

# Agrobiological features of eggplant cultivation in protected ground

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**Abstract.** The interest and spread of eggplant culture are defined worldwide due to the nutritional and dietary properties of the fruits. Nowadays, there is a rising trend towards increasing the areas under eggplant in plastic ground greenhouses. Nevertheless, the issues of the production of high-quality eggplants are essential. The studies were performed from 2018 to 2021 on the territory of the V.I. Edelstein Educational and Scientific Production Center for Horticulture and Vegetable Growing at the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy. Two methods of plant formation (two and three stems), rationing of flowers in the inflorescences of eggplant plants (without rationing, rationing for a flower, rationing for 2 flowers), and eggplant hybrids were studied. As a result of the study, the agrobiological features of growing eggplant plants in plastic ground greenhouses were defined. The highest vendibility of the fruits of the studied hybrids was observed during the formation of plants in three stems, with rationing and preservation of the first flower in the inflorescence – 87.6%, rationing for two flowers – 82.8%, and without rationing of flowers – 77.2%.

## 1 Introduction

An eggplant (*Solanum melongena* L.) is a culture from the Solanaceae plant family. It includes about 2700 plant species of the *Solanum* genus grown for food production [1,2,3]. The eggplant fruits can be rounded, cylindrical, pear-shaped, and of various colors. Eggplant is an economically viable crop for countries in Africa, Asia, India, and Central America [4]. The trend of increasing the area under the eggplant culture [5] is explained by the high content of biologically active compounds [6], eating qualities, and mixed-use fruits [7]. Eggplants originated from *Solanum insanum*. They were independently domesticated on the Indian subcontinent and in China [2,8]. The geographical origin of the primary forms influenced the biological features of the eggplant, for the growth and development of which high amounts of effective air temperatures are required [4]. Eggplant is one of the promising crops for increasing the range of greenhouse vegetables in the Russian Federation. The required temperature for optimal growth and development limits the cultivation of crops in the open field in many regions of our country. The excessive demand

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and high prices of the sold products determine the production of eggplants not only in high-tech industrial greenhouses [9] but also in spring cool plastic greenhouses [10]. Chain stores have highly demanding requirements for the quality of vegetable products grown on the protected ground [11]. Nevertheless, the technology of growing eggplant plants in plastic film ground greenhouses has not been sufficiently studied. The aim of the research was to study the agrobiological features of eggplant cultivation in cool plastic ground greenhouses.

## 2 Materials and methods

The studies were performed from 2018 to 2021 on the territory of the V.I. Edelstein Educational and Scientific Production Center for Horticulture and Vegetable Growing at the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy.

Experiment 1. Identification of optimal ways to form eggplant plants for growth, development, and yield. Two-factor experiment: factor A “formation”, variant I - two stems; variant II - three stems; factor B “genotype of hybrids” – F<sub>1</sub> Borovichok, F<sub>1</sub> Bagira, F<sub>1</sub> Nezhneyshiy, F<sub>1</sub> Patio Trio; F<sub>1</sub> Pelican was used as a control. The experiment was started in 4-fold repetition; the area of the registration plot is 8 m<sup>2</sup>.

Experiment II. To study the effect of rationing the number of flowers in rudimentary inflorescences on the early and overall yield and quality of eggplant fruits. The experiment started with the formation of hybrids in three stems. Two-factor experiment: factor A “rationing”, variant I - without rationing; variant II - rationing for a flower; variant III – rationing for two flowers. Factor B “genotype of hybrids” – F<sub>1</sub> Borovichok, F<sub>1</sub> Bagira, F<sub>1</sub> Nezhneyshiy, F<sub>1</sub> Patio Trio, and F<sub>1</sub> Pelican. The experiment was started in 4-fold repetition; the area of the registration plot is 8 m<sup>2</sup>.

