

**Eggplant (*Solanum melongena* L.) flowering and
fruiting dynamics depending on pistil type as well as
way of pollination and flower hormonization**

Grażyna Kowalska

Department of Hydrobiology and Ichthyobiology
Agricultural University in Lublin
Dobrzańskiego 37, 20-262 Lublin, Poland
e-mail: grazyna.kowalska@ar.lublin.pl

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ABSTRACT

The experiment was carried out in three unheated plastic tunnels in 1998 – 2000. The aim of this study was observation on flowering dynamics and estimation of the effects of flower's heterostyly and two ways of flower pollination (self-pollination and using bumble-bee) as well as flower hormonization on the fruiting dynamics of three cultivars of eggplant: 'Black Beauty', 'Solara F₁', and 'Epic F₁'.

Eggplants began their flowering in June in three years of study. The most intensive flowering occurred in July 1998, and in August 1999 and 2000. 'Black Beauty' produced the greatest number of flowers with medium-styled pistil, 'Solara F₁' and 'Epic F₁' – flowers with high-styled pistil.

The first fruits were set in June from flowers with long-styled pistil. The best fruit setting for every combination was observed in July and August during the abundant eggplant's flowering. For all pollination ways, the greatest number of fruits developed from long-styled flowers. Plants, whose flowers were pollinated by bumble bees and hormonized, set a great number of fruits from flowers with medium and short-styled pistils.

INTRODUCTION

Eggplant (*Solanum melongena* L.) yielding dynamics, besides weather (Abney and Russo 1997, Lawande and Chavan 1998) or agrotechnical factors (Paksoy 1994, Cebula 1996, Kowalska 2003a, 2003b, Kowalska and Buczkowska 2004, Kowalska 2005) is affected by the specific morphology of flowers. Proper flowers pollination is one of the general determinants of good-quality fruits and seeds yields. Heterostyly phenomenon present in eggplant's flowers, reduces the yielding potential of the vegetable. Flowers with long-styled pistil are the majority among all flowers on a plant (60%). Number of flowers with medium and short style is lower (15 and 22%, respectively). Eggplants set fruits from flowers with long style in 49-100% and with medium style in 46-85% (Górecki and Espinoza-Flores 1996, Passam and Bolmatis 1997, Kowalska 2003c). These flowers' stigmata have well-developed nodules and well-permissible tissues rich in polysaccharides, proteins and other nutrients. They are also characterized by good pollen absorption. Short-styled flowers have small stigmata with underdeveloped nodules and, due to worse absorption, they are not pollinated and do not set fruits (Rylski et al. 1984, Handique and Sarma 1995).

The aim of present research was to evaluate the flowering and fruiting dynamics of eggplant grown in a cold plastic tunnel using three ways of pollination: self-pollination, hormonization and pollination by bumble bee (*Bombus terrestris*).

MATERIAL AND METHODS

In the years 1998 – 2000 the experiment was conducted in a cold plastic tunnel on the Experimental Farm of Agricultural University in Lublin. Seeds were sown at the first days of April into the boxes with peat substrate. Seedlings were bedded out into the pots at the stage of total decomposition of cotyledons with the first leaves brids. 6-week-old seedlings were transplanted into a tunnel at the beginning of June. Spacing between plants was 50 × 50 cm. Plants were grown in plastic cylinders, each of 8 litres volume, in a peat substrate. Fertiliser application (pretransplant and sidedressing) was based on a prior soil test.

Three eggplant (*Solanum melongena* L.) cultivars – ‘Black Beauty’, ‘Solara F₁’ and ‘Epic F₁’ were cultivated in three foil tunnels (120 plants each). In the first tunnel flowers were pollinated by insects. Net curtains that made possible for insects to exit the tunnel were mounted at the entrance. Beehive with bumble-bee colony was introduced twice (with two-week interval) in 1998 and 1999. In 2000 eggplant plants did not grow abundantly and one bumble-bee family was sufficient to pollinate all flowers on plants. The smallest “mini” beehive (Biopartner), assigned for pollination 300 m² area, was used in the experiment. Bumble-bees were introduced onto the cultivation just after first flowers appearance: 1998 – 25.06. and 5.08., 1999 – 8.07. and 5.08., 2000 – 24.06. Control of flowers pollination by means of pistils colour observation was made several times a week. Flowers efficiently pollinated had brown-coloured pistils. In the second tunnel flowers were subjected to hormonization. Eggplant flowers were sprayed with Betokson Super preparation containing 2.5% β -naphthoxyacetic acid (NOA). Flowers hormonization was begun on 30th June 1998, 6th July 1999 and 24th June 2000 repeating the operations twice a week in the morning (9 a.m. till 11 a.m.). Control plants were cultivated in the third tunnel. Fruits on these plants were set only due to self-pollination.

