

## The influence of container and frigo planting material on the vegetative growth and fertility of the variety Clery

**Comment [BS1]:** It would be better, for an international audience, to include the common name of the crop and not just the variety.

### Abstract

The quality of planting material plays a decisive role in the profitability of strawberry production. Of all categories of seedlings in commercial strawberry plantations in Bosnia and Herzegovina, frigo seedlings predominate. The goal of the research is to obtain relevant data on the reaction to external environmental conditions, vegetative growth, and reproductive potential of both types of seedlings by comparing frigo and container planting material. By researching the vegetative and generative growth of strawberries of the Clery variety with two different types of seedlings, it was concluded that green container seedlings are vegetatively more developed compared to frigo seedlings. The container seedlings produced a higher number of buds by 14.2% and leaf mass by 17.5% and entered the resting phase more readily. The percentage of unrooted container seedlings after planting is only 1.1% compared to frigo seedlings, where this percentage is 11.3%, due to the fact that container seedlings have less stress after transplanting, which is the result of the substrate around the roots of the seedling. On the other hand, green container seedlings form a higher percentage of stolons, which additionally burdens the work engagement when removing them in intensive strawberry production. Finally, the container seedlings had a higher and better yield, which amounted to an average of 10.34 grams per fruit, while the average fruit weight of the frigo seedlings was 9.84 grams. In the end, this difference in weight gave 80.29 grams more yield per plant in favor of container seedlings.

**Comment [BS2]:** This seems to imply that whatever factor is being considered reacts to vegetative growth and reproductive potential. This is odd because normally vegetative growth and reproductive potential are dependent variables and not, as implied, independent variables. The author should be consistent in using past tense.

**Key words:** type of seedlings, frigo seedlings, green container seedlings, intensive cultivation

**Comment [BS3]:** It would be better if the levels of significance were included with the stated figures.

### Introduction

Strawberry (lat. *Fragaria vesca*) is a culture that has a long tradition of cultivation in the territory of Bosnia and Herzegovina. Considering the climate, land quality, location of agricultural land and human potential, Bosnia and Herzegovina has all the necessary conditions for the production of berry fruits, of which the strawberry (*Fragaria vesca*) has the longest growing tradition. The production of this fruit species and its significance for the producers is that fruit comes very quickly after planting, quickly returning the invested money. The basis of successful strawberry production is its planting material. The production of varietal pure, healthy, high-quality and market-valued seedlings is carried out in strawberry nurseries under the supervision of the competent government institution. The most important types of planting material are: fresh green seedlings, cooled seedlings obtained from sprouts (Frigo seedlings), waiting seedlings (Waiting bed) and container seedlings. Considering that fresh green seedlings from plantations are traditionally used in Bosnia and Herzegovina, as such they cannot achieve maximum yields compared to other countries, and average strawberry yields in our conditions are 3-4 t/ha. In order to overcome such obstacles on the way to maximizing the yield and quality of this culture,

**Comment [BS4]:** It is necessary to give more detail in describing the type of seedlings being used. The author seems to assume that the reader has significant pre-knowledge about how the different types of seedlings are prepared.

**Comment [BS5]:** To whom does this refer to?

**Comment [BS6]:** It is not clear which culture is being referred to.

it is necessary to first establish mother plants, that is, the production of seedlings in special or standard plants for such purposes. Whether it is the production of new sprouts from virus-free seedlings or the processing of virus-free seedlings into container ones, better possibilities of yield quality and reduction of infectious potential are offered compared to the traditional approach of forming new strawberry plants for cultivation. For a long time, frigo seedlings have been the most represented in the establishment of new intensive plantings, precisely because of their great reproductive potential and health condition. On the other hand, container seedlings are recording an expansion of growth in the establishment of new plantings, and according to data from Lieten (2000), they have a history of about 30 years with the beginnings of production in the Netherlands and Belgium.

### Materials and methods

The experiment was set up in Topličko polje under the lease of Plant d.o.o. Tuzla (picture 1). The number of seedlings placed in the experiment was 97 for frigo and 97 for green container seedlings. Seedlings are planted at a distance of 25x25 cm. Seven days after planting, treatment with Ridomil was carried out in the amount of 10 ml/10 l of water by pouring into the soil. The drip irrigation system ensured a daily and even supply of water to the seedlings. During the experiment, two types of seedlings were examined, namely the "frigo" seedling and the green container seedling (green/mini tray plant). The variety Clery (Figure 1) was represented on both types of seedlings. The results of the work were obtained by measuring the seedlings using physical methods and presented in a table.



