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ORAL PRESENTATION

Productivity of Strawberry Depending on Planting Time and Varieties in the Conditions of the Republic of Moldova

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Abstract: The purpose of this study was to establish the optimal timing of planting strawberries using "frigo" seedlings, as well as to assess the productivity of CIV Italy varieties under the conditions of the Republic of Moldova. The strawberry varieties Marmolada, Aprica, Sibilla, Arosa, and Laetitia and three planting dates were taken as the object of research - mid-June, mid-July, and mid-August. The plantation was established in the summer of 2021, research was carried out during 2022-2023. Research has shown that early planting periods contributed to good tillering and the formation of 3.5 to 4.4 fruiting shoots per bush, as well as a well-developed leaf surface, not significantly different from the second year of the growing season while planting in mid-August led to a reduction in the number of leaves by 2.3 – 2.9 times. The most productive among the studied varieties was the Laetitia variety, which in total for 2 years of fruiting amounted to 55.69 t/ha. The varieties Aprica and Sibilla have the fastest ripening of berries. The most optimal time for planting "frigo" seedlings for the conditions of Moldova is the first ten days of July, which contributes to obtaining the first harvest more than 2 times higher compared to the recommended planting in mid-August.

Keywords: Strawberries, Planting Dates, Variety, Productivity.

1. INTRODUCTION

Strawberries are the leading berry crop both in the world and in the Republic of Moldova. Over the last decade, due to the increased demand for berries, the area under strawberries in our country has almost doubled, reaching 2000 ha in 2023, and the annual production exceeded 12 thousand tons. The efficiency of strawberry production, as well as the variety and technology of its cultivation, are determined by several factors: soil-climatic, technological, organizational, market, and macroeconomic of a particular country or region where it grows. Currently, in the Republic of Moldova, there is no scientifically based data on the optimal timing of planting using "frigo" type seedlings, and such elements of technology as the application of fertilizers with irrigation water and the use of growth regulators have not been developed. The problem of regionalized strawberry assortment is also relevant, which in Moldova includes 3 obsolete varieties that are practically not propagated anywhere in the world. The purpose of this research is to develop scientifically based planting terms for strawberry plantations with garden seedlings of the "frigo" type, for the conditions of the northern regions of Moldova, and to obtain the maximum yield of high-quality berries in the first year of operation, as well as to offer production the most productive, attractive and manipulation-resistant varieties of strawberries.

2. MATERIALS AND METHODS

To realize the set objectives, in the summer of 2021 in GȚ "Fedorciucova Zoia" Kunicha village, Floresti district, a strawberry plantation was planted in an area of 2.2 ha. The farm purchased "frigo" type seedlings of the A+ category from Mazzoni vivai and Salvi vivai nurseries (Ferrara) in Italy. The Marmolada variety recommended in Moldova for production trials was taken as a control. For the research, seedlings of Aprica, Sibilla, Arosa, and Laetitia varieties were also purchased. To establish optimal planting dates, the varieties Marmolada, Aprica, and Arosa were planted on June 15, July 15, and August 16, the main array of strawberries was planted in the period from July 15 to 19. The seedlings were planted on beds 25-30 cm high, covered with black polyethylene film, and a drip irrigation system laid underneath it. The planting scheme was 140+(60x25) cm.

The placement of variants was carried out in blocks, with 3 repetitions in each variant. Each iteration consists of 10 plants.

3. RESULTS AND DISCUSSION

The reserve for increasing the efficiency of strawberry cultivation is the establishment of plantations in the best agronomic terms, which contribute to good plant establishment, promising varieties with different maturity.

The strawberry varieties we took as an object of research belong to different ripening periods and have different growth vigor.