Taking into account the eggplant heterostyly, flowers morphology observations were performed and flowers with long, medium and short-styled pistil were marked. In each combination, observations referred to 10 randomly selected plants (experimental units). Every flower at full flowering stage was marked, recording the date of flowering, style length, fruit setting and number of the flowers on a plant.

A pest management and cultural practices during the growing season were carried out according to recommended standards. Fruits were collected at a harvesting maturity stage, from the second decade of June to the first decade of October.

The experiment was established as a completely randomised design. Each combination of the factor at stake was represented by 10 experimental units (replications). The yield data were analysed using the analysis of variance. Significant differences were detected using t-Tukey’s multiply confidence intervals at $\alpha = 0.05$.

RESULTS

In 1998 – 2000, eggplants were characterized by various flowering dynamics. In the first year, plants of ‘Black Beauty’ began flowering in the mid of July in every combination (Fig. 1). First flowers with long and medium pistil of ‘Solara F₁’ and ‘Epic F₁’ appeared at the end of June. The most intensive flowering occurred in July for all studied cultivars. In each combination the highest number of ‘Black Beauty’ flowers had medium style, for ‘Solara F₁’ – long style. In combinations with hormonization and self-pollination, ‘Epic F₁’ developed the highest number of long-styled flowers in July, with short style – in August, and with medium style –

in
September.