Picture 1. - Location of experiment Picture 2. - Frigo seedlings (variety Clery)

### Results and discussion

After planting and recording the initial state, the monitoring of the further development of the seedlings and their response to the new environment was started for two years after planting. In the first year, the vegetative and generative development of the plants was monitored in the second. In the first year, the vegetative growth, the height of the above-ground system, the number and area of leaves, the comparison of the intensity of formation of new leaves, the intensity of formation and number of stolons, the intensity of flowering, the number of flowers,

the number of fruits and budding were recorded. The listed items are compared between two types of planting material in order to see the difference between them and define effectiveness and profitability. As can be seen immediately after planting, green container seedlings are more ready for the beginning of vegetation.

Table 1. - The results of measuring leaf mass seven days after planting

| PARAMETRES                                 | FRIGO SEEDLINGS | GREEN CONTAINER SEEDLINGS |
|--|-----------------|---------------------------|
| Number of seedlings with 3-4 leaves        | 0               | 59                        |
| Number of seedlings with 2-3 leaves        | 56              | 38                        |
| Number of seedlings with 3-4 leaves        | 36              | 0                         |
| Number of seedlings that were not received | 5               | 0                         |

According to the measurement results, 7 days after planting, 5 frigo seedlings already showed signs of non-rooting, unlike the green container seedlings, which all continued to develop. The minimum number of leaves in green container seedlings is 2 leaves, and more than 57% of seedlings have 3-4 formed true leaves. Unlike them, 55% of frigo seedlings have a maximum of 2-3 true leaves, and the rest of the plants have only one formed true leaf. Differences in vegetative growth can already be seen, and they are in favor of green container seedlings.

Fifteen days from the moment of planting (August 1, 2019), the results in the growth and development of the seedlings were measured. Plant growth (height), average number of leaves, average leaf area, number of flowers and number of stolons were monitored. The results of measuring the vegetative and generative mass are shown in table 2 for both types of seedlings.

Table 2. -Measurement results of vegetative and generative organs 15 days after planting

| PARAMETRES   | FRIGO SEEDLINGS         | GREEN CONTAINER SEEDLINGS |
|--|-------------------------|---------------------------|
| The average height of the seedling at the level of the root neck | 6,33 cm                 | 15,7 cm                   |
| Average number of leaves   | 2,4                     | 4,48                      |
| Average leaf area  | 5 x 3,5 cm <sup>2</sup> | 9,8 x 7,2 cm <sup>2</sup> |
| Number of seedlings in the flowering phase                       | 33                      | 0                         |
| Number of plants in the budding phase                            | 0                       | 0                         |
| Number of seedlings that did not form sprouts                    | 5                       | 0                         |
| Number of seedlings with formed stolons                          | 0                       | 7                         |

In Table 2, it can be noted that the stage of flower formation started with the frigo seedlings, while this was not the case with the container seedlings. Unlike frigo, the container seedlings started to develop stolons, which is a clear sign that the development of container seedlings is aimed at vegetative mass.

One month after planting, the same parameters as in the previous tables were monitored, with an emphasis on flower and fruit formation in frigo seedlings, stolons and young sprouts in green container seedlings.

Table 3. - Measurement results of vegetative and generative organs 30 days after planting

| PARAMETRES   | FRIGO SEEDLINGS         | GREEN CONTAINER SEEDLINGS |
|--|-------------------------|---------------------------|
| The average height of the seedling at the level of the root neck | 9 cm                    | 17,9 cm                   |
| Average number of leaves   | 3,3                     | 6,80                      |
| Average leaf area  | 6,8 x 5 cm <sup>2</sup> | 13 x 11,4 cm <sup>2</sup> |
| Number of plants that formed fruit                               | 45                      | 0                         |
| Average number of germinal fruits per plant                      | 6                       | 0                         |
| Number of plants without fruit                                   | 43                      | 96                        |
| Number of not received, desiccated and ill plants                | 11                      | 1                         |
| Number of plants with formed stolons                             | 0                       | 92                        |
| Average number of stolons per plant                              | 0                       | 2,13                      |
| Number of plants in phase of sprouting                           | 0                       | 16                        |

Plants obtained from frigo seedlings did not enter the sprout and stolon formation phase, unlike green container seedlings. Plants obtained from container seedlings have not entered the stage of forming generative organs. The results from the field displayed in the table show that 46% of the plants obtained from the frigo seedlings started fruiting, while the green container seedlings did not enter this phase or start flowering. On the other hand, 94.8% of the plants obtained from container seedlings started with the forming of stolons, while the frigo seedlings did not reach the period of their forming.

