THE VARIABILITY OF YIELD STRUCTURE OF BLACK CURRANT CULTIVARS (*RIBES NIGRUM* L.) IN DIFFERENT POLLINATION CONDITIONS

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Abstract

Field experiments were established according to the randomised block method on experimental plots in Puławy, Poland (51^{0}14'N 22^{0}00'E). Eight cultivars were tested: Ben Alder, Ben Lomond, Ben Nevis, Ben Tirran, Ceres, Ojebyn, Titania, Triton. Three pollination methods were compared: 1. free-pollination, 2. pollination with own pollen by one bumblebee queen, 3. self-pollination. The fruits were assorted into 4 size classes. In the case of all examined cultivars the pollination treatment considerably influenced the yield structure. Under free-pollination the participation of berries ø > 12mm and ø 10-12mm was over 70%. A similar yield quality was obtained after pollination by one bumblebee under isolator cover. The fruits set in self-pollination condition were significantly smaller - 43-60% of berries ø >12mm and ø 10-12mm.

Keywords: *Black currant (*Ribes nigrum *L.) / free-pollination / self-pollination / pollination by one bumblebee / yield structure*

Introduction

Adequate geographical conditions, the introduction of highly effective methods of cultivation as well as the frequent use of machine harvest make Poland the leading producer of black currant in Europe. The stable economic situation in the foreign markets results in a large proportion of blackcurrant crop being exported to the EU countries, which additionally increases the profitability of production.

Profitability of production is secured by high quality bumper crop. Commercially viable yield depends not only on the genetic characteristics of cultivars, or the use of appropriate agrotechnical methods but also on the proper pollination of flowers. Pollination is a particularly important factor for increasing black currant yield since most presently grown cultivars are clones displaying high degree of self-fertility but little ability for self-pollination (KOŁTOWSKI et al.,1999; DENISOW, 2003). In general, black currant benefits from a high number of pollen grains reaching stigmas. The most effective vectors carrying pollen are insects - mainly honey bees. Bee activity is essential for transporting pollen to stigmas even in self-fertile cultivars and the number of pollen grains deposited on stigmas in insect pollinated flowers is on average three times higher than in the case of stigmas of self-pollinated flowers (DENISOW, 2002 a,b).

The positive impact of the honey bee on the yield of black currant has been repeatedly emphasised in the Polish and foreign literature alike. Insect pollinated bushes set more berries per one raceme and the average weight of berries increases (MCGREGOR, 1976; FREE, 1993; SZKLANOWSKA and DĄBSKA, 1993; HOFMANN, 1995; SZKLANOWSKA and DENISOW, 1998; KOŁTOWSKI et al., 1999). However, DIJKSTRA et al. (1987) did not report any positive effects on Bulgarian plantations of black currant supplemented with honey bee colonies.

Apart from the amount of yield its quality is also economically relevant as small berries are not readily bought by the consumers and the industry. The quality of black currant yield depends predominantly on the size of berries as weak and insufficient pollination does not result in the deformation of fruits commonly observed in the case of poor pollination of other species (MCGREGOR, 1976; FREE, 1993). Because the available literature extremely rarely concentrates on the analysis of the impact of pollination on the quality of crop, the present study is an attempt to find out to what degree the presence or complete absence of insects influence the structure of black currant yield.

Material and Methods

Black currant cultivars and the study site

The experiment was conducted on a test plantation in Puławy, south-eastern Poland between 1994 and 1997. The following cultivars were examined: Ben Alder, Ben Lomond, Ben Nevis, Ben Tirran, Ceres, Ojebyn, Titania, Triton. The bushes were planted in the spring of 1993 with the density of 3200 bushes per 1 ha. The plants were growing in pseudo-podzolic soil, pH 5,2. In the autumn of 1992 100 kg P_2O_5/ha and 200 kg K_2O/ha were applied. In the following years, the cultivation and fertilization treatment followed the usual recommendations for commercial plantations.

The outline of the experiment

The experiment was carried out using the randomised block method with five bushes of a given cultivar on a plot, i.e. 32 bushes in one row. Three methods of pollination were used. The first method (A) – free-pollination included bushes available for various pollinating insects throughout the whole period of blooming. The second method (B) was applied to bushes with flowers pollinated by one bumblebee under isolator. Just before blooming the chosen experimental bush was covered with a plastic net isolator. Each isolator was supported on four poles so that the net would not touch the bush. A bumblebee hive (Biliński type) (BILIŃSKI, 1976) was placed under each isolator and then one bumblebee queen was put inside. The third method (C), i.e. self-pollinating was achieved by means of isolating all bushes in a row from insects. Isolators were removed after the end of blooming when all fruits in raceme were set.