Table 1. Features of formation of the above-ground part of the strawberry bush depending on the variety and terms of planting seedlings

Variety name	Plant height, cm	Number of leaves, pc	Leaf area, cm^2	Leaf wet weight, g	Number of stolons, pc/bush
1. Marmolada	27	29	3156	66.5	12
2. Aprica	33	25	3398	85.2	9
3. Sibilla	28	32	3208	81.1	13
4. Arosa	25	34	3361	67.8	10
5. Laetitia	26	30	2967	61.4	11

Aprica variety belongs to the early group, Marmolada and Sibilla to the middle group, and Arosa and Laetitia to the late group. The obtained results showed that among the studied varieties the most powerful bush development was characterized by the variety Aprica (Table 1). Thus, the next year after planting, the plant height of this variety was 33 cm and was the highest in the experiment. Further, according to this indicator, the studied varieties were arranged in descending order - Sibilla 28 cm and Marmolada 27 cm. Regarding the number of leaves per bush, the highest value was achieved in the Arosa variety, which at the end of the growing season had an average of 34 leaves per bush. The varieties Sibilla and Aprica had a lower number of leaves per bush, which amounted to 23 and 25 leaves per bush. The highest value of leaf surface area was observed in the variety Aprica, which averaged 3398 cm2/bush. Despite the small number of leaves, this variety developed the largest leaf plate. The raw weight of leaves was also the highest in the variety Aprica and corresponded to the value of 85.2 g/bush, a little less this indicator was in the variety Sibilla and the lowest value of this indicator - 61.4 g/bush was noted in the variety Laetitia. Along with plant height and number of leaves, the formation of a third type of shoots in strawberries, called stolons, is an indicator characterizing the varietal features of bush development. Stolons appear towards the end of fruiting. In our experience, the beginning of stolon formation was noted by the end of June and depended on the maturity of the variety. Removal of stolons in industrial strawberry plantations is an important and labor-intensive agronomic technique. The less the variety forms creeping shoots, the lower the cost of its care. In our experience, the largest number of stolons, on average, was noted in the Sibilla variety, which amounted to 13 stolons/bush, followed by Marmolada - 12 stolons/bush and Arosa – 10. The most technologically advanced variety was Aprica, which formed only 9 pieces of stolons per bush.

Thus, the study of the main indicators of strawberry bush growth: plant height, number, and area of leaves, showed that the most powerful above-ground part among the studied varieties was developed by the Aprica variety. The vegetative organs of the Arosa and Sibilla varieties were slightly smaller and the lowest indicators of the above-ground part were in the Laetitia variety.

The above-ground strawberry system consists of three types of shoots, which differ in their biological functions. Shoots have an apical (terminal) bud, a rosette of three or five leaves, lateral axillary buds in the leaf axils, and adventitious roots (Chukhlyaev I., 1982, Shamanskaya L., 1991). Under favorable conditions, young plants form 4 shoots, two-year-olds up to 8, and three-year-olds up to 17 or more, and since varieties of the standard type have the potential for a shoot to have one peduncle, then by the number of shoots one can judge its productivity (Burmistrov V., 1985). Note that an intensive increase in the number of shoots occurs throughout the entire period of plant growth and development, then slows down due to plant aging.

Table 2. The influence of planting terms on the formation of shoots and leaves by the end of the first year of vegetation, Kunicha village as of November 12, 2021.

Variety name	June 15		July 15		August 16	
	Total shoots, ***pc/bush***	**Total leaves,** ***pc/bush***	**Total shoots,** ***pc/bush***	**Total leaves,** ***pc/bush***	**Total shoots,** ***pc/bush***	**Total leaves,** ***pc/bush***
1. Marmolada	4,8	33	4,2	29	1,8	11
2. Aprica	4,2	29	3,9	25	1,8	9
3. Arosa	4,0	36	3,8	34	1,9	12

Our experiments have shown that young plants, under favorable conditions, can form from 2 to 6 shoots in the year of planting (Table 2). An important condition affecting plant growth and strawberry yield is the optimal planting time, which is determined by the climatic conditions of the area and soil type, as well as the availability of planting material. To determine the best planting terms, 3 planting dates were studied in the experiment: June 15, July 15 and August 16. In the first two terms, seedlings of the "frigo" type were planted, and purchased from the company "Salvi vivai". For planting in the third period, seedlings grown in cups directly on the farm were used.