After 45 days from planting, strawberry fruits obtained from frigo seedlings are ready for harvesting, and the flowering phase is over. The measurement results are displayed in the table below.

Table 4. - Measurement results of vegetative and generative organs 45 days after planting

| PARAMETRES   | FRIGO SEEDLINGS           | GREEN CONTAINER SEEDLINGS |
|--|---------------------------|---------------------------|
| The average height of the seedling at the level of the root neck | 16,7 cm                   | 20,3 cm                   |
| Average number of leaves   | 9,4                       | 9,5                       |
| Average leaf area  | 12,21 x 9 cm <sup>2</sup> | 17 x 13,2 cm <sup>2</sup> |
| Number of plants with formed stolons                             | 44                        | 96                        |
| Average number of stolons per plant samples                      | 2,1                       | 3,9                       |
| Average size of fruit (based of 10 plant samples)                | 1,8 cm                    | 0                         |
| Number of not received, desiccated and ill plants                | 11                        | 1                         |

Table 4 shows that frigo seedlings started with the forming of stolons, but not with lateral rooting. Green container seedlings form a large number of stolons with an even greater number of sprouts ready for transplanting, as well as a larger area of leaf mass compared to frigo seedlings.

After the expiration of the scheduled period of the entire measurement lasting 2 months, the last measurement of the vegetative and generative organs of frigo and green container seedlings was performed. As shown in table, the measurement referred to the examination of plant height parameters, the number of branches, the number and area of leaves, the number of stolons and the number of sprouts in order to obtain the final results of the comparison of growth and development.

Table 5. - Measurement results of vegetative and generative organs 60 days after planting

| PARAMETRES   | FRIGO SEEDLINGS            | GREEN CONTAINER SEEDLINGS   |
|--|----------------------------|-----------------------------|
| The average height of the seedling at the level of the root neck | 17,9 cm                    | 22 cm                       |
| Average number of leaves   | 12                         | 17                          |
| Average leaf area  | 16 x 12,25 cm <sup>2</sup> | 22,4 x 15,2 cm <sup>2</sup> |
| Number of plants with formed stolons                             | 85                         | 96                          |
| Average number of stolons per plant                              | 4,3                        | 8                           |
| Average number of lateral root per plant                         | 5,4                        | 17                          |
| Average number of sprouts per plant                              | 1,65                       | 2,2                         |
| Number of not received, desiccated and ill plants                | 11                         | 1                           |

By observing the last analysis shown in table 5, compared to the initial state, the overall vegetative habitus of the plant is better in green container seedlings. The average plant height of a green container seedling is 10.2% higher than a plant obtained from a frigo seedling. The average number of leaves in green container seedlings is 17.5% higher compared to frigo seedlings. The leaf area of green container seedlings is 27% larger than the leaf area of frigo seedlings. The number of seedlings that formed stolons is 6.2% higher in green container seedlings. The number of stolons per plant is 30% higher in green container seedlings. Green container seedlings entered the budding phase earlier, which means that the average number of buds per plant is 14.2% higher when we compare the same parameter with frigo seedlings. We observe that 11.3% of frigo seedlings did not take root after planting. The percentage of unrooted plants in container seedlings is only 1.1%, while in refrigerated seedlings that percentage is 11.3%.

In the second year of the study, the difference between the average weight of the fruit as well as the development of bokor and stolon of strawberries was monitored. The results of the work were obtained by measuring the weight of the fruits (g) as well as by measuring the length and thickness of the sprouts and stolon.

**Comment [BS7]:** This is raw data and should not be included in the body of the paper. There is basically no discussion of the findings. The findings are only described without the author trying to give any scientific explanation to why the findings are as they are.