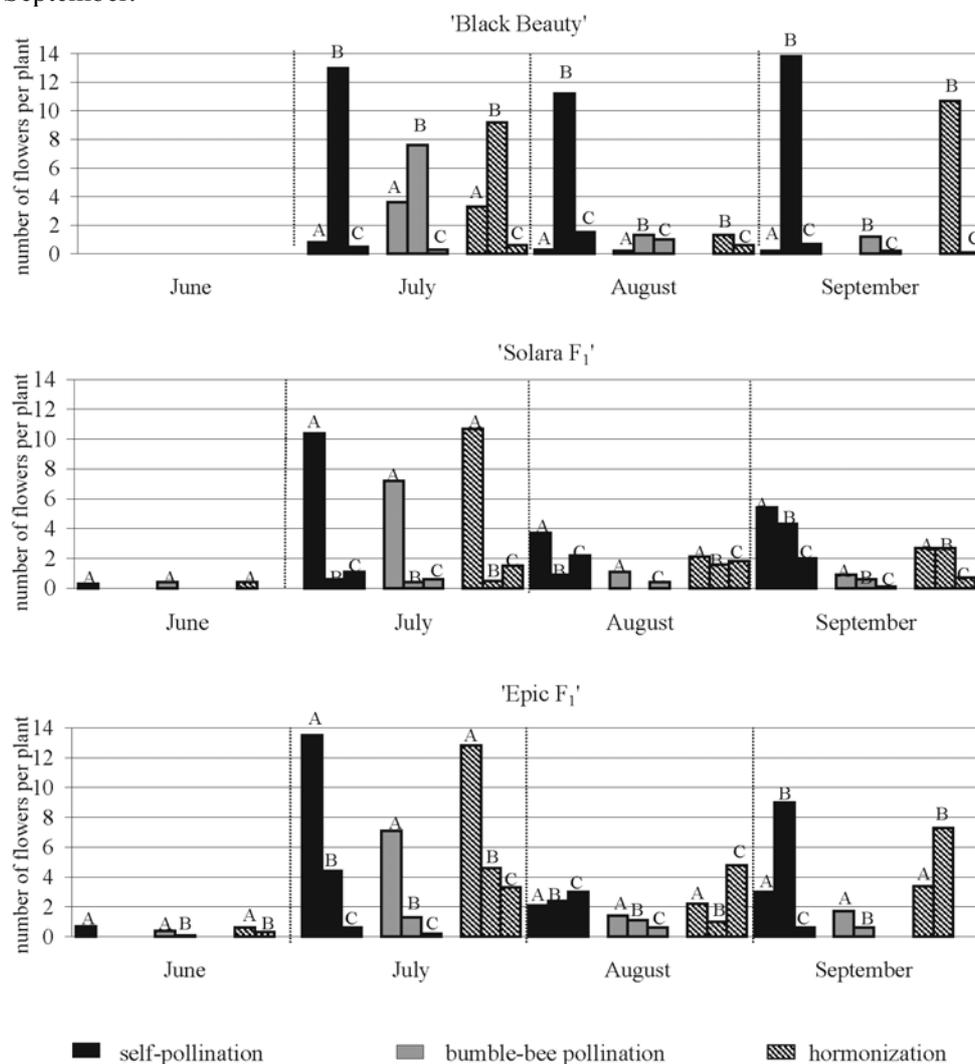


Figure 1. Eggplant flowering dynamics with different pistil type (A – long-styled pistil, B – medium-styled pistil, C – short-styled pistil) depending on pollination and flower hormonization in 1998

In June 1999, for all the combinations applied, only flowers with long style were observed at plants of all cultivars (Fig. 2). In July in the case of 'Solara F₁' and 'Epic F₁' long-styled flowers dominated in all combinations, in the case of 'Black Beauty' – flowers with medium style. Eggplants flowered the most

intensively in August. In combination, where fruits developed due to self-pollination, 'Solara F₁' and 'Epic F₁' reduced the highest number of long-styled flowers, and 'Black Beauty' – medium styled flowers. In September, number of flowers per plant decreased. In the case of 'Solara F₁' and 'Epic F₁' in all studied combinations, flowers with long style dominated.

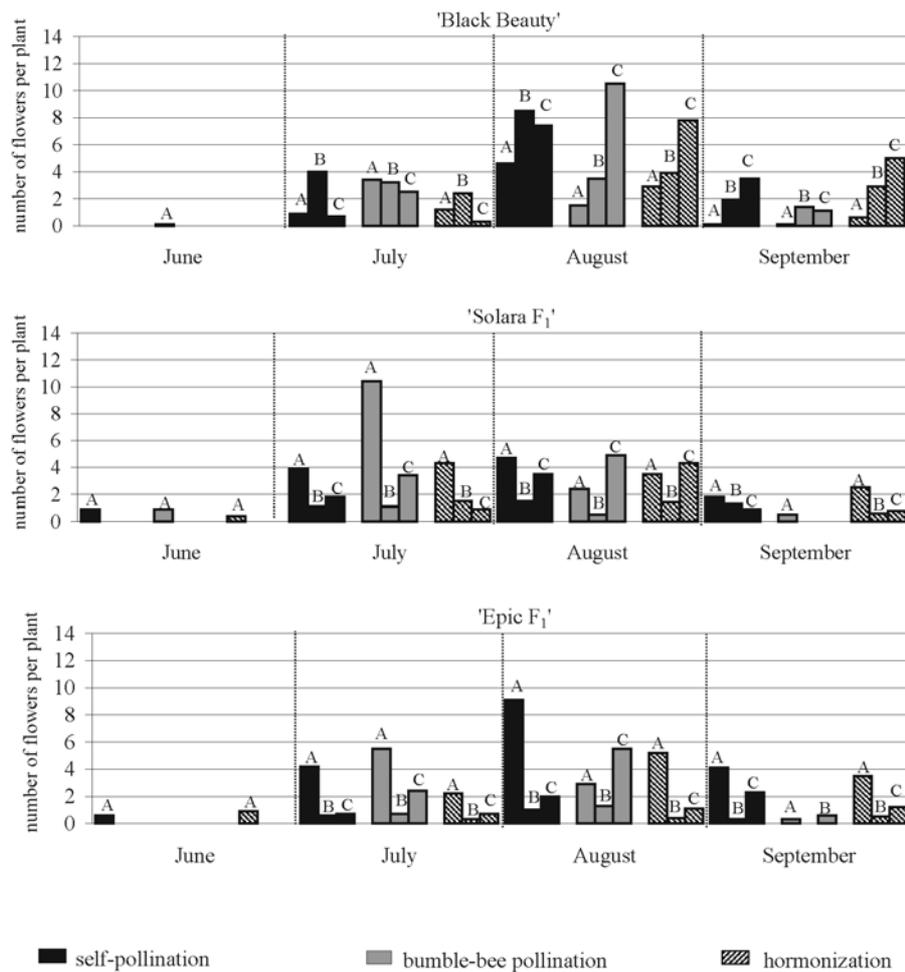


Figure 2. Eggplant flowering dynamics with different pistil type (A – long-styled pistil, B – medium-styled pistil, C – short-styled pistil) depending of pollination and flower hormonization in 1999

