THE IMPACT OF ANNUAL STEM DENSITY ON VEGETATIVE GROWTH AND FRUITING IN THE RASPBERRY VARIETY ENROSADIRA

IMPACTUL DENSITĂȚII TULPINILOR ANUALE ASUPRA CREȘTERII VEGETATIVE ȘI A FRUCTIFICĂRII LA SOIUL DE ZMEUR ENROSADIRA

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Abstract.
Field study conducted in open ground to determine how growth and fruiting vary at five levels of annual stem density and to identify the optimal density level for the raspberry variety Enrosadira. Plants were planted at a distance of 2.5 m × 0.45 m. The density of annual stems varied between 12 and 20 plants per linear meter, on a strip 0.5 meters wide, spaced approximately 20–30 cm apart. Stem density was studied per linear meter in randomized blocks with replication: V1 – 12 stems, V2 – 14 stems, V3 – 16 stems, V4 – 18 stems (control), and V5 – 20 stems. Plant height, stem thickness, yield per stem and per hectare, fruit size, sugar/acidity content, and timing of fruiting were evaluated. Yield per stem and per hectare differed significantly between densities. The highest productivity was recorded in the variant with 14 stems per linear meter, without affecting fruit quality. At densities of 12–14 stems per linear meter, a delay in fruiting by 9 days was observed compared to those with a number greater than 16 stems per linear meter. Density above this level led to a reduction in the fruiting period and a decrease in fruit quality.
Key words: Raspberry; Density; Harvest period; Yield; Quality.

Rezumat.
Studiu de câmp realizat în teren deschis cu scopul de a determina cum variază creșterea și fructificarea la cinci niveluri de densitate a tulpinilor anuale și de a identifica nivelul optim de densitate pentru soiul de zmeur Enrosadira. Plantele au fost plantate la distanța de 2,5 m × 0,45 m. Densitatea tulpinilor anuale a variat între 12 și 20 de plante pe LM, pe bandă cu lățimea de 0,5 metri, distanțate la aproximativ 20–30 cm. Densitatea tulpinilor a fost studiată pe LM în blocuri randomizate cu repetiție: V1 – 12 tulpini, V2 – 14 tulpini, V3 – 16 tulpini, V4 – 18 tulpini (martor), și V5 – 20 tulpini. Au fost evaluate înălțimea plantelor, grosimea tulpinilor, randamentul pe

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tulpini și pe hectar, mărimea fructelor, conținutul de zaharuri/aciditate, precum și momentul perioadei de fructificare. Randamentul pe tulpini și pe hectar diferă semnificativ între densități. Cea mai mare productivitate s-a înregistrat în varianta cu 14 tulpini pe LM, fără a afecta calitatea fructelor. La densități de 12–14 tulpini pe ML s-a observat o întârziere a fructificării cu 9 zile față de cele cu un număr mai mare de 16 tulpini pe LM. Densitatea peste acest nivel a dus la reducerea perioadei de fructificare și la scăderea calității fructelor

Cuvinte cheie: Zmeură; Densitate; Perioadă de recoltare; Randament; Calitate

INTRODUCTION

The demand for raspberry (*Rubus idaeus* L.) is very high in the local market, which has driven the large-scale expansion of its cultivation [Sava, 2016; Balan & Dodica, 2023; Turețchi, 2021]. The introduction of new raspberry varieties requires testing and study to determine the most adapted varieties to local conditions, which have the potential for high yields. An essential factor in increasing productivity is the improvement of the photosynthetic apparatus activity, especially by regulating the density of canes and suckers [Babuc, 2012; Sava, 2016; Balan et al., 2017].

The cultivar Enrosadira, known for its remontant characteristics, offering quality fruit over multiple periods of the year, was used in the research. Standardizing the density of annual fruiting canes represents an essential agronomic practice, directly influencing the growth, development, and fruiting of the plants. In open-field cultivation, maintaining a balance between planting density and plant health is crucial for obtaining high yields and extending the harvest period.

The study proposes to analyze the influence of standardizing the density of annual fruiting canes on the productivity, size, and quality of the fruit, as well as on the fruiting period of the primocane-fruiting raspberry cultivar Enrosadira, grown under open-field conditions. By adjusting plant density, the goal is to identify the optimal configuration for maximizing yield and prolonging the harvest period.