The analysis of fruits

Fruits were picked up when ripe. Berries from a few branches of each experimental bush of a given combination were sorted according to size. Four classes of diameter: > 12, 10-12, 8-10, <8 mm were obtained. Fruits in each size class were counted and their percentage share was established. Additionally, all fruits in each class were weighted and an average weight of 100 fruits was calculated. The data collected allowed the evaluation of the yield structure. The number of seeds in fruits was calculated on the basis of the sample of 40 fruits, repeated 4 times (160 per sample) in each combination of pollination and cultivar.

Weather conditions

During the blooming period in 1994 and 1995 the temperatures ranged between 3.2^{0}C – 13.1^{0}C and 5.0^{0}C – 11.5^{0}C, respectively. The following two years were characterised by higher temperatures in the period of blooming: 9.4^{0}C – 17.8 ^{0}C and 10.2 ^{0}C – 21.0 ^{0}C, respectively. In the period of the intensive growth of fruits in 1994 and 1996 heavy rainfall occurred (May/June 146 mm in 1994 and 183 mm in 1996, compared with the long-term average for May/June 110 mm. 1995 was exceptionally dry with a rainfall of 68 mm in May/June, while in 1997 in July it was particularly rainy (132 mm, while the long-term average for July was 85 mm).

Statistical analysis

The data were tested by double and trifactor analysis of variance. Differences between pollination treatments, between cultivars within pollination treatment and between years were tested by Duncan's t-test. The significance of differences was set at p=0.05. The data are presented as means and standard deviations.

Results

In the years of the study, the period of blooming of black currant in the Puławy conditions occurred between April 15th and May 15th. The examined cultivars were differentiated according to the period of blooming and fruit ripening into early (Ceres), half-early (Ben Lomond, Ben Nevis, Ojebyn, Titania, Triton), and late (Ben Alder, Ben Tirran).

Fruits were picked up in the consecutive years of the experiment in the following days: July 4-22, July 11-25, July 6-18 and July 7-11.

The structure of yield most significantly depended on the applied method of pollination (Fig. 1).