In the last year of the study, eggplants began flowering in June at each factor combination (Fig. 3). The first observed flowers of 'Black Beauty' had only long style, of 'Solara F₁' and 'Epic F₁' also medium style. Long-styled flowers were majority at three studied cultivars in each object in July. In every combination of studied factors, period of the most intensive flowering occurred in August. In the

case of every cultivar, number of flowers with long and short style much exceeded the medium-styled flowers. The greatest number of short-styled flowers of 'Black Beauty' and 'Solara F₁' as well as long-styled flowers of 'Epic F₁' was recorded in control objects in September.

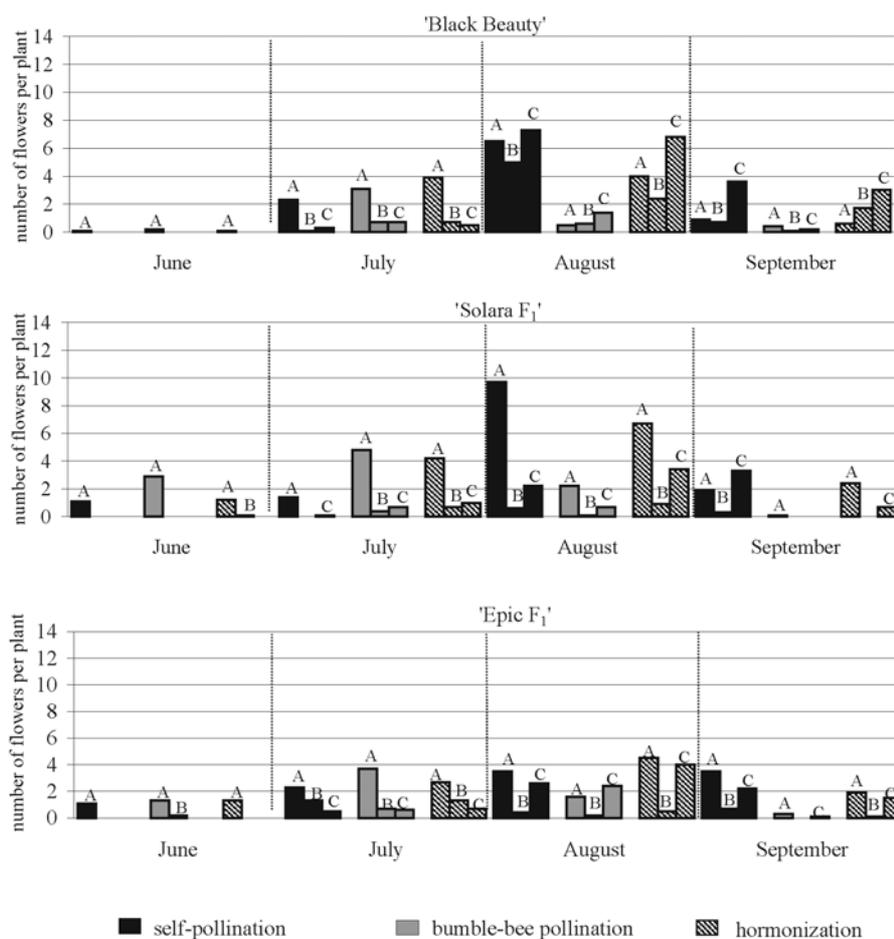


Figure 3. Eggplant flowering dynamics with different pistil type (A – long-styled pistil, B – medium-styled pistil, C – short-styled pistil) depending of pollination and flower hormonization in 2000

Great differences referring to eggplant fruits setting since June till September between particular years were found. In June 1998, fruit setting in the case of 'Solara F₁' and 'Epic F₁' was recorded for every studied combination (Fig. 4).