MATERIAL AND METHOD

The research was conducted during 2023 – 2024 in the Centru fruit growing area of the Republic of Moldova. The plantation of remontant raspberries of the Enrosadira variety was planted in the spring of 2021 at a distance of 2.5 x 0.45 m. The raspberry plants were trained on a simple trellis, in a strip, 0.5 m wide, palisade on three rows of double wire. Soil and plant maintenance are maintained at a high level. The standardization of annual cane density varied between 12 and 20 plants per LM (linear meter) of the 0.5-meter-wide band, spaced at approximately 20-30 cm. The following variants were analyzed: V1: 12 canes per LM; V2: 14 canes per LM; V3: 16 canes per LM; V4 Control (C): 18 canes per LM; V5: 20 canes per LM

Observations on the degree of flowering were made during the white bud stage and after the ovaries dropped, at the beginning of July. The quantity of fruit was calculated

by counting, in the first week of harvest. The length and diameter of the fruits at the base were measured with the mechanical caliper, taking into account 50 fruits from 3 plants per variant [Babuc, 2012; Cimpoieș, 2018; Balan et al., 2019]. The yield was determined by variant, repetition, and fruit harvesting date. Fruit harvesting was carried out in multiple passes, as the fruits reached maturity, with the harvest being performed vertically, downwards, along the length of the canes. Productivity per cane and per hectare was calculated for each variant. Excess suckers were cut twice during the season, at the beginning and end of May, when the suckers were 25-30 cm high from the soil. The periods of bud break, flowering, and harvesting were investigated for the years 2023 and 2024.

RESULTS AND DISCUSSIONS

During the research years, the primary growth of the suckers was most intense in variants V1, V2, and V3, and weakest in V5. At the second measurement, in the green fruit formation stage, a height increase of 115 cm was recorded in the control variant, while in the variants with 12–14 fruiting canes, the increase was 130 cm in V1 and 110 cm in V2. In practice, it has been shown that the density of suckers per LM determines the growth and development of the annual fruiting canes, which are better developed in the case of less dense sucker variants. Thus, the smallest cane diameter was observed in the variants with 20 suckers, followed by the variant with 18 suckers, while the largest diameter was recorded in the variants with 12 and 14 suckers per LM.

The larger spacing between plants in the band promoted a higher number of inflorescences and fruits in the variants with 12–14 annual canes per LM, compared to the variants with 16–20 annual canes per LM, where the difference is approximately 30%. As the plants become denser per LM, the volume of the foliage, the number of lateral branches, and the number of inflorescences is reduced, which leads to a smaller number of fruits on the lateral fruiting branches (Table 1).

Table 1

Fruiting period of the Enrosadira raspberry cultivar depending on annual cane sucker density and the number of fruits per Inflorescence

Variant	Number of annual Shoots (pcs.)		Number of Fruits per Inflorescence (pcs.)		Period of fruiting stages	
	2023	2024	2023	2024	2023	2024
V1	22	20	8	8	08.08-05.10.23	27.07 -20.09.24
V2	22	20	8	8	08.08 -05.10.23	27.07 -20.09.24
V3	20	18	6	6	08.08 -05.10.23	27.07 -20.09.24
V4	17	16	6	6	02.08. -24.09.23	21.07.-11.09.24
V5	16	15	5	5	02.08. -24.09.23	21.07.-11.09.24

The growth and fruiting conditions of the raspberry variety Enrosadira were slightly more favorable in 2023 compared to 2024. In 2023, the fruit weight was 3.8 g in the control variant and 4.9 g in variants 1 and 2, and the fruit production

obtained per LM of the band in the control variant was 2.7 kg, being 18.5-55.5% lower than in the researched variants. The yield per hectare in the control variant was 10.8 t/ha in 2023 and 8.64 t/ha in 2024, which represents a decrease of 6 -7.04 t/ha compared to V2 and a difference of 2.0-3.96 t/ha compared to V3. The lowest production per hectare in the two years of research was in V5, with a volume of 8 t/ha, being 80-110% lower than V1 and V2.

The research highlighted the fact that, with the increase in the density of annual stems above 14 stems per LM, there was a decrease in the mass of fruits in the control variant by approximately 19.5-19.6% compared to the variants V1 and V2 (Table 2).

Table 2

The production potential of raspberry, variety Enrosadira depending on the density of annual fruiting stems

Variant	Fruit Mass (g)		Fruit Yield (kg/plant)		Fruit Yield per LM (kg)		Yield (t/ha)	
	2023	2024	2023	2024	2023	2024	2023	2024
V1	4.9	4.6	0.30±0.005	0.28±0.007	3.6*	3.36*	14.4*	13.44*
V2	4.9	4.6	0.30±0.006	0.2±0.008	4.2*	3.92*	16.8*	15.68*
V3	4.2	4.1	0.20±0.005	0.1±0.007	3.2*	3.04*	12.8*	12.16*
V4 (M)	3.8	3.7	0.15±0.006	0.12±0.008	2.7	2.16	10.8	8.64
V5	3.7	3.7	0.10±0.005	0.1±0.007	2.0	2.0	8.0	8.0
DL, 5%	0.22	0.19	-	-	0.15	0.21	0.66	0.57