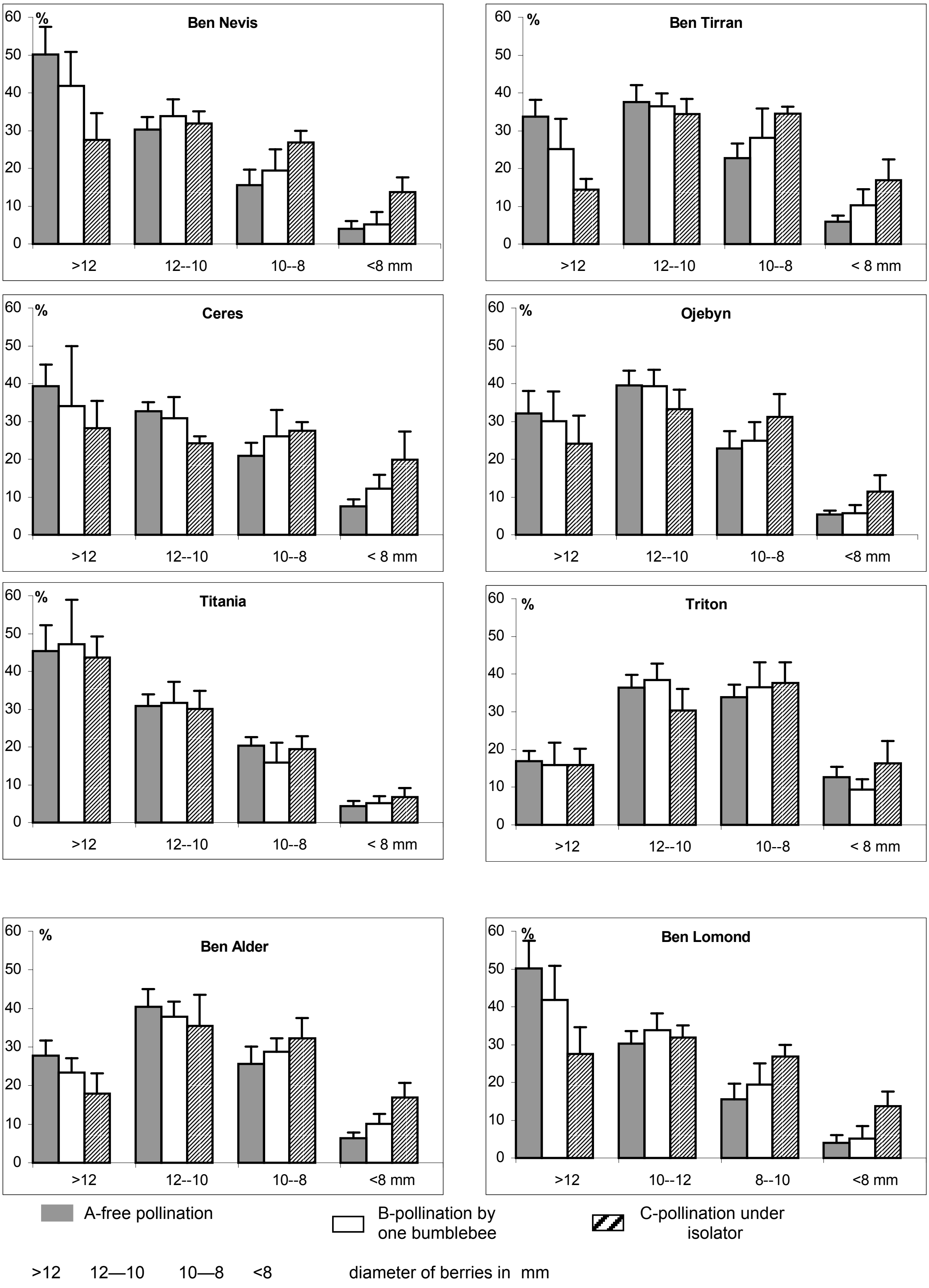
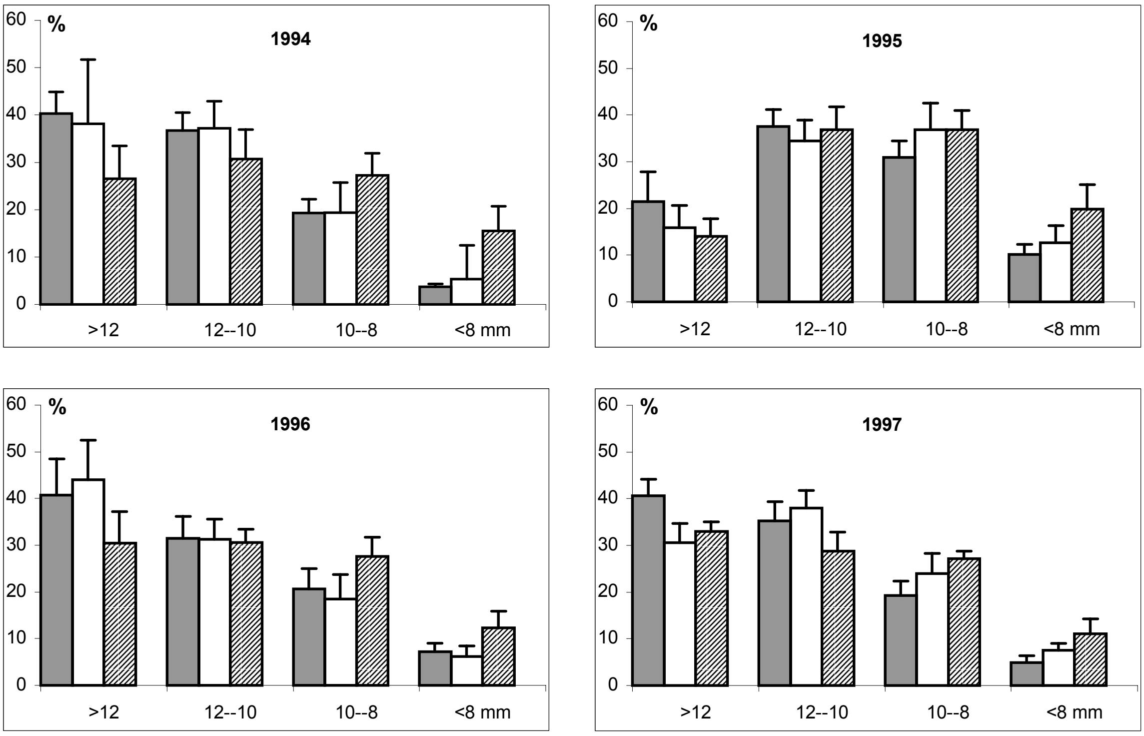


Figure 1 - The percentage of fruits of eight black currant cultivars in size classes depending on pollintion treatment (average from 4 years) - for statistical significance see results.