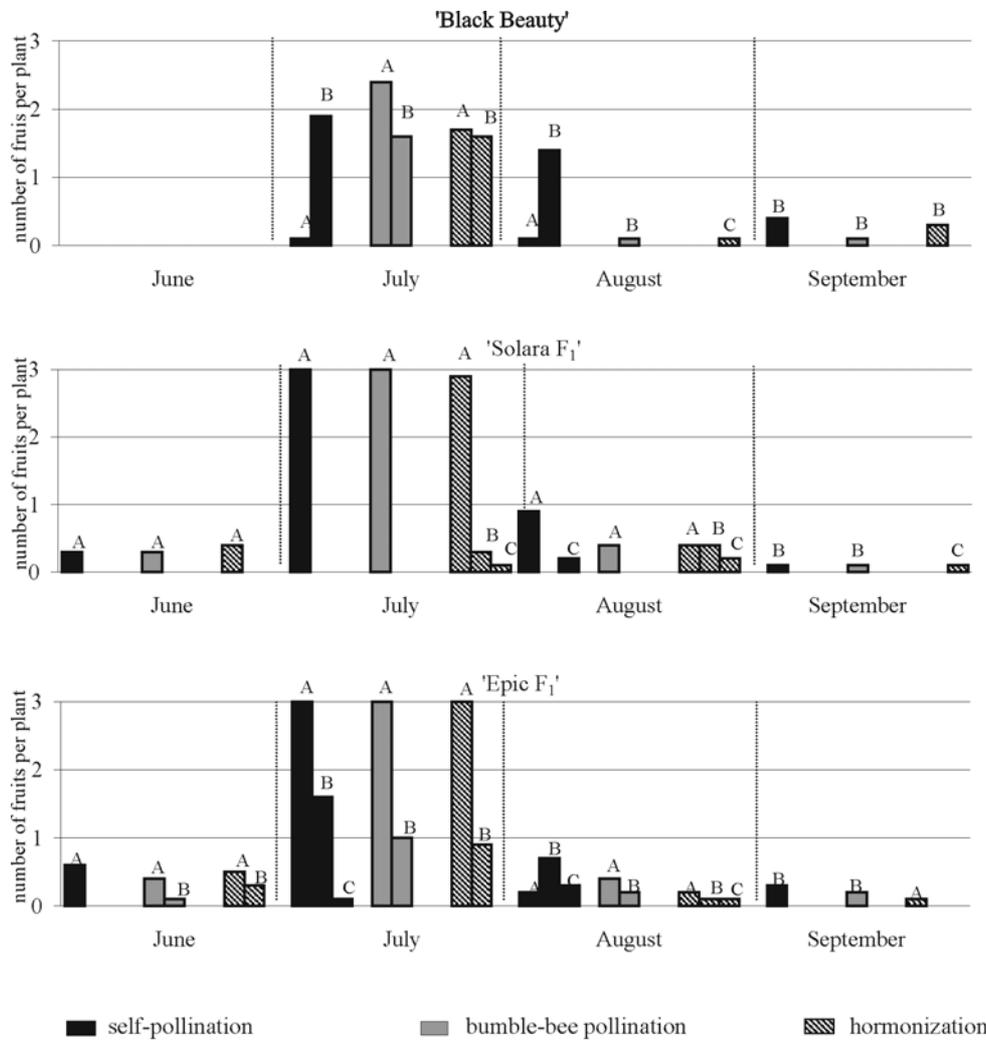


Figure 4. Eggplant fruiting dynamics with different pistil type (A – long–tyled pistil, B – medium–styled pistil, C – short–styled pistil) depending of pollination and flower hormonization in 1998

In the case of 'Solara F₁' fruits developed only from long-styled flowers, in the case of 'Epic F₁', also from medium-styled flowers. The period of maximum eggplant fruits setting occurred in July. Differences in fruits setting depending on the cultivar and pistil type, as well as pollination manner and flower hormonization, were observed in this month. 'Black Beauty' and 'Epic F₁' developed fruits from long and medium-styled flowers at every pollination manners and flowers hormonization. In the case of 'Solara F₁' after self-pollination and pollination by bumble bees, fruits developed only from flowers with long style,

and after hormonization, also from medium and short-styled flowers. A number of set fruits was much lower for all cultivars and combinations in August, fruits were set from all types of flowers. In the first year of the study, fruits setting was observed also in August for all cultivars. In 1999, differences between cultivars referring to fruit setting earliness were recorded. The first sets were observed in June in the case of 'Solara F₁' and 'Epic F₁' (Fig. 5).