(*) – Significant for $p \leq 0.05$

In 2024, the reduction in fruit weight led to a lower harvest per plant of 0.12 kg in the control variant, being 0.16 kg lower than V1 and 0.08 kg lower than V2, and 0.02 kg higher than V5. The harvest obtained in the control variant was inferior both in terms of the number of fruits and fruit weight. As a result, the fruit production harvested on the LM band in 2024 in the control variant was lower by 1.04-1.12 kg compared to V1 and by 1.6-1.76 kg compared to V2. Thus, reducing the density of fruiting stems from 18 to 14 units in a dry year and unfavorable for raspberry cultivation can lead to a harvest increase of 6.4-7.04 t/ha, which represents a higher value increase by 81.48% compared to the control variant.

An analysis of the research results highlighted an extremely important factor related to fruit ripening and the harvest period of the raspberry [Baraldi et al., 1999; Koraqi, 2019; Spasojevic et al., 2024; Yiping et al., 2022]. In variants V1, V2, and V3, fruit ripening was delayed by approximately 9 days compared to V4 and V5. This directly influenced the harvest period, which in 2023 was 58 days for variants 1–3, compared to 53 days for variants 4 and 5. In 2024, these periods were reduced to 53 days for variants 1–3 and 50 days for variants 4 and 5, and the delay in ripening in variants 1–3 compared to 4–5 was 6 days.

The impact on fruit quality was influenced by the number of annual fruiting stems per LM. Variants with 12-14 stems produced higher quality and larger fruit, while variants with 16-20 stems had a lower yield and smaller fruit. The choice

between standardizing with more than 16 stems or with a smaller number involves economic and management considerations. The variant with more stems (V4, V5) requires less manual effort, but produces smaller fruit and a lower yield, while the variant with fewer stems (V1, V2) offers larger fruit, but requires stricter control and higher costs for standardizing the fruiting stems, especially in the case of industrial areas.

Organoleptic analysis demonstrated that the longest fruit length in the two years of research (1.9-2.0 cm) was obtained in variants with 12-14 fruit stems per LM of tape. The study on the dynamics of the concentration of soluble dry matter (CSM) depending on the density of fruit stems at ML did not reveal a clear connection, with only an insignificant difference of 1.82-2.73% recorded between the variants in the experience (Table 3). The highest CSM indicator in 2023-2024 was recorded in V1 and V2, while the lowest in variants 4-5. The Brixº content depends on the biological characteristics of the variety and the number of sunny days during fruit development. Titratable acidity varied insignificantly, being between 1.36-1.45% in both years of study.

Table 3

Quality of Enrosadira raspberry fruits depending on annual cane density per LM

Variant	Soluble dry matter (%)		Titratable acidity (%)		Grade I fruit (%)		Grade II fruits (%)	
	2023	2024	2023	2024	2023	2024	2023	2024
V1	10.85	10.95	1.39	1.36	90	80	10	20
V2	10.85	10.95	1.39	1.36	90	80	10	20
V3	10.88	10.90	1.40	1.38	78	70	22	30
V4 (M)	10.5	10.85	1.40	1.39	75	68	25	32
V5	10.4	10.85	1.40	1.45	73	65	27	35
Media	**10.69**	**10.9**	**1.39**	**1.38**	**81.2**	**72.6**	**18.8**	**27.4**

The visual appearance of the raspberries in the plastic casserole demonstrated the most attractive appearance in V1 and V2, characterized by pronounced and intense gloss, out of the 100 fruits, 80 quality I fruits and 20 qualities II fruits were obtained, all without significant deformations. The lowest quality fruits were obtained in variants 3-5, year 2024 (30-35 fruits) and in V5, year 2023 (27 fruits).

Following organoleptic analysis and mechanical handling, it was found that the firmness and transportability of the fruits are higher in V1, V2, and V3, while these characteristics are lower in the control variant (V4) and V5. Production losses during manual raspberry harvesting in the control variant are approximately 2–3% of the total harvested production, while in V1, V2, and V3, they are approximately 1–1.5%.

CONCLUSIONS

A moderate density of 14 canes per LM optimizes both productivity and the extension of the fruiting period. At this density, a significant increase in the number

of fruits per plant and a longer harvest period were recorded. The optimal density for open-field raspberry cultivation is 14 canes per LM on a wide band, ensuring a balance between yield and the extension of the harvest period. Thus, the density of fruiting canes per LM represents a decisive factor for obtaining superior quality raspberry harvests, with a variable economic impact depending on climatic conditions.

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