For the conditions of the Republic of Moldova, the recommended time for planting strawberries is the second decade of August. However, it was noted that the harvest for the next year was not very high due to insufficient development of bushes. The main indicator of the productivity of strawberry plants is the formation of shoots, from the terminal bud of which a peduncle is subsequently formed and fruiting occurs. Thus, the data obtained in our experiment showed that the timing of planting strawberry seedlings had a significant impact on both the development of bushes in general and the formation of shoots. Thus, for the Marmolada variety, the maximum number of shoots - 4.8 pcs/bush - were formed in the first year of planting at the earliest date - June 15. This indicator was also quite high when planting on July 15, amounting to 4.2 pcs/bush. Late planting dates, recommended in Moldova for planting the classic form of current seedlings, led to the formation of only 1.8 shoots per bush. Strawberry plants planted in the second half of August have time to root well in the presence of sufficient moisture, but the shortfall period allows the formation of no more than two shoots per bush. The timing of planting also had a significant impact on the formation of leaves. Thus, when planted on June 15, the most powerful variety Aprica produced 29 leaves by the end of the growing season, which was only 12 fewer than the plants in the second year of planting. When planting on July 10, the number of leaves for the studied varieties decreased by 2 - 4 pieces. Visually, the power of development of the leaf surface of plants planted on June 15 and July 15 did not differ from each other. When planting on August 16, the number of leaves per bush decreased by 3 - 3.2 times and, according to the studied varieties, amounted to only 9 - 12 pieces per bush.

Thus, the early planting of strawberries contributed to good tillering and the formation of an average of 4.0 to 4.8 shoots per bush for the studied varieties, while when planting on August 16, no more than two shoots per bush were formed. Strawberry plants also form a well-developed leaf surface, 25 - 36 leaves per bush, slightly different from the number of leaves formed in the second year of the growing season. Planting on August 16 led to a 3-3.2 times decrease in the number of leaves per bush.

Yield is the most important economic and biological trait and depends on the following factors: the number of leaves, the number of peduncles, the number of berries in the peduncle, and the average weight of berries. The reserve for increasing strawberry yields is the establishment of plantations in the best agronomic terms, which contributed to good plant establishment and selection of promising varieties with different ripening dates.

Table 3. Strawberry productivity depending on planting dates and variety in the first year of fruiting, Kunicha village 2022.

Variety name	Number of inflorescence per plant, *pc/plant*	Number of fruits, *pc/ inflorescence*	Average berry weight, *g*	Productivity, *g/bush*	Yield, *t/ha*
planting June 15					
1. Aprica	4,2	5,4	23,8	540	23,2
2. Marmolada	4,4	6,7	22,9	675	29,0
3. Arosa	4,0	6,3	21,7	547	23,5
planting July 15					
1. Aprica	3,9	5,1	22,9	455	19,6
2. Marmolada	4,2	6,5	21,3	581	25,0
3. Arosa	3,8	6,2	23,8	667	28,7
planting August 16					
1. Aprica	1,8	4,3	28,3	219	9,4
2. Marmolada	1,8	4,6	26,8	221	9,5
3. Arosa	1,9	4,0	25,1	191	8,2

Analyzing the number of flower stalks per plant (Table 3), it should be noted that their formation was greatly influenced by the timing of planting seedlings. When planted late on August 16, the number of peduncles varied from 1.8 in the Aprica and Marmolada varieties to 1.9 in the Arosa varieties. Earlier planting dates led to an increase in this indicator, so when planting on July 15, the number of peduncles ranged from 3.8 for the Arosa variety to 4.2 for the Marmolada variety. This indicator reached even greater values when planting on June 15, for example, the Marmolada variety formed 4.4 peduncles, which was 2.4 times more than when planting on August 16.

Analyzing the fruit formation per peduncle indicator, we see that early planting dates contributed to an increase in this indicator. The largest number of fruits was formed in the Marmolada variety when planted on June 10 and amounted to 6.7 pieces per peduncle. It should be noted that no significant differences in the formation of fruits per one peduncle were observed between the planting dates of June 15 and July 15. With late planting, the number of fruits decreased in the studied varieties by 33-37% and ranged from 4.0 pieces in the Arosa variety to 4.6 pieces for the Marmolada variety.