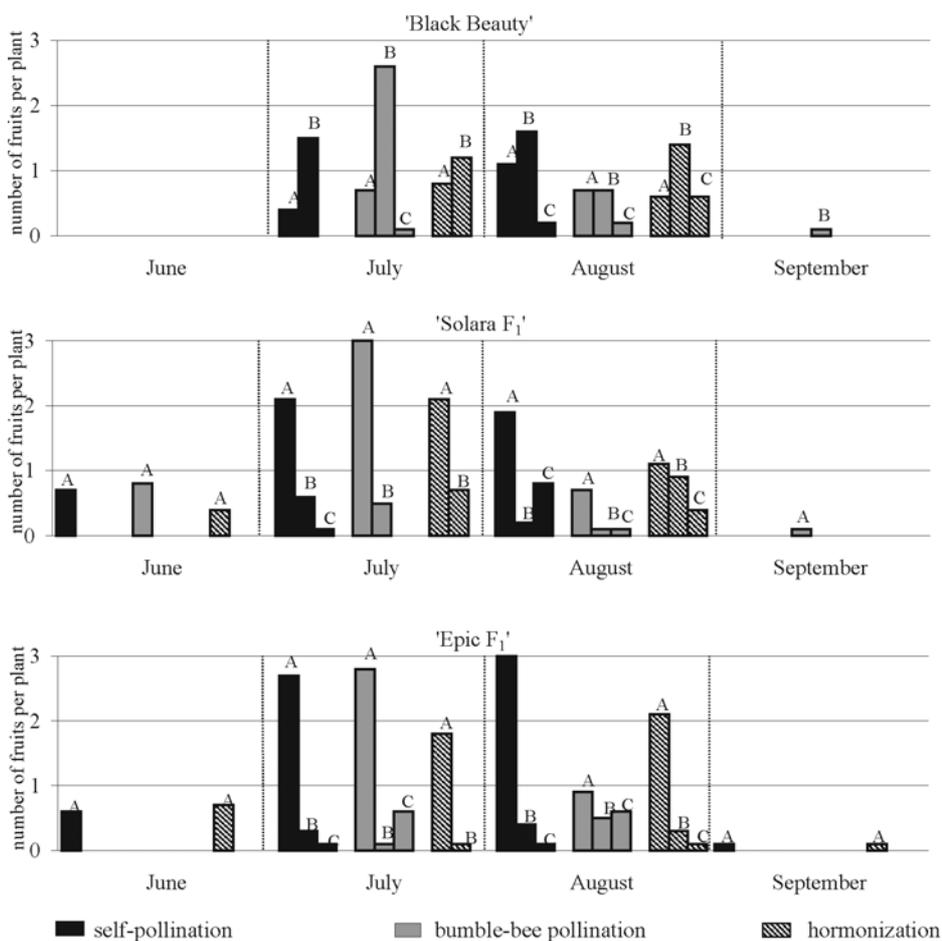


Figure 5. Eggplant fruiting dynamics with different pistil type (A – long-styled pistil, B – medium-styled pistil, C – short-styled pistil) depending of pollination and flower hormonization in 1999

Plants set less fruits from long-styled flowers in bumble bee-pollination and hormonization combinations in comparison to the control object. In July 'Solara F₁' set the greatest number of fruits from high and medium-styled flowers; and 'Black Beauty' and 'Epic F₁' also from short-styled flowers in all object. In August, eggplant set fruits from flowers with every type of pistils. 'Solara F₁' and

'Epic F₁' developed the highest number of fruits from long-styled flowers, in the case of 'Black Beauty' from medium-styled pistils. In September, eggplant fruits were formed only in small number and they were of no significance for its fruiting. In June 2000, eggplant set fruits from long-styled flowers in each combination (Fig. 6).