Table 6. - Weight and number of fruits

| Harvest | FRIGO SEEDLINGS     |                  | GREEN CONTAINER SEEDLINGS |                  |
|---------|---------------------|------------------|---------------------------|------------------|
|         | Weight of fruit (g) | Number of fruits | Weight of fruit (g)       | Number of fruits |
| 1       | 700                 | 90               | 850                       | 78               |
| 2       | 750                 | 80               | 950                       | 85               |
| 3       | 820                 | 90               | 1320                      | 128              |
| 4       | 1200                | 110              | 1380                      | 130              |
| 5       | 1250                | 112              | 1390                      | 136              |
| 6       | 1380                | 121              | 1420                      | 140              |
| 7       | 1540                | 143              | 1620                      | 155              |
| 8       | 1550                | 148              | 1650                      | 160              |
| 9       | 1660                | 152              | 1680                      | 165              |
| 10      | 1610                | 165              | 1700                      | 168              |
| 11      | 1580                | 161              | 1750                      | 160              |
| 12      | 1640                | 165              | 1780                      | 165              |
| 13      | 1650                | 158              | 1800                      | 175              |
| 14      | 1590                | 165              | 1820                      | 185              |
| 15      | 1680                | 170              | 1850                      | 180              |
| 16      | 1700                | 178              | 1740                      | 169              |
| 17      | 1630                | 172              | 1710                      | 165              |
| 18      | 1530                | 165              | 1760                      | 170              |
| 19      | 1540                | 159              | 1700                      | 172              |
| 20      | 1400                | 155              | 1630                      | 168              |
| 21      | 1420                | 154              | 1690                      | 164              |
| 22      | 1500                | 166              | 1660                      | 167              |
| 23      | 1260                | 138              | 1560                      | 159              |
| 24      | 1210                | 120              | 1490                      | 142              |
| 25      | 1220                | 122              | 1370                      | 135              |
| 26      | 1100                | 115              | 1380                      | 128              |
| 27      | 1050                | 99               | 1350                      | 130              |
| 28      | 800                 | 85               | 1280                      | 122              |
| 29      | 800                 | 82               | 1100                      | 90               |
|         | <b>38760</b>        | <b>3940</b>      | <b>44380</b>              | <b>4291</b>      |

From the research results, the average fruit weight of the Frigo seedling was 9.84 g and the average fruit weight of the green container seedling was 10.34 g.

Table 7. -Weight of fruit (g)

| Type of seedlings         | Total weight (yield) of the fruit (g) | Mass per plant (g) |
|---------------------------|---------------------------------------|--------------------|
| Frigo seedlings           | 38760                                 | 553,71             |
| Green container seedlings | 44380                                 | 634                |

Table 8. - Sprouts and stolon development in container seedlings

|                           |      |
|---------------------------|------|
| Average number of sprouts | 3.76 |
| Average number of stolons | 8.1  |

**Comment [BS8]:** The columns in these tables are named.

Tabela 9. - Development of sprouts and stolon, in second year after planting, frigo seedlings.

|                           |      |
|---------------------------|------|
| Average number of sprouts | 3.63 |
|---------------------------|------|

|                           |      |
|---------------------------|------|
| Average number of stolons | 6.06 |
|---------------------------|------|

From Tables 8 and 9, it is evident that green container seedlings produce a greater number of sprouts and stolons.

### Conclusion:

1. Frigo seedlings begin the flowering and fruiting phase earlier already in the year of planting, although they have not developed enough vegetative mass, due to the fact that their flowers are not removed during the production of seedlings
2. Green container seedlings do not enter the phase of flowering and fruiting in the year of planting, but direct their energy to the phase of vegetative growth, reason is that in the process of producing the seedlings, the flowers are removed so that the producers have less work later in process,
3. There is a higher percentage of forming stolon by 30%, leaf mass by 17.5% and sprouts by 14.2% in plants obtained from green container seedlings,
4. The percentage of rooting for green container seedlings in the soil after planting is 91.6% higher compared to frigo seedlings, which we can see from the data in table 5, and this indicates to producers a higher percentage of receptivity and survival of plants per unit of production area when planting green container seedlings ,
5. Green container seedlings have an approximately optimal number of sprouts (3-4) per plant in the year of planting, which proved to be positive also in the second year after planting, because they produce more developed sprouts and stolons, as shown in table 9. More developed sprouts and stolons indicate better fruit bearing in the coming period as well,
6. Based on the results of the analysis of vegetative growth from tables 1, 2, 3, 4 and 5, preference is given to green container seedlings,
7. On the basis of daily picking and weighing of fruits in the second year after planting, it was established that the container planting material has a higher average fruit weight. Total number of fruit was 4291 which weighted 44,380 g, which is a mass of 634 g for container seedlings.

**Comment [BS9]:** It would be expected that explanations for the findings would be in the discussion section of the manuscript and not in the conclusion.

## References

**Comment [BS10]:** All the reference in the list are not explicitly cited in the document.

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