An important indicator of strawberry productivity is the average weight of the berry. Analyzing the data obtained, it should be noted that both planting dates and varietal characteristics significantly influenced the size of the berries. Among the studied varieties, the highest average berry weight was noted for the Aprica variety and varied from 23.8 to 28.3 g. Next comes the Marmolada variety with indicators of 22.9 – 26.8 g and the smallest fruits were from the Arosa variety, amounting to 21.7 – 25.1 g. It should be noted that the studied varieties in terms of average berry weight exceeded the established standards for strawberries, equal to 15 g (O.A. Gorelikova, 2017). The larger size of the berries when planted on August 16 is primarily due to the smaller number of fruits formed on 1 peduncle. With earlier plantings, the yield per bush was significantly higher, which mainly affected the decrease in the average berry weight.

Analyzing the productivity indicator per bush, it should be noted that it reached its highest values for the Marmolada variety when planted on June 15 and amounted to 675 g/bush. Among the studied varieties, Marmolada was distinguished by the highest productivity, regardless of planting time, exceeding the Arosa variety by 128 g, and the Aprica variety by 135 g/bush.

The integral indicator of productivity is the yield per hectare. The highest yield in the experiment was in the variety Marmolada at planting on June 15 and amounted to 29.0 t/ha. When planted on July 15, the yield was slightly lower, amounting to 28.7 t/ha for the Arosa variety. Late planting date of August 16 led to a decrease in yield more than 3 times and amounted to 8.2 to 9.5 t/ha for the varieties studied. Thus, early planting dates contributed to the increase in the number of peduncles per plant by 2.2 - 2.7 times, as well as to the increase in fruits per peduncle. This indicator reached

the highest values in the Marmolada variety. Among the studied varieties, the Aprica variety has the highest average berry weight, regardless of planting time. The most productive among the studied varieties is the Marmolada variety, the productivity of which in the first year of fruiting was the highest when planted on June 15 and amounted to 29.0 t/ha. The late planting date of August 16 also led to a 3-fold decrease in the yield of the plantings.

Table 4. The effect of variety on strawberry plantation yield in two years of fruiting.

Variety name	2022		2023		Total yield over 2 years, t/ha
	Average berry weight, g	Yield, t/ha	Average berry weight, g	Yield, t/ha	
1. Marmolada	21,3	25,0	17,3	26,7	51,7
2. Aprica	22,9	19,6	20,4	22,6	42,2
3. Sibilla	23,4	27,6	18,1	24,5	52,2
4. Arosa	26,7	28,7	17,8	26,2	54,9
5. Laeticia	27,3	27,5	19,5	28,2	55,7

Analyzing the yield of the varieties studied in the experiment (Table 4), it should be noted that all of them have high potential productivity and there was no significant difference in this indicator between them. The average berry weight of all varieties was higher in the first year of fruiting and ranged from 21.3 g in Marmolada to 27.6 g in Laetitia. In the second year of fruiting the berry size it decreased significantly, especially in varieties with higher yields. Thus, in the variety Laetitia, this indicator decreased by 30% and amounted to only 19.5 g. The yield of all studied varieties during 2 years of fruiting remained stably high and fluctuated within 19.6 -28.2 t/ha. It was slightly lower in the early maturing variety Aprica, amounting to a total of 42.2 t/ha for 2 years, but this does not reduce the value of this variety because it is characterized by excellent marketability, flavor qualities, and higher selling price. In total for two years of fruiting the highest yield was obtained by the variety Laetitia, amounting to 55.7 t/ha.

4. CONCLUSION

The conducted studies have shown that the most optimal time for planting strawberry plants with “frigo” type seedlings for the conditions of the Northern zone of the Republic of Moldova is the first half of July. Until the end of vegetation plants have time to develop a strong vegetative mass, to form an average of 4 fruit-bearing shoots, which provides the second year of berry yield in the range of 25 -28 t/ha. Earlier planting leads to the formation of a large number of stolons that need to be removed, damaged by powdery mildew, and provokes premature fruiting in some varieties.

All varieties studied in the experiment have high potential productivity, deserve to be included in the State Register, and are recommended for planting new strawberry plantations.

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