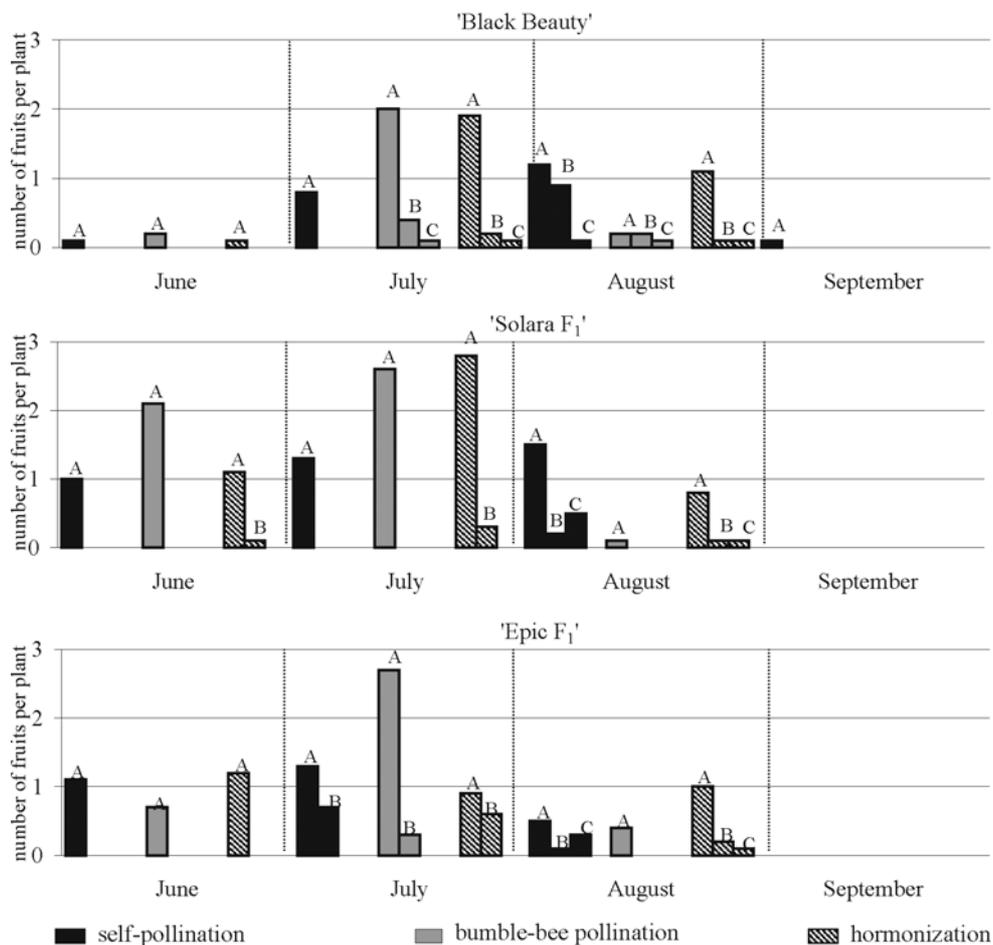


Figure 6. Eggplant fruiting dynamics with different pistil type (A – long-styled pistil, B – medium-styled pistil, C – short-styled pistil) depending of pollination and flower hormonization in 2000

The highest number of fruits was set in the case of 'Solara F₁' and 'Epic F₁'. The peak of fruits setting was observed in July. Long-styled flowers produced the highest number of fruits then 'Black Beauty' and 'Epic F₁' pollinated by insects and hormonized, set fruits from each type of pistils. In September, investigated cultivars did not set fruits, except of 'Black Beauty', whose long-styled flowers were self-pollinated.

DISCUSSION

Different factors affect the dynamics of eggplant flowering with different-length styled pistils: genetic basics of a given cultivar, weather conditions during the cultivation, plant's age and fruiting dynamics.

Results referring the flowering and fruiting dynamics of eggplant in particular months of cultivation and presented in this paper are pioneer in this branch. There is a lack of data associated with observations on flowers production and fruits setting intensity at eggplant in Polish and foreign literature, except of studies of Passam and Bolmatis (1997), who evaluated the influence of different types of pistils on fruiting and seeds setting of two eggplant cultivars. In the present paper, the period of the most intensive fruiting occurred in July 1998 as well as August 1999 and 2000 during abundant flowering of eggplant, as opposite to Passam and Bolmatis (1997) research performed under Greek conditions, where eggplants produced the greatest number of flowers in June and July.