All experiments were performed in the conditions of summer-autumn turnover in a plastic ground greenhouse under the generally accepted procedures for vegetable crops in the protected ground. Crop recording was done in progress, weighing the fruits from the plot at each harvest, followed by conversion into kilograms from m<sup>2</sup> [12].

Statistical data processing (calculation of the standard error of the arithmetic mean (Sx) was done in Microsoft Excel 7.0 and STATISTICA 6.0. The significance of differences was assessed by the Student's t-test and considered statistically significant at  $p \leq 0.05$ ).

Agrotechnics in experiment:

Transplant seedlings were grown in the seedling place of a multi-row greenhouse of the Richel 9,6 SR series. Sowing of seeds was performed on March 14-16 in seedling trays with a cell size of 5 x 5 x 5 cm and a volume of 125 cm<sup>3</sup>; peat was used as a substrate. Mass sprouts appeared on the 10th – 12th day after sowing. Deplantation was performed on the 20th day from mass sprouts in pots with a volume of 0.8 liters. At the time of linking the leaves, a single spacing of transplant seedlings up to 20 plants/m<sup>2</sup> was conducted. The daily mean temperature was set depending on the stage of plant development.

Before transplant seedlings, the soil in the greenhouse underwent mulching with a black molded fabric. Seedlings were planted in cool plastic ground greenhouses on May 21-22; the transplant seedlings' growing period was 55 days. The plant population is 2.5 plants/m<sup>2</sup>. After planting transplant seedlings in the greenhouse, a twine was hung on each plant. Once a week, twisting of the stem to the twine was done. A system of forming plants in two and three stems was used.

Plant nutrition was performed with a complex fertilizer Yara Kristalon 18.18.18 +3 with an interval of 5 days. The first plant nutrition was done 5 days after the planting of transplant seedlings.

Treatment with pesticides was performed when single foci of infection were found: against fungal diseases – Ridomil MC Gold, VDG (Active ingredient: mancozeb +

mefenoxam) and Quadris, CS (Active ingredient: azoxystrobin). During the growing season, irrigation by sprinklers was carried out. When the temperature in the greenhouse rose above 30 ° C, aeration irrigation was applied.

3 Results and discussion

About 51.28 million tons of eggplants are produced worldwide on open and protected ground [13,5]. At the beginning of the XX century, Kakizaki [14] suggested growing heterotic F1 hybrids in industry, proving their high crop yield and vendibility compared to varieties [15]. Therefore, to achieve the research objective and to increase plant productivity, not only by introducing high-yielding hybrids into production but also by mitigating abiotic factors [16], agronomic techniques for growing vegetable crops [17] in plastic ground greenhouses, methods of formation and options for rationing flowers in eggplant inflorescences have been studied.

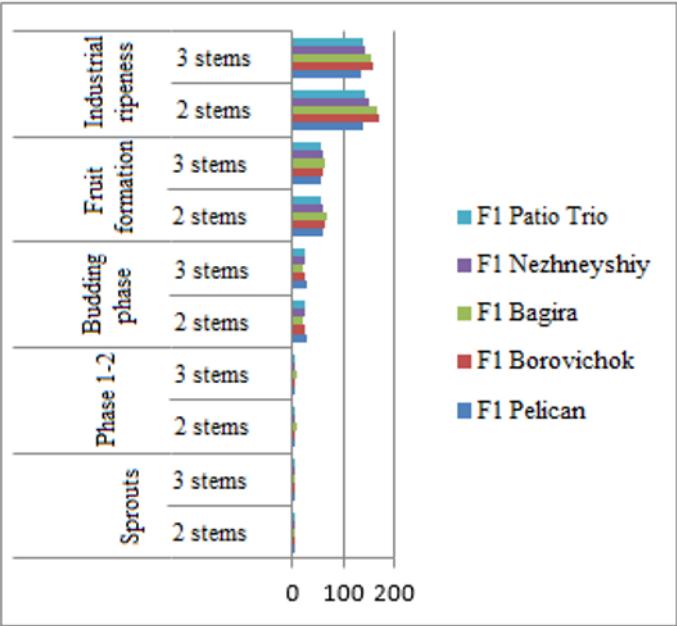
**Table 1.** Duration of the phenological phases of development of eggplant hybrids during the formation of two and three stems (average for 2018-2021).

