 12(4):345-362.

Mesquida J., Renard M., Pierre J.S. (1988) - Rapeseed (*Brassica napus* L.) productivity: The effect of honeybees (*Apis mellifera* L.) and different pollination conditions in cage and field tests. *Apidologie*, 19(1):51-72.

Wałkowski T., Krzymański J., Mrówczyński M., Jajor E., Ochodzki P. (1996) - Rzepak ozimy [Oilseed rape]. IHAR Poznań 1996, ss.60.

Westcott L., Nelson D. (2001) - Canola pollination: an update. *Bee World*, 82(3): 115-129.

Williams I.H. (1985) - The pollination of Swedish rape (*Brassica napus* L.). *Bee Word*, 6(1):16-22.

Woźnica J. (1982) - Wpływ pszczół jako zapylaczy na plon rzepaku ozimego [Effect of honeybees as pollinators on seed yield of winter rapeseed]. *Pszczelarstwo*, 33(12):5-6.

WPŁYW OWADÓW ZAPYLAJĄCYCH NA PLONOWANIE ODMIAN RZEPAKU OZIMEGO (*Brassica napus* L. var. *napus f. biennis*)

Kołtowski Z.

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

W latach 1999-2001 w Oddziale Pszczelnictwa ISK w Puławach badano reakcję 7 odmian rzepaku ozimego (Kana, Lirajet, Liropa, Marita, Polo, Silvia i Skrzeszowicki) na brak owadów zapylających. Prowadzono analizę prób roślin z poletek swobodnie dostępnych dla owadów zapylających oraz z poletek przykrytych jedynie na czas kwitnienia izolatorem z siatki plastykowej o wymiarach oczek 2 x 2 mm.

Badane odmiany nie wykazywały swoistych reakcji na brak zapylenia przez owady i wszystkie reagowały tak samo. Przy bardzo zbliżonych warunkach wzrostu i rozwoju roślin dla obu wariantów doświadczenia, tzn. przy podobnym ich zagęszczeniu na jednostce powierzchni, podobnej wysokości roślin, stopniu ich rozgałęzienia oraz obfitości ich kwitnienia, stwierdzono, że rośliny swobodnie odwiedzane przez owady zapylające w porównaniu do zamkniętych pod izolatorem zawiązują podobną liczbę owoców ze 100 kwiatów, ale wykształcają średnio o 22% więcej nasion w łuszczynie, co przy zbliżonej ale jednak nieco niższej masie 1000 nasion przekłada się na wzrost plonu nasion średnio o 10%.

Słowa kluczowe: rzepak ozimy, kwitnienie, zapylanie, plonowanie.