In all pollination ways, there were 42.6-50.9% flowers with long styled pistil in whole number of flowers produced on a plant. Much less flowers with medium pistil were observed (20.1-35.1%) and 22.3-28.9% of those with short styled pistil. Górecki and Espinoza-Flores (1996) investigated the dependence between eggplant flower structure and fruit setting with similar results. Flowers with long-styled pistil were about 63.0% of total number of flowers produced on a plant and those with medium and short styled pistil – 15.0 and 22.0%, respectively. Thus, it can be concluded that application of bumble-bees and flowers hormonization in present study did not affect the pistil anatomical structure. Therefore, present paper results does not confirm research by Handique and Sarma (1995), who proved that hormones can modify heterostyly in eggplant flowers through the impact on the flower's anatomical structure and transition of nutrients in pistil's canals. Remarkable role was attributed to auxins (NAA), that influenced significant reduction of flowers with short-styled pistil, but increased number of formed flowers with long-styled pistil.

Eggplants with flowers with long-styled pistil set the most fruits, then those with medium one and the least – with short styled pistil. The results of the present paper are confirmed by research of Prasad and Prakash (1968), who showed that eggplants set fruits with long styled pistil in 70.0-86.7%, while flowers with short pistil set no fruits. The greatest differences referring to the number of set fruits were observed in flowers with medium-styled pistil (12.5-55.6%). Rylski et al. (1984) achieved similar results recording the highest number of fruits set from flowers with long-styled pistil (90.0%), while only 5.0% from flowers with short-styled pistil. Present results also correspond to research of Passam and Bolmatis (1997) who achieved the highest percentage of fruits set from flowers with long and medium-styled pistil, but flowers with short-styled pistil did not set fruits at all.

CONCLUSIONS

1. Eggplants began their flowering in June in three years of study. Period of the most intensive flowering occurred in July 1998, and in August 1999 and 2000. 'Black Beauty' produced the greatest number of flowers with medium-styled pistil, 'Solara F₁' and 'Epic F₁' – long-styled flowers.
2. The first fruit sets appeared in June from flowers with long-styled pistil. For all pollination methods, the greatest number of fruits developed from long-styled flowers. Plants, whose flowers were pollinated by bumble bee and hormonized, set great number of fruits also from flowers with medium and short-styled pistil.
3. The best fruit setting for every combination was observed in July and August during the abundant eggplant's flowering. In 1998 – 1999, the greatest number of fruits developed from long-styled flowers in the case of 'Solara F₁' and 'Epic F₁' and from medium-styled flowers at 'Black Beauty'. In 2000 at three eggplant cultivars, there was higher number of fruits developed from long-styled flowers than from flowers with medium and short-styled pistil.

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**DYNAMIKA KWITNIENIA I ZAWIĄZYWANIA OWOCÓW OBERŻYNY
(*SOLANUM MELONGENA* L.) W ZALEŻNOŚCI OD RODZAJU SŁUPKA
ORAZ SPOSOBU ZAPYLANIA I HORMONIZACJI KWIATÓW**

Streszczenie: Doświadczenie przeprowadzono w trzech nieogrzewanych tunelach foliowych w latach 1998 – 2000. Celem badań była obserwacja dynamiki kwitnienia oraz ocena wpływu heterostylii, sposobu zapylania (samozapylenie i zapylanie przez trzmiela) oraz hormonizacji na owocowanie trzech odmian oberżyny – ‘Black Beauty’, ‘Solara F₁’ i ‘Epic F₁’.

W trzech latach badań rośliny oberżyny rozpoczęły kwitnienie w czerwcu. Okres najbardziej intensywnego kwitnienia wystąpił w roku 1998 w lipcu, zaś

w latach: 1999 i 2000 w sierpniu. U odmiany 'Black Beauty' dominowały kwiaty o słupku pośrednim, zaś u odmian: 'Solara F₁' i 'Epic F₁' kwiaty o słupku długoszyjkowym.

Pierwsze owoce zawiązały się w czerwcu z kwiatów o słupku długoszyjkowym. W każdej badanej kombinacji stwierdzono najlepsze wiązanie owoców w lipcu i w sierpniu, w okresie najbardziej obfitego kwitnienia roślin oierzyny. Niezależnie od sposobu zapylania najczęściej owoców powstało z kwiatów o słupku długoszyjkowym. Rośliny, których kwiaty zapylane były przez owady a także hormonizowane, wiązały dużą liczbę owoców również z kwiatów o słupku pośrednim i krótkoszyjkowym.

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