Name of F <sub>1</sub> hybrids (B)	Duration of phenological phases of development, day					
	sprouts-early bloom		early bloom - industrial ripeness		mass sprouts - industrial ripeness	
	formation techniques (A)					
	2 stems	3 stems	2 stems	3 stems	2 stems	3 stems
F <sub>1</sub> Pelican	68±2	66±2	58±4	60±3	124±3	120±3
F <sub>1</sub> Borovichok	62±2	64±2	52±4	56±3	112±3	108±2
F <sub>1</sub> Bagira	58±4	58±4	45±3	50±3	103±2	110±2
F <sub>1</sub> Nezhneyshiy	62±2	62±4	48±3	54±4	112±3	118±3
F <sub>1</sub> Patio Trio	70±1	68±2	48±2	52±4	120±3	124±3

Table 1 presents the development duration of the phenological phases of the studied eggplant hybrids during the formation of two and three stems. Structural variations in the duration of the period “mass sprouts – industrial ripeness” were found. During the formation of hybrids in two stems, 60% of hybrids belonged to the group of middle-early and 40% to the group of the medium. The formation of eggplant plants in three stems resulted in an insignificant increase in the duration of the “mass sprouts – industrial ripeness” phase. Consequently, there was a redistribution within the ripeness groups; in the group of medium hybrids - 40% and in the group of late-ripening - 60%.

In the conditions of plastic ground greenhouses, there is less labor (h / ha) when growing eggplant hybrids. Their height remains the height of the espalier since it is easier to conduct a set of measures to care for plants and harvest eggplant fruits. Figure 1 shows the assessment results.

There was no statistically significant effect of the factor “formation techniques” on the growth processes. Analysis of the growth processes of eggplant hybrids during the formation of two and three stems showed the following: after planting seedlings, the growth rate enhanced in both variants of the formation of eggplant hybrids and continued during the growing season, reaching by the time of mass fructification 146 ± 20cm and 154 ± 25cm in the first and second variants of formation.



**Fig.1.** The formation effect of eggplant hybrids in two and three stems on the dynamics of plant growth in the conditions of summer-autumn turnover in plastic ground greenhouses, sm (average for 2018-2021)

Table 2 presents the effect of the formation of eggplant hybrids in two and three stems on early and total yields under summer-autumn turnover conditions in a plastic greenhouse. The effect of factor A “formation techniques” and factor B “hybrid genotype” on early and total yield has been statistically verified. A comparison of the variants of the formation techniques of eggplant hybrids demonstrated a more positive effect of the formation of three stems on early yield. After analyzing the effect of the “hybrids” factor, it was discovered that the studied hybrids did not outperform the control hybrid F<sub>1</sub> Pelican in terms of yield. A hybrid Bagira F<sub>1</sub> (9.6 kg/m<sup>2</sup>) should be distinguished by comparing the total yield of the studied hybrids. As to other hybrids, when forming two stems, it had a yield slightly lower than the control hybrid Pelican F<sub>1</sub> (10.0 kg/m<sup>2</sup>) per 0.4 kg/m<sup>2</sup>.

**Table 2.** The formation effect of eggplant hybrids in two and three stems on early and total yield under summer-autumn turnover conditions in plastic ground greenhouses (average for 2018-2021).