The examined cultivars showed a similar reaction to the pollination methods applied. The highest percentage of high-quality berries was present in the yield of free-pollinated bushes. In combination the fruits >12 and 10-12 mm of diameter made up more than 70% of all fruits. Only in 1995 the percentage of large berries was significantly lower, i.e. 59%. A similar percentage share of different size categories was also observed after pollination with one bumblebee under an isolator. The fruits in the two highest size classes made 75%, 51%, 75% and 69% of the yield in the successive years. The percentage of large berries in the yield from self-pollinated bushes was significantly lower than in the case of the aforementioned combinations and did not exceed 60%, while in 1995 it was only 43%. The percentage share of smaller berries (8-10 mm and <8 mm) was significantly higher and reached 43%, 57%, 39%, 38% in the consecutive years of the experiment (Fig. 2).



A-free -pollination

B-pollination by one bumblebee

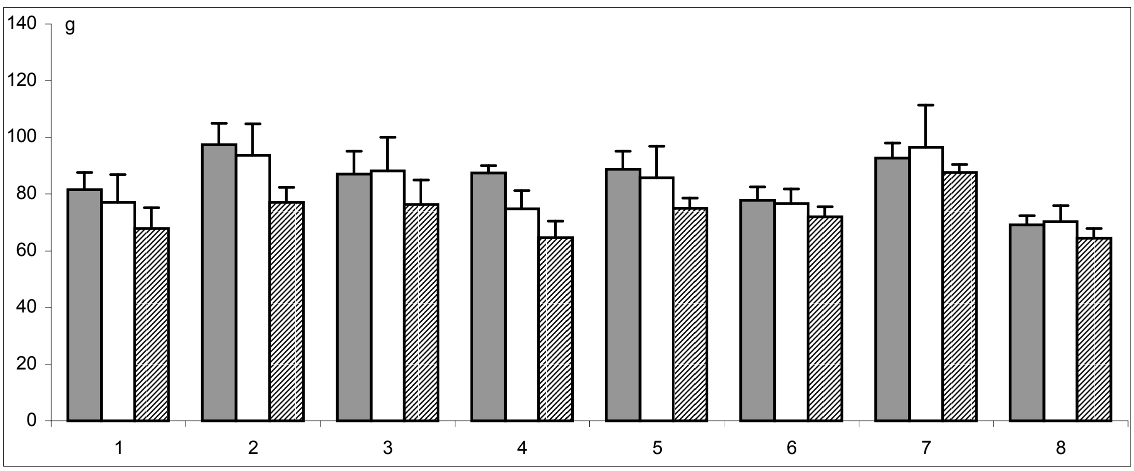
C-self-pollination under isolator

>12 12—10 10—8 <8 diameter of berries in mm

Figure 2 - The percentage of black currant berries in size classes depending on pollination treatment in the years 1994-1997 (average from 8 cultivars) – for statistical significance see results.

The differences between cultivars were estimated by comparing the structure of the yield achieved under free pollination. The biggest percentage of large berries (>12 mm and 10-12 mm) was observed in all years in the yield of Ben Lomond and Ben Nevis (approx. 80%) and Titania (approx.75%). The smallest number of large berries was observed in the yield of Triton (only 50% in the I and II size class, while the number of the largest berries > 12mm was only 16%).

The observed structure of the yield was also connected with the average weight of fruits (Fig. 3).



A-free pollination

B-pollination by one bumblebee

C- self-pollination under isolator

1-Ben Alder 2-Ben Lomond 3-Ben Nevis 4-Ben Tirran 5-Ceres 6-Ojebyn 7-Titania 8-Triton

Figure 3 - The weight of 100 berries of 8 black currant cultivars depending on pollination treatment (average from 4 years)- for statistical significance see results.

This factor depended on the method of pollination, the cultivar, and the year of the experiment. The largest berries were obtained by Titania – with the average weight of 100 berries at 92.3 g, and Ben Lomond with 89.4 g. The smallest berries were set by Triton (67.9 g per 100). All cultivars set the biggest fruits after free-pollination, the average weight of 100 berries was 84.4 g. Statistically insignificant difference (82.9 g per 100 berries) was observed in the weight of fruits set after pollination by one bumblebee. On the other hand, the fruits set from self-pollinated flowers weighted only 73.1g per 100 berries, which is significantly lower in comparison with pollination treatments A and B. The higher weight of berries was always connected with the bigger amount of seeds present. Free-pollinated flowers set berries containing approx. 26-29 seeds. The berries set on bushes pollinated by one bumblebee contained approx. 21-26 seeds. No significant differences between combinations A and B were found. The berries set after autogamy had approx. 13-22 seeds, which was statistically lower than for A or B (Fig.4).

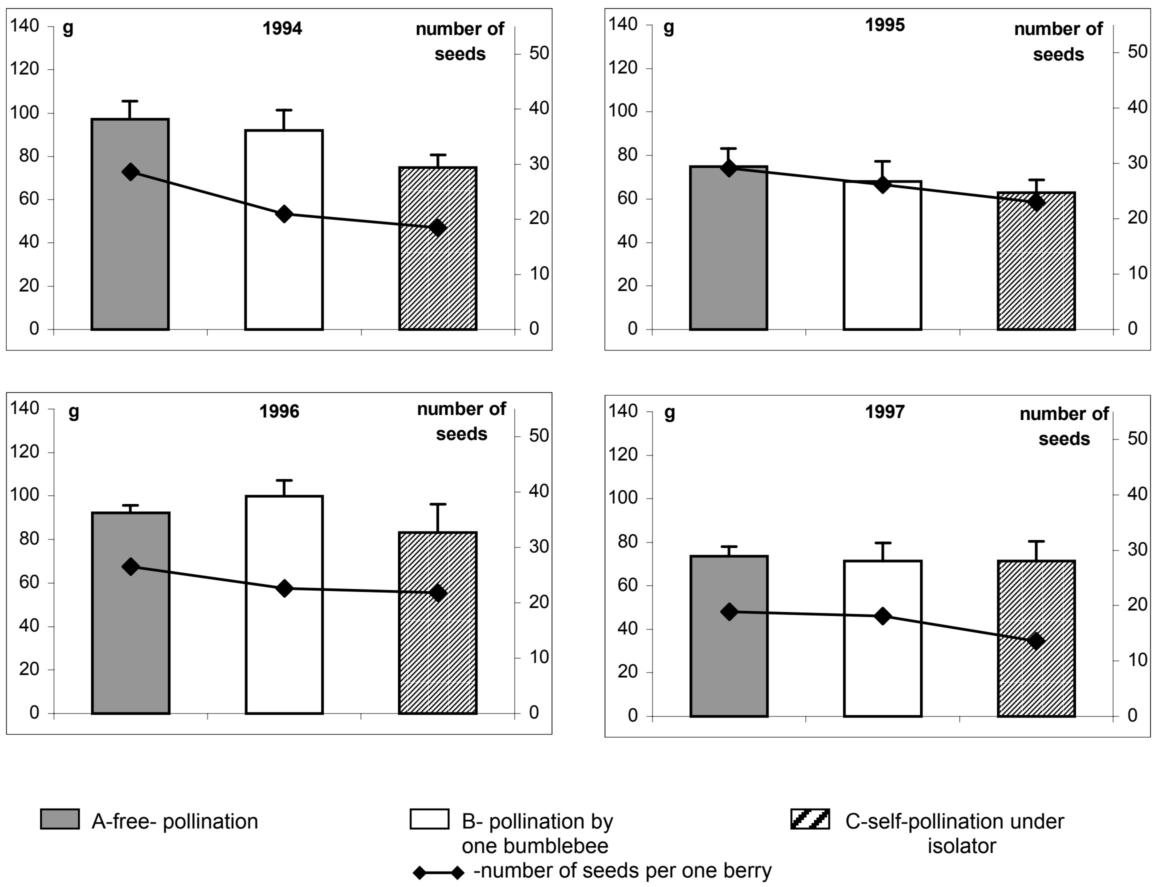


Figure 4 - The weight of 100 fruits of black currant depending on pollination treatment in succesive years of study (average from 8 cultivars). For clarity standard deviations are not given for the number of seeds, SD does not exceed 9.8% of the mean.