Formation techniques (A)	Hybrids (B)				
	Pelican	Borovichok	Bagira	Nezhneyshiy	Patio Trio
	Early yield, kg/m <sup>2</sup>				
2 stems	4,5	3,2	3,6	4,0	2,6
3 stems	5,6	5,3	5,4	4,7	3,4
Sx=3.4%, HCP <sub>05</sub> A =4,76; HCP <sub>05</sub> B=0,16					
	Total yield, kg/m <sup>2</sup>				
	Pelican	Borovichok	Bagira	Nezhneyshiy	Patio Trio
	10,0	8,4	9,6	8,1	7,2
2 stems	12,7	10,0	9,4	8,4	8,4
3 stems	Sx=2.2%, HCP <sub>05</sub> A =1,29; HCP <sub>05</sub> B=0,02				

In the formation of eggplant plants in 3 stems, all the studied hybrids had significant differences in yield with the control hybrid Pelican F<sub>1</sub> (12.7 kg/m<sup>2</sup>). The formation of hybrids in three stems promoted an increase in the crop load on the plants. This resulted in

the use of more assimilates for generative development processes and, consequently, reduced growth processes of all studied hybrids.

To define the share of commercial eggplant fruits and the number of products in the summer-autumn turnover, studies were performed to evaluate the effect of rationing the number of flowers in rudimentary inflorescences on the early and total yield and quality of eggplant fruits during the formation of hybrids in three stems. In our studies, the effect of rationing flowers in rudimentary inflorescences of eggplant hybrids had a variety-specific nature. It did not have a significant impact on the early yield of the studied hybrids but significantly affected the vendibility of the fruits. The largest percentage of commercial fruits was obtained during the formation of hybrids in three stems in the variant “rationing for a flower” (tab.3). Therefore, the increase in commercial fruits in the variant “rationing for a flower” is because we keep the normally developed first flower in the inflorescence (the remaining two or three flowers are weaker and form non-standard fruits). Table 3 shows the results.

**Table 3.** The effect of rationing the number of flowers in rudimentary eggplant inflorescences during the formation of three stems on early and overall yield and fruit quality under summer-autumn turnover conditions in plastic ground greenhouses (average for 2018-2021).

Rationing of flowers (A)	Hybrids (B)				
	Pelican	Borovichok	Bagira	Nezhneyshiy	Patio Trio
	Early yield, kg/m <sup>2</sup>				
Without rationing	5,5	5,1	5,2	4,4	3,4
Rationing for a flower	5,6	5,3	5,4	4,7	3,4
Rationing for two flowers	5,8	5,0	5,2	4,6	3,6
Sx=2,6%, HCP <sub>05</sub> B=0,23					
	Total yield, kg/m <sup>2</sup>				
Without rationing	11,1	10,4	10,2	9,2	8,5
Rationing for a flower	12,7	10,0	10,8	9,4	8,4
Rationing for two flowers	12,8	9,8	10,4	9,6	8,6
Sx=3,1%, HCP <sub>05</sub> A =0,24; HCP <sub>05</sub> B=0,18					
	Vendibility of fruits, %				
Without rationing	80	78	76	80	72
Rationing for a flower	90	90	90	88	80
Rationing for two flowers	79	90	81	82	82
Sx=14%, HCP <sub>05</sub> A =10,9					

According to the results of the two-factor experiment, evaluating the influence of the “rationing” factor and the “hybrid genotype” factor, it should be noted that the early yield was statistically significantly affected by the “hybrid genotype” factor (HCP<sub>05</sub>=0,24kg/m<sup>2</sup>) (tab.3). Only the overall yield was statistically significantly affected by both factors (rationing and hybrid genotype). The “rationing” factor made a statistically significant contribution (HCP<sub>05</sub>=10,9%) to the vendibility of fruits. In the variants of the experiment with rationing for a single flower, the largest number of commercial fruits was found (87.6%), which is 4.8% more in comparison with the option of rationing for two flowers (82.8%) and 10.4% more than the option without rationing flowers (77.2%).

## 4 Conclusion

Studies have revealed the prospects of using formation and rationing techniques for flowers in rudimentary inflorescences of eggplant plants. The highest vendibility of the fruits of the studied hybrids (87.6%) was achieved during the formation of plants in three stems with rationing and preservation of the first flower in the inflorescence.

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