Meteorological conditions at the time of blooming and fruit setting had also an important influence on the quality of blackcurrant yield. The weight of 100 berries was highest in 1994 and 1996 (88.1 g and 91.8 g, respectively). In these years at the time of fruit growth and ripening the rainfall was higher than the long term average. In 1995 it was particularly dry and consequently the weight of 100 berries was smallest (68.7g).

Discussion

The quality of yield in the conducted experiment was assessed on the basis of the percentage share of berries in one of the four size classes and the weight of 100 berries. Both features depended considerably on the method of pollination.

In all years of study the highest percentage of large berries (size class >12 and 10-12 mm) was obtained from free–pollinated bushes and bushes pollinated by one bumblebee queen. At the same time, the weight of 100 berries acquired from bushes pollinated by different insects was 84.4 g and was only slightly higher than the weight of berries set as a result of pollination by one bumblebee – 82.9 g. Such similar results regarding the weight of berries and the structure of the yield obtained after free-pollination and after pollination by only one bumblebee point to a positive role of even a small number of pollinators on black currant plantations, since one bumblebee pollinating flowers under an isolator proved to be very effective at carrying pollen, which resulted in a satisfactory structure of the yield.

The lack of statistical differences in the results obtained from combinations A and B corroborates the observations made by DIJKSTRA et al. (1987), to the effect that supplementing plantations with honey bee colonies does not necessarily bring positive effects and results in higher yield. This suggests, in turn, that in areas with numerous wild pollinators such as bumblebees and solitary bees satisfactory yield can be achieved without the need for the additional supplementing of plantations with honey bee colonies. However, in Polish conditions populations of bumblebees in early spring are limited to nesting queens or to very small young colonies with only a few workers and as a result supplementary bees colonies seem necessary.

My results, although bases primarily on the structure of yield, confirm numerous experiments whose results suggest that black currant cultivars require insects pollinators for sufficient yield (MCGREGOR, 1976; SZKLANOWSKA and DĄBSKA, 1993; KOŁTOWSKI et al., 1999). The considerably better structure of the yield achieved from insect pollinated bushes demonstrates the strong need for pollinators on black currant plantations.

In all years of the experiment, the bushes which were completely isolated produced the lower percentage of fruits >12 and 10-12 mm in diameter– only 40-60%. Also the weight of fruits set after self-pollination under an isolator was considerably lower in comparison to free-pollination (less by 13% on average). According to different authors the average weight of a given number of fruits set from flowers pollinated by insects can be 10%-50% higher than that of fruits obtained from self-pollinated flowers under isolators (FREE, 1993; SZKLANOWSKA and DĄBSKA, 1993; HOFMANN, 1995; SZKLANOWSKA and DENISOW, 1998).

It seems that the higher weight of berries achieved from insect-pollinated flowers in the case of the examined cultivars and, as a result, the higher and better quality yield may compensate the cost of hiring honey bee colonies.

The differences regarding the size of the berries produced by different cultivars observed in the experiment are connected with the genetic characteristics of cultivars. In all years the biggest fruits were produced by Titania and Ben Lomond, while the smallest by Triton. Similar observations regarding the examined cultivars were also made by KOŁTOWSKI et al., (1999), who note that Titania and Ben Lomond have biggest fruits while those of Triton are smallest.

The observed reduction in the quality of yield as well as the weight of fruits in 1995 affected all combinations of pollination. This demonstrates a significant influence of a factor other than pollination. Most probably the dry weather conditions at the time of fruit ripening influenced the weight of the berries. On the other hand, intensive rainfall (heavier than a long-term average) occurring at the time of fruit ripening resulted in the rise of the average weight of berries. A similar influence of weather conditions on this important feature of fruits is also reported in KOŁTOWSKI et al. (1999). Additionally, a worse structure of yield achieved in 1995 under free-pollination might be due to the lack of pollinators on a plantation. Honey bee colonies in the nearby apiary were very weak after a severe winter and, as a result, the density of insects was much smaller compared with their density in other years. The second problem was cool, windy weather during the time of black currant blooming. Adverse weather conditions prevent pollinators from flying. One way of overcoming this problem is to increase honey bee density in order to compensate the reduction of flight efficiency.

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